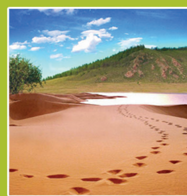
MARCC 2009

MONGOLIA: Assessment Report on Climate Change 2009



ULAANBAATAR, 2010

THE MINISTRY OF NATURE, ENVIRONMENT AND TOURISM

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MONGOLIA: Assessment Report on Climate Change 2009

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Mongolia Assessment Report on Climate Change 2009

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Disclaimers

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Executive Summary

The Mongolia: Assessment Report on Climate Change 2009 (MARCC 2009) brings together the findings of climate change research in Mongolia for the first time, to raise awareness of decision makers and the general public so that they can develop appropriate responses to the challenges and threats.

Mongolia joined the rest of the world in addressing the issue of global climate change affecting its people and economy by affirming, among others, the United National Framework Convention on Climate Change (UNFCCC) in 1993 and its Kyoto Protocol in 1999. The Government of Mongolia has taken considerable steps toward the implementation of the UNFCCC, by accomplishing the required commitments such as the Initial National Communication (INC), Technology Needs Assessment (TNA) and the National Action Plan on Climate Change (NAPCC) to address climate change and other legal commitments.

The impacts of climate change on the ecological system and the natural resources are real and will dramatically affect almost all sectors of the national economy and human and animal life and therefore all aspects of the life support system. Therefore, climate change response measures should address the need to adapt to climate change and to mitigate greenhouse gases (GHG) emissions in order to meet the requirements of the sustainable development strategies of Mongolia. Climate change will directly influence achievement of the Millennium Development Goals (MDGs) of Mongolia.

In the case of Mongolia, its fragile ecosystems, pastoral animal husbandry and rainfed agriculture are extremely sensitive to climate change. As such, Mongolia's traditional economic sectors and its people's nomadic way of life are highly vulnerable to climate change. Mongolia is very sensitive to climate change due to its geographic location and socioeconomic condition. As a result of climate change and variability and the impacts of climate change, in the last forty years, Mongolian ecosystems have been notably altered. These changes have affected environment, desertification, water supply and natural disasters leading to financial, environmental and human losses.

The Government of Mongolia has established an interagency and intersectoral National Climate Committee (NCC) led by the Minister for Nature, Environment and Tourism to coordinate and guide national activities and measures aimed to adapt to climate change and to mitigate GHG emissions. The NCC approves the country's climate policies and programmes, evaluates projects and contributes to the guidance to these activities. It is directly responsible for implementing the commitments under the UNFCCC and Kyoto Protocol and for managing the nationwide activities to integrate all climate-change-related problems in various sectors. For operational requirements of the programme, a permanent Climate Change Office (CCO) is planned to be established under the supervision of the Chairman of the NCC. Mongolia has also started the preparation of the Second National Communication (SNC) to the UNFCCC which will be ready for submission early part of next year.

In 2006, Mongolia's net GHG emission was 15,628 gigagrams (Gg) in CO_2-equivalent. The energy sector (including stationary energy, transportation and fugitive emissions) was the largest source of GHG emissions comprising 65.4% (10,220.09 Gg) of total emissions. The second largest source of GHG emissions was the agricultural sector (41.4%). The total CO_2 removal was more than total CO_2 emissions at 2,083.6 Gg (13.3%) in 2006 due to an increase in the area of abandoned lands and a reduction in newly cultivated land. Other relatively minor sources currently include emissions from industrial processes and the waste sectors. As a whole, this translates to a CO_2 emissions per capita at 6 ton CO_2 equivalent.

Among the energy sources, coal is the most important fuel in Mongolia. Its share in 2005 was 66.3%. Next was petroleum, which accounts for 22.7%. Share of hydro and other renewable energy was only 11%.

Based on the projections made during the preparation of the Initial National Communication by Mongolia regarding future emissions, by 2020 total emissions will rise by more than five (5) times over. Although Mongolia as a developing country has made no definitive commitments to reduce GHG emissions, the NAPCC aims to curb their growth.

The abatement scenario of emissions foresees the introduction and implementation of different options mainly focused on clean coal technology, energy saving through energy efficiency measures and promotion of renewable energy sources. Previous studies regarding the energy sector identified a number of mitigation options. For the energy supply sector, to increase renewable options such as hydropower plants, wind farms and PV and solar heating; to improve the efficiency of heating boilers and convert steam boilers into small capacity thermal power plants; to improve household stoves and furnaces; to improve coal quality by coal beneficiation and effective mining technology and to improve power plants efficiency. For the energy demand sector, the mitigation measures include: district heating and building environment; improve lighting efficiency; improve industry housekeeping and implement motor efficiency improvements and introduce energy efficient technologies such as dry-processing for cement industry, etc.

A number of GHG mitigation measures for all GHG relevant sectors with a more significant focus on the agriculture, livestock and energy sectors have been evaluated in terms of various criteria, which does not consist only of reduction potential and cost and benefit, but also the contribution to reduce poverty and social acceptability.

Research activities will continue to focus on systematic observation and monitoring of the climate system, assessment of observed climate change, development of climate scenarios, vulnerability and risk assessment, potential impacts on ecosystems and society, and possible measures to adapt to climate change and mitigate the GHGs emissions at the national level. Based on such comprehensive studies and analyses, the NAPCC should be updated and hence facilitate the implementation of Mongolia's strategy and policy on climate change.

According to the records from 48 meteorological stations which are distributed evenly over the territory of Mongolia, the annual mean temperature of Mongolia increased by 2.14^{0}C during the last 70 years. However, annual mean temperature decreased in winter season for the period of 1990-2006. Since 1940, average summer temperature has been increasing noticeably. Precipitation changes in Mongolia can be classified by locations: since 1961 in the Altai mountain region, Altai Gobi and in the eastern part of the country has increased, and in all other regions has decreased by 0.1-2.0 mm/year.

The future climate scenario for Mongolia projects changes such as increased air temperatures, increased precipitation amount in some areas and reduction of water resources and arable land. Potential evapotranspiration increase would be higher than precipitation amount increase. The most vulnerable areas in Mongolia are the agricultural, livestock, land use, water resources, energy, tourism and residential sectors. Future climate changes are expected to negatively impact mostly the agricultural and livestock sectors, which in turn will affect the society and economy of Mongolia. This is an issue that needs to be taken into serious consideration.

Impacts, Vulnerabilities, and Adaptation Options for Key Economic Sectors

Sustainable development depends on close links between the environment and the economy. A significant portion of the economic activity has always been based on natural resources such as pasture, animal husbandry, arable land and water resources. Today, Mongolia not only faces with the same problems as developing countries caused by the global climate change, but it also has specific concerns which relate to Mongolia's unique geographical and climatic conditions. For instance, Permafrost covers more than 60 per cent of the territory of Mongolia. Melting of permafrost area caused by global warming will have very adverse effects on agricultural practices, water resources and infrastructure development like bridge and road constructions, buildings, etc. In addition, climate change would seriously affect ecosystem, natural grassland, arable farming, pasture animal husbandry and soil quality. Therefore, the adaptation problem would be a higher priority concern than the GHG mitigation problem for Mongolia.

The Way Ahead

Mongolia's ability to adapt to a changing climate should be strengthened. Adaptation is an essential investment in Mongolian's common future, in making the communities more resilient and in reducing the vulnerability to climate change and its adverse impacts. This will continue also to be an investment in the ecosystems that sustain Mongolia in the long term.

The Comprehensive National Development Strategy of Mongolia approved by the Great Khural (Parliament) in 2008 is anchored on the Millennium Development Goals (MDGs) and defines in a comprehensive manner its policy for the next fourteen years (up to 2021). It aims at promoting human development in Mongolia, in a humane, civil, and democratic society, and intensively developing the country's economy, society, science, technology, culture and civilization in strict compliance with global and regional development trends. The strategy identified six priority areas of development for Mongolia, of which the Priority Area 5 says that *"to create a sustainable environment for development by promoting capacities and measures on adaptation to climate change, halting imbalances in the country's ecosystems and protecting them*". In Strategic objective 6 titled "*Promote capacity to adapt to climate change and desertification, to reduce their negative impacts*" of this priority area, the climate change adaptation activities and measures were identified.

Public awareness is an important component that is crosscutting the overall National Communication exercise. Efforts to raise awareness on climate change have contributed positively to the mainstreaming process. This component will also continue to be developed under the Second Communication phase that is presently being prepared. The National Communication process has not only been considered as a tool for reporting to the UNFCCC but also for mainstreaming — identifying and integrating — the main directions into the national planning process and programming through the mobilization of new resources.

Due to such efforts, the Mongolia National Energy Plans and Programmes have already integrated many findings and outputs from Mongolia's INC and TNA. The strategy aims at increasing the security of energy supply through optimisation of supply and efficient consumption while ensuring minimal impact to the environment.

The main components of the energy supply and utilization program of Mongolia which are directly or indirectly related to and would impact on climate change are the energy supply and utilization programs with focus on clean coal technologies and energy efficiency. The government also includes measures in the non-energy GHG-related technology programs.

In the frame of the MDG program led by UNDP, Mongolia managed to naturally link up national energy planning, poverty and climate change issues. According to the Mongolia National Energy Plan being updated, national targets will be set for saving energy and increasing the share of renewable energy sources mainly from hydro resources with the corresponding GHG reduction goals in CO_2 equivalent.

Supporting policies, laws and regulations on climate change, renewable energy, energy efficiency and non-energy, GHG-related sectors are being set for the immediate term.

A number of GHG climate change projects are in the pipeline for building adaptive capacities for the different projects intended to support the climate change program of Mongolia. Recognizing its strategic role in North-eastern Asia, among similarly situated countries, Mongolia is especially active in establishing a sub-regional cooperation to tackle common issues, including climate change.

The various options on future climate change plans are being considered by the Government of Mongolia consistent with the Overall Strategy in the National Action Plan which will be updated and be approved through the Second National Communication process. It will include mostly plans for adaptation, to a greater degree, and the innovative mitigation measures, through local mobilization, private sector partnerships and international cooperation under a renewed climate change policy and institutional agenda for Mongolia for the years to come.

Preface

This year's country report on **Mongolia: Assessment Report on Climate Change** (MARCC 2009) is the first attempt to assess and synthesize the findings and results of climate change research and studies conducted in Mongolia. The Report serves also as a compendium of scientific background and reference documents written with an intention to provide the general public and researchers with knowledge and latest information on climate change and its consequences. The Report also aims to assist decision makers in government organizations, the public and private sectors in formulating and implementing appropriate responses to the challenges and threats posed by the global climate change.

The scope of the MARCC includes information and inputs from various relevant reports and reference materials conducted and written since the 1990s in Mongolia. The content of this Report include the following:

- Observed changes in climate of Mongolia and its future projections
- Potential impacts of climate change on natural and ecological components, and social and economic sectors of Mongolia
- Vulnerability and Adaptation to climate change
- Greenhouse gas monitoring and inventories
- Greenhouse gas mitigation potentials and options
- Climate-friendly technology needs

The development of the MARCC was carried out by the leading practitioners and authors based on the reports and papers submitted by the contributors from different fields and sectors.

A special note of appreciation and gratitude is extended to the Lead Authors: D.Dagvadorj, L. Natsagdorj, J.Dorjpurev, B.Namkhainyam, who prepared this Report and to the researchers and experts: P.Gomboluudev, P. Batimaa, G. Davaa, D.Jugder, B.Bolortsetseg, T.Ganbaatar, D.Jugder, B.Erdenetsetseg, Sh.Bayasgalan, T.Tuvaansuren, S.Khudulmur, who made valuable contribution to the chapters on specific issue areas and without their generous time and efforts, the Report could simply not have been produced.

Great appreciation is extended to Dr.Damdin Dagvadorj, the UNFCC Focal Point & Director-General of the Department of Information, Monitoring and Evaluation of the Ministry of Nature, Environment and Tourism, Prof. B.Khuldorj, National University of Mongolia, who together acted as the Review Editors, for their great efforts in integrating, reviewing and finalizing the Report. Great appreciation is also extended to Ms.Anna Stabrawa, Mr.Jinhua Zhang and Ms.Tunnie Srisakulchairak of UNEP, as well as Dr.Shaohong Wu and Ms.Catherine McMullen for their participation in the review process and valuable comments.

Also expressed is the sincere gratitude to the UNEP Regional Office for Asia and the Pacific, who provided technical assistance and financial support, and Mr.Rogelio Z.Aldover, the International Consultant, and the UNDP Mongolia Country Office, for their technical assistance in the review and preparation of the Report.

Acronyms and Abbreviations

CDM	Clean Development Mechanism
CGE	Consultative Group of Experts
COP	Conference of Parties
DNA	Designated National Authority
FNC	First National Communication
GEF	Global Environment Facility
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
LEAP	Long-range Energy Alternatives Planning
LUCF	Land Use Change and Forestry
MDGs	Millennium Development Goals
NAPCC	National Action Plan for Climate Change
NCSP	National Communication Support Programme
NES	National Energy Strategy
NGOs	Non-governmental Organisations
SNC	Second National Communication
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Foreword

The global climate change, that humankind is facing today is a serious environmental threat with clear economic and social consequences. It is inextricably linked to the broader sustainable development agenda of all countries in the world, including rich and poor, big and small, developed and developing. However, the effects of climate change will have disproportionately adverse impacts on the poorest and most vulnerable world communities.

In the lecture on Climate Change, given to the public during his visit to Mongolia in July 2009, the UN Secretary-General Ban Ki-moon noted that "*Here, as elsewhere around the globe, I have seen the human face of climate change. Already, hundreds of millions of people are facing increased hardships. Three-quarters of all disasters globally are now climate related, up from half just a decade ago. You must have seen it.*"

Climate change is already a fact in Mongolia. The results of observations at meteorological stations show that the annual mean temperatures have risen by 2.1^{0}C between 1940 and 2007. Scientists are warning that climate in Mongolia will continue to change dramatically over the 21st Century and the likely future climate patterns emerging from the study results are very clear. Natural disasters such as drought, heavy snow fall, flood, snow and wind storms, and extreme cold and hot temperature are recurrent all the year round and the forecasts suggest higher temperatures and less rain in summer and more snow in winter. It also may bring more variable weather conditions with longer and/or frequent droughts and *zud (*or harsh winter*).*

Depending on the specific geographical and climatic conditions, Mongolia might be more heavily influenced by the global climate change. The impacts of climate change on the ecological system and the natural resources would be dramatic affecting directly almost all sectors of the national economy and all spheres of social life, i.e. it touches the all aspects of life supporting system. Therefore, climate change response measures would help to address the inevitable need to adapt to climate change and to mitigate greenhouse gas emissions in order to meet the requirements of the sustainable development strategies of Mongolia. Climate change will influence directly the achievement of the Millennium Development Goals of Mongolia.

We must strengthen our ability to adapt to a changing climate. Adaptation is an essential investment in our common future, in making our communities more resilient and in reducing our vulnerability to climate change and its adverse impacts. This is also an investment in the eco-systems that sustain us.

The Government of Mongolia pays close attention to climate change issues and has been undertaking concerted actions to address challenges posed by climate change, in particular, with an emphasis on adaptation and mitigation. With an aim of establishing and promoting sub-regional cooperation on climate change and of contributing to the global community efforts to deal with climate change, Mongolia has launched an initiative to hold a Northeast Asia Summit on Climate Change. The Summit is proposed to be held as a sideline with the UN High-Level Event on Climate

Change on 22 September 2009 at the UN Headquarters.

We are confident that the global and sub-regional efforts and dialogues will present an excellent opportunity for the policy and decision makers to gain common understanding of the threats imposed by climate change and to reach a political consensus.

The Mongolia: Assessment Report on Climate Change 2009 (MARCC 2009) brings together the findings of climate change research in Mongolia for the first time, to raise awareness of decision makers and the general public so that they can develop appropriate responses to the challenges and threats.

On behalf of the Government of Mongolia and on my behalf, I would like to thank UNEP regional team in Asia and the Pacific for both technical and financial assistance in preparing this report and the UNDP Mongolia office for their technical assistance in the peer review of the report. Special acknowledgements and thanks are given to Mongolia team for all the efforts in preparing this valuable report. It is my hope that the Report would be a useful comprehensive source document for decision-makers and all levels of society in Mongolia.

Luimed Gansukh

Member of the Great Khural (Parliament)
& Minister for Nature, Environment and
Tourism of Mongolia

Foreword

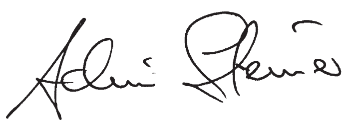
The United Nations Environment Programme (UNEP) is mandated to regularly assess major environmental developments and trends. This is implemented through the Global Environment Outlook (GEO) process with global, regional, sub-regional, national and city-level assessments. The GEO process is participatory and consultative, with capacity building at its core. The result is scientifically authoritative information for environmental management and policy development tailored to a wide target audience.

The *Mongolia: Assessment Report on Climate Change 2009 (MARCC 2009)* is one of the outputs of this capacity building programme, and the first UNEP endeavour in partnership with a national government to assess climate change impacts, support decision makers in understanding the need for urgent action, and mobilize public awareness and participation in climate change mitigation and adaptation.

Mongolia's economy has traditionally been based on agriculture and the breeding of livestock. The *Mongoli:a Assessment Report on Climate Change 2009* reveals that the country is already experiencing the impacts of climate change, which may undermine these economic activities. Mongolia's terrestrial ecosystems have been changing over the last two decades. Significant decreases in surface water, grassland and forest areas have been observed, by 19%, 7% and 26%, respectively, and barren land (without grass) has almost tripled, from 52 thousand square kilometers to 149 thousand square kilometers, almost 10% of the total land area. The size of the snowcap on major mountains has been reduced by 30 percent as compared with that in the 1940s. The increase in frequency of heavy rain has led to a twofold increase in climate related disasters, including flashfloods, with high social and economic costs.

The report further reveals that changes in climate and land conditions have significantly affected livestock productivity and related economic sectors. Over the last two decades sheep, goat and cattle shearing times have shifted ahead by about a week due to the climate change.Therefore, for Mongolia and similar countries, adaptation to climate change remains the most urgent priority. The *Mongolia: Assessment Report on Climate Change 2009* sets out a number of adaptation options, including the need for new pastureland management and livestock production systems, and early warning systems for extreme weather events to prevent related disasters.

UNEP's Medium Term Strategy (2010-2013) directs the organization to strengthen the ability of countries to integrate climate change responses into their national development processes, based on scientific information and local climate data. I believe this report fulfils this mandate and provides valuable information and options to help Mongolia to sustain the quality of life and livelihoods of the country's residents.



Achim Steiner

United Nations Under-Secretary General and Executive Director, United Nations Environment Programme

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1 Introduction

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1. Introduction

1.1. Global Climate Change Perspective

The continuing and ever increasing emission of greenhouse gasses (GHG), which are mainly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), envelop the earth like an invisible blanket that traps the heat of the sun, causes heat build up and therefore, poses a very serious threat to mankind that he has ever imagined to be real. These gases are basically induced by human activity. No country, big or small, can live in isolation because of shared causes and effects.

A predicted increase in temperature of up to 3°C before the end of this Century is just part of the concern. The scientific community thinks that the current changes in climate being manifested already could even worsen at a continuing progression, with higher intensity and frequency, of the variations in the world's climate system.

The issue becomes a global one and so are the solutions to adapt to the change or mitigate the root causes that brought in this climate change phenomenon. Approaches and effects differ from country to country. In this connection, each country, including Mongolia, signed international covenants to address the issue as a big community. Failure to respond adequately, individually and collectively, will hamper the efforts to reduce poverty, hunger and diseases and the access to basic services in any particular country.

The recent report of the Intergovernmental Panel on Climate Change (IPCC 2007) manifests that the change is real from the increases observed around the world, both in air and water temperatures.

1.2. The Mongolian Context

Mongolia is situated in the central part of the Asiatic continent. The country is bounded on the north by Russia and on the east, south, and west by China. It has a total area of 1,565,000 sq. km. It is the 19th largest country in terms of area in the world. It is also one of the largest mainland countries with no access to sea.

The topography of Mongolia consists mainly of a vast plateau with the elevation ranging from 914 to 1,524 meters (m) broken by mountain ranges in the north and west. The Altai Mountain in the southwest rises to heights of 4,267 m above the sea. Mongolia is very vulnerable to immensely changing weather conditions which are exacerbated by the landlocked geography, dispersed and sparse population and harsh temperate climate.

The signs of climate change are already evident in Mongolia as in any other country in the world, but with some unique situations which also made the climate change approach slightly different. The government and the people need to sustain their joint efforts in facing the challenges that pose ahead, to determine the vulnerabilities, to prepare to adapt to changes and to help curb the causes through every means possible.

The Government of Mongolia ratified the Kyoto Protocol in 1999 following the United Nations Framework Convention on Climate Change (UNFCCC) which was adopted in the Earth Summit in Rio de Janeiro in 1992. Hence, Mongolia has been involved in climate change activities for about a decade. After the First National Communication was submitted by the government, a national strategy for the climate change program has been developed.

In this context and status of related activities and initiatives, an assessment was done by a national team, for which this report, the Mongolia Assessment Report on Climate Change (MARCC), is prepared. The MARCC primarily includes, therefore, the following with regards to the situation, progress and directions of climate change activities in the country:

- Global and national climate change perspectives
- Current changes and projections
- Impact assessments
- Legal and institutional arrangements
- Adaptation and mitigation strategies

This Report gives a detailed description of observed changes in climate factors and variables and the possible causes of the change, It also gives the projection of future climate change trends possibly influenced by human activities in this century. It also provides climatic scenarios for climate change impact research in the different sectors of the Mongolian economy. The report has become longer than the usual assessment report as a result of voluminous inputs from different relevant agencies and groups especially on the aspect of scientific methodologies and analysis of impacts. Hence, the Report provides a comprehensive source of information also for the government and interested parties in establishing strategic plans for adaptation and mitigation responses as well as the key conclusions and options for planning on climate change seen in the Report.

2 Current Climate Change and Projections for the 21st Century

2. CURRENT CLIMATE CHANGE AND PROJECTIONS FOR THE 21ST CENTURY

2.1. Global Perspective

2.1.1. *Observed Climate Change*

The Fourth Assessment Report on Climate Change issued by the Intergovernmental Panel on Climate Change (AR4-IPCC) in 2007 concluded that *"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level".*[**1**]*

Changes in the atmospheric abundance of greenhouse gases (GHG) and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing which is used to compare how a range of human and natural factors drive warming or cooling influences on global climate.

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide and other GHG have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

Carbon dioxide is the most important anthropogenic greenhouse gas (**Figure 1.1**). The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million (ppm) to 379 ppm in 2005. The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1,732 parts per billion (ppb) in the early 1990s, and was 1,774 ppb in 2005. The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005.

The atmospheric concentration of carbon dioxide and methane in 2005 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores.

CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA

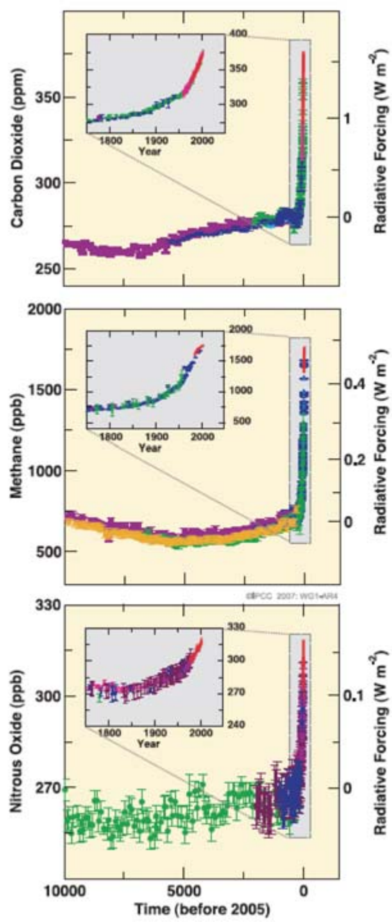


Figure 1.1 Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores and atmospheric samples (red lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. .[1]*[1]

[1] **[1]*** The digit means the number in the List of Reference.

The growth rate of nitrous oxide has been approximately constant since 1980.

Due to accumulation of GHG in the atmosphere numerous long-term changes in climate have been observed at continental, regional and ocean basin scales. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.

In the AR4 IPCC 2007 it was estimated that the global surface air mean temperature has increased by 0.74°C during the last 100 years (1906 to 2005) (**Figure 1.2**). The linear warming trend over the last 50 years (0.13°C per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76°C. Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850).

The average atmospheric water vapour content has increased since at least the 1980s over land and ocean as well as in the upper troposphere. The increase is broadly consistent with the extra water vapor that warmer air can hold.

Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise. More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts.

The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour.

Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent.

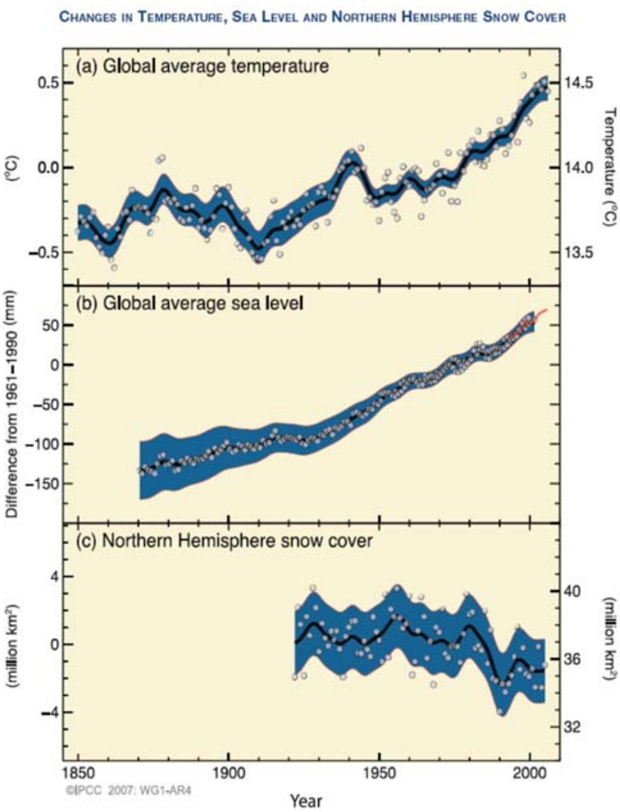


Figure 1.2. Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). [1]

2.1.2. *Climate Change Projection*

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would be larger than those observed during the 20th century.

Advances in climate change modelling now enable best estimates and *likely* assessed uncertainty ranges to be given for projected warming for different emission scenarios. Projected global average surface warming for the end of the 21st century (2090–2099) relative to 1980–1999 are estimated for six Special Report Emission Scenarios (SRES) emissions marker scenarios. For example, the best estimate for the low scenario (B1) is 1.8°C, and the best estimate for the high scenario (A1FI) is 4.0°C.

For the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Model experiments show that even if all radiative forcing agents were held constant at year 2000 levels, a further warming trend would occur in the next two decades at a rate of about 0.1°C per decade, due mainly to the slow response of the oceans. About twice as much warming (0.2°C per decade) would be expected if emissions are within the range of the SRES scenarios. Best-estimate projections from models indicate that decadal average warming over each inhabited continent by 2030 is insensitive to the choice among SRES scenarios and is *very likely* to be at least twice as large as the corresponding model-estimated natural variability during the 20th century.

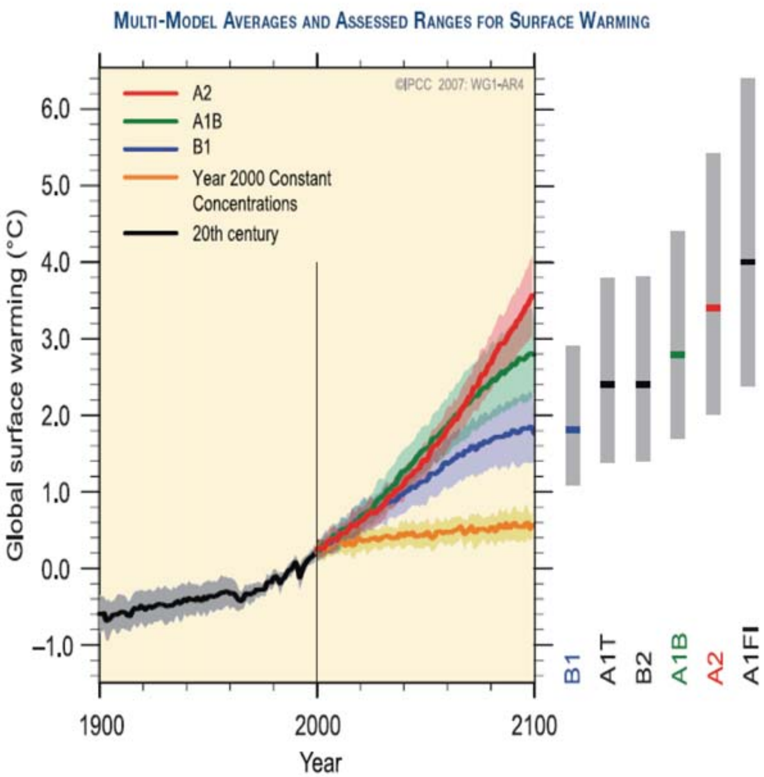


Figure 2.1 Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios. The assessment of the best estimate and likely ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints.

2.2. Climate Change Observation and Research in Mongolia

2.2.1. *Climate Systematic Observation Networks*

Currently, 120 operational weather stations in Mongolia are working according to the World Meteorological Organization's guidelines and procedures, monitoring and measuring the air pressure, atmosphere and soil temperatures, air humidity, rainfall, wind velocities, snowfall, depth (when snow) and other weather phenomena for 8 times a day.

Around 40 stations monitor soil temperature in depths of 20 - 320 cm, 25 weather stations record precipitation amount and 32 weather stations used to estimate the sunshine durations. (Please see related **Figure A2.1.1 in Annex 2.1**). At present, only 5 soil stations are operational.

Early Weather Monitoring

According to the historical documents of Mongolia, the first weather station in Mongolia was installed in 1869 and operated for about 20 years during years of 1869-1875 and 1889-1909. There are also evidences that they have established a weather station and made observations from March 1879 to September 1880 in Uliastai City and from August 1895 until June 1897 in Khovd City. Information and data obtained were studied and included in the databases which were continued even today. Some materials are published in Irkutsk geo-physics chronicles on an annual basis.

Weather stations have monitored the weather according to the average local time and synoptic observations every 3 hours for a whole day between 1936 and 1975. After January 1, 1975, the new international code for weather information exchange was introduced and all the observations are being done using the Greenwich Mean Time (GMT) since then.

There are 40 weather stations of Mongolia that are included in the World Meteorological Organization's (WMO) synoptic network base stations and 10 stations are included in the Climate Observation base station list. (Please see related **Figure A2.1.2 in Annex 2.1**)

Each *Soum* (the smallest administrative unit of government in Mongolia) has a weather post that measures temperatures of atmosphere and soil, moisture, wind, atmosphere occurrence 3 times a day at 00, 06, 12 GMT. (**Figure A2.1.3 in Annex 2.1**).

Historical Notes on Reporting

*Famous Russian traveller, N.M.Prejvalskii, has noted that "Mongols have an extraordinary ability to forecast strong winds, storms, rains and they can find their lost horses and camels with a help of tiny signs and symptoms"***[1].** *First historical document about climate is dated back to 72 BC. This information is related to the Hun dynasty which was a great dynasty and lived in the soils of Mongolia. They have documented the first written notes about climate and weather in ancient Chinese scripts – "Snow fall in a single day has reached higher than two adults, which caused many people and livestock to be frozen to death. One out of ten did not come back".*

Nomads of Mongolia have established a whole system of lifestyle based on their knowledge and tradition of weather forecast. They would calculate the weather, livestock and pasture lands.

Since the 1990s, the number of the weather observation posts has been decreasing continuously due to the policy to upgrade and expand the posts to weather stations.

Solar Radiation Network

The solar radiation observation network in Mongolia was established in 1961. Since the 1970s until 2004-2005, Mongolia had 19 points to measure solar direct and indirect radiation, long and short wave radiation balance and apparatus to measure surface albedo. Currently, there are 5 operational stations in Mongolia which are included in World Meteorological Organization's actinometer network as seen in **Table 2.1** below.

Table 2.1. International Solar Radiation Network Stations

Name	Index	Latitude	Longitude	Elevation
Ulaangom	212	49.97	92.07	940
Murun	231	49.65	100.15	1285
Uliastai	272	47.73	96.85	1761
Ulaanbaatar	292	47.92	106.87	1307
Dalanzadgad	373	43.58	104.42	1465

Upper Air Observation Network

The aerologic observation in Mongolia started in 1941. Currently, there are 7 aerologic stations; however, with the financial difficulties the partial observations are being conducted only in Ulaanbaatar, Murun and Ulaangom stations.

Greenhouse Gas Monitoring Station

Mongolia established jointly with the National Oceanic and Atmospheric Administration of USA the first observation site in Central Asia for monitoring the atmospheric greenhouse gas concentrations in Ulaan Uul, Dornogovi *aimag* (the regional administrative level of organization comprising a number of *soums*) in 1992. The observation data are being archived in world greenhouse gas database in Tokyo Centre, Japan.

Agrometeorological observation network

The weather stations and posts (consisting of 39 units) in the agricultural part of Mongolia observe on phenology phases, heights, density, thickness, damage rates, causes and harvest of grains, potatoes and vegetables. In some areas, precipitation, quality and other measurements (e.g. weight of 1000 seeds) are carefully being observed.

Grassland Observation Network

Since the 1960s, the observation and measurement on pasture lands have been done through the National Meteorological and Hydrological Services monitoring and diagnostics network stations and posts in 317 points (Please see related **Figure A2.2.1 in Annex 2.2.**) The pasture land observation is monitored since 2001 through three types of observations: a). Pasture plant phenology; b). Pasture major insects that damage pasture lands, small mammals; and c). Pasture degradation and desertification.

a. Pasture plant phenology observation includes:

   - Plant growth and development period, Plants height, Growth rate (quality measurements, green plants and gray land growth rate, etc., Plants damage, Harvest, Migrations and movements of animals, etc.

   The observation is done in Spring during sprouting stage and in Fall, in the normal unfenced pasture land. The observation is done on every 9th, 19th, 25th day of the month.

b. Pastureland damage measurement from voles (Microtus brandtii) and insects (grasshoppers) is done on 9th, 19th, 25th day of every month. As a result, the observation and surveys show pastureland damages, density of voles and insects and their influence to the plants as well as area of degradation and damages.

c. Pasture thorough survey method is important for pastureland management, and gathering of important information such as pastureland status in winter-spring and summer-fall periods as well as pastureland capacity and degradation level. There are two kinds of pasture thorough survey method – the constant and periodic survey methods. The winter-fall assessment on the pastureland is conducted in the 2nd week of August by observation and survey on pastureland growth, types of livestock in the Sum, and number of livestock.

Animal Husbandry Meteorological Observation

Surveys on influence of the environment on livestock organisms were carried out in more than 10 *Soums* with different climate conditions between 1976 and the 1990s. A similar survey was done in 3 areas of Gobi, grassland steppes and forest on cattle, sheep and goats. The survey includes:

- Behaviour
- Body mass and feed mass
- Micro climate of fence or farm
- Sickness, loss and their causes, etc.

Observation on Soil Moisture

The moisture measurement in pastureland and farmland is measured at 64 sites every 10 days before plantation. Soil moisture is also being measured in 135 sites during frost and thawing periods.

Surface Water Monitoring Network

The surface water monitoring is done by the Mongolian National Water Weather Authority. The hydrometer observations on Mongolian rivers and streams have been done since 1942. At present, 126 observation points are measuring the daily water level, passing through, ice occurrence, ice thickness, flow speed and water temperature. A number of observation points collect samples for further analyses. Observations are done in other 16 small and big lakes. (Please see related **Figure A2.3.1** in **Annex 2.3**).

In addition water plankton, benthos organisms and plants samples are collected in 64 observation points. In addition, water chemistry research samples are collected in more than 140 points.

Satellite Observation System

Since 1970, Mongolia has received information and images from the Polar orbit satellite which is an analogue system. A digital information station was installed during 1986 -1988. The Arc/INFO GIS package on Sun Sparc Workstation was installed in 1994. Cooperation agreement with NASA was signed in 1993 to use satellite SEASTAR. With the satellite-aided observation, the monitoring of forest fires and bushfires became possible. Since 2007, Mongolia has been receiving satellite images from MODIS which increased monitoring quality significantly.

2.2.2. *Climate Research*

Brief Overview of Climate Change Studies

Russian scientists have been interested in Mongolian climate change issues since begining of 20th century. However, there are issues on the time frame. For example, according to the detailed paleo-geographic study in Mongolia conducted by B.M Sinits, drought increased in Mongolia due to increased elevation of mountains and high lands. It is common in Central Asia that ancient cities and river beds are buried by sand, which suggests that this region experienced drought historically.. The theory that was suggested by G.E Grumm-Grijailo and his followers (H.B Pavlov, B. A. Smirnov) about evolution of plants and the salt and other chemical changes in some of the great lakes are based on histrorical time period. Famous meteorologist, L.S. Berg, and botanist, A.A. Yunatov, said Mongolian weather has not became dryer during those times.

Climate change study began in 1979, after the 2nd World Meteorological Conference. "Climate Change" was the first symposium which was conducted by the Institute of Meteorology and Hydrology in June 1980.

Because of Mongolian nomadic culture, there is not much recorded information on historical climate and climate of Mongolia. However, a few facts about the weather of Mongolia have been recorded in ancient and medieval Chinese manuscript. There are some study on climate change using tree-ring dating, climatic snow line and moraine, but there is no systematic study covering the entire country. The longest period of study was conducted by Columbia University of USA and National University of Mongolia. Some efforts have been made to reconstruct the historical climate data on the basis of tree-ring analysis on the Solongot Mountain, which is part of Khangai mountain range located in the western part of Mongolia.

National Archive's former staff D.Tsedevsuren's work to collect data of extreme climate events and climate variation of Eastern part of Mongolia since 1740, has contributed greatly to the reconstruction work of the historical accounts on the climate of Mongolia.

While systematic meteorological observations began in the 1940s, the first articles on climate change were published in 1980s. Since then, this work has been carried on. There are a very few studies on climate change future scenarios and trend. In 1980, L. Natsagdorj studied the relationship of the country's precipitation and temperature change in last 40 years and the northern half of global air flow. He concluded that dry spell would continue until 1990s. In the mid 1990s, R. Mijiddorj, a scientist, studied the relationship among precipitation, air temperature and atmosphere using non-linear model and tried to define climate trend to 2020.

In 1994-1996, the *"Country Studies Programme on Climate Change" project* was *implemented* with technical assistance of the United States *Environmental* Protection *Agency. During the project, for the first time Mongolian scientists and meteorologists estimated the* precipitation and temperature changes when CO_2 is doubled *in the atmosphere, using some simulation models of Global Climate System. Thus, the study was used in preparation of National Action Programme on Climate Change (NAPCC) and the* 21st Century National Sustainable Development Program.

The scenario of IS92a was used to examine the impacts of increased GHG on ecosystem and economic sectors of Mongolia. The scenarios selected for the current study were the climate models developed by the Hadley Center (HadCM3) of United Kingdom Meteorological Office, the Canadian Climate Center Model (CCCM), CCGM3 of Analyze Center, Australia (CSIROMK-2) model, the Max Plank Institute of Hydrology and Meteorology of Germany (ECHAM4) model, and the Geophysical Fluid Dynamics Laboratory (GFDL) model. Mongolia's future climate changes until 2100 was determined on the base of the IS92a scenarios listed above and developed the NAPCC which was approved by the government in July 2000.

From 2002-2004, the project on "Climate change - Its Impacts and Adaptation on Livestock and Biosphere" supported by AIACC, UNEP and START were completed in Mongolia. These were funded primarily by a grant from the Global Environment Fund (GEF). Mongolia's future climate changes until 2100 was determined on the basis of the A1, A2, A1, and A2 scenarios of the SRES 2000 using the results of climate models mentioned above. Thus, strategies for livestock sector adaptation to climate change were developed.

Climate Regime

The climate of Mongolia is described to be severe and greatly variable geographically and timewise. Mongolia is far from the world oceans, surrounded by high mountains and highly elevated above the sea level averaging 1.5 km. The climate of Mongolia is characterized by short dry summer (June to middle of August) and long cold winter (end of November to April) with spring (April to beginning of June) and autumn (end of August to end of October). Summer rainfall seldom exceeds 380 mm in the mountains and is less than 50 mm in the desert areas.

Geography

Mongolia is situated in the central part of the Asiatic continent (41^{O}35'N - 52^{O}09'N and 87^{O}44'E - 119^{O}56'E). The country is bounded on the north by Russia and on the east, south, and west by China. It has a total area of 1,565,000 sq. km. Mongolia's longest stretch from west to east is at 2,392 km., and from north to foremost southern point is 1,259 km. Mongolia is the 7th largest country in terms of area and 18th largest country by population in the world. It is alsoone of the largest mainland countries with no access to sea.

The topography of Mongolia consists mainly of a plateau with the elevation ranging from 914 to 1,524 m. (about 3,000 and 5,000 ft.) broken by mountain ranges in the north and west. The Altai Mountain in the southwest rises to heights 4267 m (14,000 ft) above the sea level.

Air Temperature

The temperature ranges between -15° and -30°C (-5° and -22°F) in winter and 10° and 26.7°C (50° and 80°F) in summer. Annual mean temperature in Altai, Khangai, Khentii, Khuvsgul mountainous region is lower than –4^{0}C, and between the mountains and in base of large rivers, the average temperature is lower than –6 to -8^{0}C. In the steppes and desert regions it is lower than 2^{0}C, while in south Gobi, the average temperature is higher than 6^{0}C (**Figure 2.2**.). The average temperature of 0^{0}C in Mongolia is around the 46^{0}N latitude which is the northern part of Gobi desert region. Permafrost exists in the areas where the annual mean temperature is below –2^{0}C.

The air temperature in January, which is the coldest month, averages -30^{0}C to – 34^{0}C in the high mountain areas of Altai, Khangai, Khuvsgul and Khentii; while it is -20 to -25^{0}C in the steppe and -15 to -20^{0}C in the Gobi desert. In the south Gobi regions the temperature averages –15^{0}C to –12^{0}C. On the weather record since the 1940s, the coldest temperature in Mongolia recorded was -55.3^{0}C (in December 1976 at the Zuungovi sum, Uvs aimag) while it is -49.0^{0}C in the capital city of Ulaanbaatar (in December 1954). The influence of inverse on the temperature in the cold season is significant. According to the data from the upper air stations located in the large rivers basins during the cold seasons, low layer surface inverses with 600 to1,000 m. thickness and the 6-17^{0}C intensity are observed everyday. Due to this weather features in the rivers basins and low lying areas at 100 m., it is observed that as the elevation rises, the air temperature rises by 0.8-0.9^{0}C. On the sides of mountains and steppes, the temperature rises by 0.6^{0}C (**Figure 2.2**)

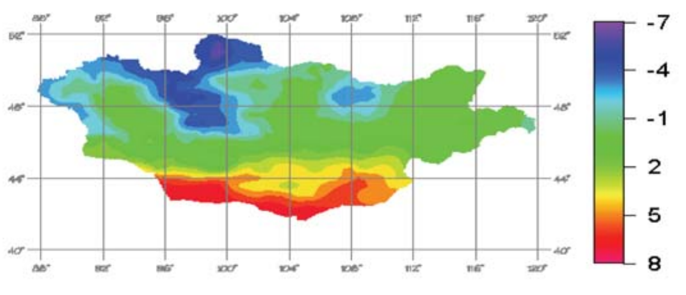


Figure 2.2 Annual Mean Air Temperature Map

In July, the warmest month, average temperature in Altai, Khangai, Khuvsgul, and Khentien mountains is 15^{0}C, and 10^{0}C in lower parts of the mountains. In the areas of Basins of Great Lakes (Ikh nuuruudyn khotgor) Altai, Khangai, Khuvsgul and Khentii mountain regions and is the basis of Orkhon, Selenge and Khalkh rivers, the average temperature is

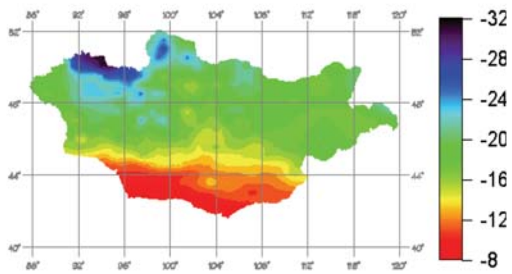


Figure 2.3. Map of Mean Temperature in Winter

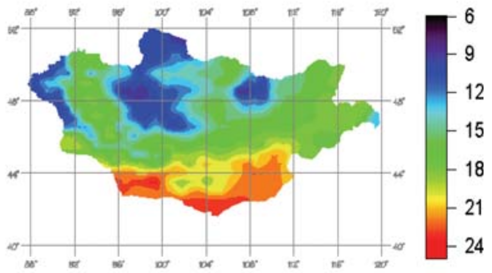


Figure 2.4. Map of Mean Temperature in Summer

between 15^0C and 20^0C. In the south parts of steppes of Dornod and the Gobi deserts, the temperature averages $20\text{-}25^0C$, while in the areas of Dornogovi, the temperature is higher than 25^0C (**Figure 2.3**). The hottest temperature ranges between 28.5^0C and 44.0^0C. The hottest temperature of 44^0C was recorded in Darkhan Uul aimag, Khongor sum (July 24^{th}, 1999).

In the warm seasons, the air temperature drops by $0.5\text{-}0.6^0C$ for every 100 m. rise in altitude. In high mountain regions, the cold season in spring ends late (mid of June) and cold season starts early (mid of August), which leaves only 70 days for warm period. The warm days last for 90-130 days in the rest of the country.

The number of days with temperatures higher than 10^0C is 90 days in the mountainous areas which are elevated more than 2,000m. and forested,while in the steppe areas, it is 90-110 days. In the grassland steppes, it is 110-130 days, while in the desert, it is 130-150 days and in the Gobi desert, it is more than 150 days.

Precipitation

In general, the amount of precipitation in Mongolia is low. Annual mean precipitation is 300-400 mm. in the Khangai, Khentein and Khuvsgul mountainous regions; 250-300 mm in Mongol Altai and forest-steppe zone; 150-250 mm in the steppe zone and 50-100 mm in the Gobi-desert. Precipitation distribution depends very much on relief and landscape and decreases from north to south and from east to west (**Figure 2.5)**. Total precipitation amount is much lower than the

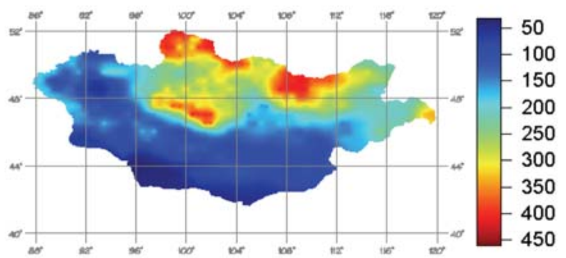


Figure 2.5 Geographical Distribution of Annual Total Precipitation

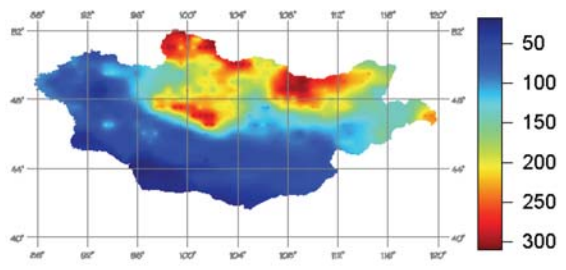


Figure 2.6a Geographical Distribution of Summer Precipitation

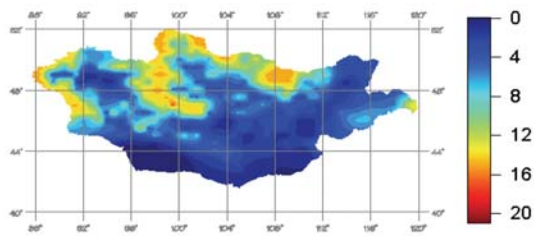


Figure 2.6b Geographical Distribution of Winter Precipitation

potential evapotranspiration. The potential evapotranspiration is less than 500 mm in the mountain regions, 550-700 mm in the forest-steppe zone, 800-900 mm in the forest-steppe, 650-750 mm in the steppe zone, and 800-1,000 mm in the desert-steppe and desert zone.

About 85% of total precipitation falls from April to September, of which about 50-60% falls in July and August **(Figure 2.6a)**. Although annual precipitation is low, its intensity is high. The maximum precipitation (138 mm/day) recorded since 1940 occurred on 5 August, 1956 at Dalanzadgad, and the second greatest (121 mm/day) on July 11, 1976 at Sainshand. It is possible, however, that an intense rainstorm of 40-65 mm may fall in a single hour.

In Mongolia, the number of rainfall days in the mountainous area is 60-70; 40-60 rainy days in the Khangai, Khentein mountains, mountain valleys and Dornod steppe; and about 30 days of rain in the Gobi-desert. Rainfall contributes most of the annual precipitation, though the amount is low. In other words, the intensity of precipitation is high although the amount precipitation is low and more than 50 mm of rain may fall in any region.

During the winter months (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 **(Figure 2.7)**. Accordingly, the number of days in which snow cover is present is more than 150 in the Mongol Altai, Khangai, Khentei, and Khuvsgul mountains, 100-150 days in the steppe and forest-steppe zone, 50-110 days in Dornod steppe and steppe zone, 50 and less in the Gobi-desert zone. 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)—but winters without snow cover are very rare and have occurred only in the Gobi region.

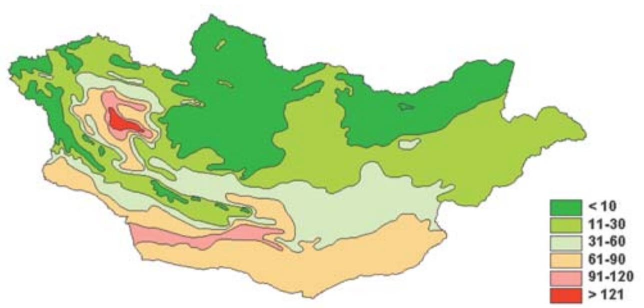


Figure 2.7. Geographical Distribution of Dust Storms in Mongolia

Other Climate Parameters

Sunshine. Mongolia receives an average of 230-260 days of sunshine annually, which is 2,600-3,300 hours of sunshine a year.

Winds. Mongolian steppe and desert-steppe zones are very windy. Annual average wind speed in these areas is in 4-6 m/s, and the other areas is 2-3 m/s. Wind speed is in 1-2 m/s in the Khentii mountain valleys and the other areas is around 2-3 m/s. According to meteorological data, annual mean wind speed is more than 4.0 m/s in one-fourth of the country's 250 settlements. West-northwest-north wind dominates, but the wind depends very much on relief and landscape.

The Gobi-desert zone is 41.3% of Mongolian entire land. The number of days with sand-dust storm in a year in this area is 30-100 while it *is* 120 in the southern part of the *Mongol els* (**Figure 2.7**). Around 61% of dust storm occurs in March, while 7% occurs in summer. However, it occurs differently in different regions. Dust storms do not occur at the Uvs lake depression in winter. However, dust storms occur at the *Artsiin holoi* for 1/3 day in the 3 months of winter. 80% of the dust storm occurs in day time. According to the observation, 300-600 hours of dust storm occurs in a year in Gobi-desert zone. Mongolian dust storms are one of the main sources of "Asian yellow dust".

2.2.3 Current Climate Change

Because of its location, fragile natural ecosystems, the lifestyle of the people and the economic situation, Mongolia is relatively sensitive to climate change. Clearly, climate change issues are as important to Mongolia as for coastal countries. Mongolian people have been living as nomads for thousands of years and the risk caused by weather is still the same.

Studies show that in the last 40 years certain impacts of climate changes have already been observed. In the coming century, climate change will probably radically change the traditional way of living that was established in Mongolia for more than thousands of years.. Impacts resulting from observed climate change cause high damage not only to the livestock sector but also to the ecology and socio-economic sectors.

Air Temperature Change

The impact of global warming is observed in Mongolia more than most of the regions in the world. Global warming observation has been conducted in different meteorological stations with different data (Natsagdorj, Dagvadorj. Gomboluudev 1999, Natsagdorj, Bayasgalan, Gomboluudev 2005). Thus, UK Meteorological Hedley Center conducted research using Reanalysis datum of *NCEP/NCAR* and ECNWF (Natsagdorj, Bayasgalan, Gomboluudev 2005).

According to the records at 48 meteorological stations which are distributed evenly over the territory of Mongolia, the annual mean temperature of Mongolia increased by 2.14⁰C during the last 70 years. However, annual mean temperature decreased in the winter season for the period of 1990-2006. (**Figure 2.8**).

Linear trend analysis is used to analyze the trends of average winter temperature for the periods of 1940-2006, 1961-2006, 1981-2006, and 1990-2006 which is shown in **Figure 2.8.** According to the trend, temperature is increased by 0.051⁰C/year during the period of 1940-2006, by 0.045⁰C / year in the period of 1961-2006, by 0.018⁰C/ year in the period of 1981-2006. But during the period of 1990-2006, slight temperature decrease -0.119⁰C/year is observed.

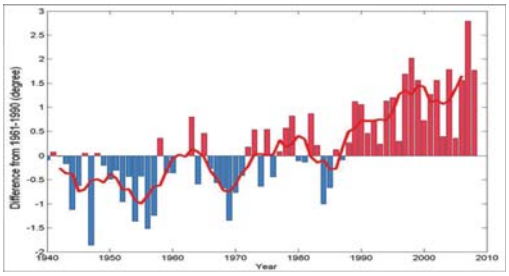


Figure 2.8. Annual Mean Temperature Change for 1940-2005

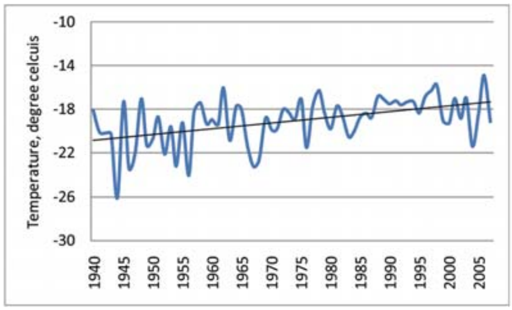


Figure 2.9a. Average Winter Temperature Trend for the Period 1940-2005

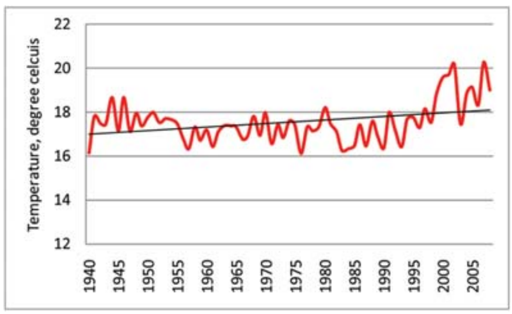


Figure 2.9b. Average Summer Temperature Trend for the Period 1940-2005

Since 1940, average summer temperature has been increasing **noticeably (Figure 2.9)**. According to the **results** of coefficient **equation** of the observed monthly mean data of temperature in different seasons, only

Table 2.2. Coefficient Results of Linear Equation of Mean Temperature of Different Seasons

	Equation of linear regression coefficient			
	1940-2006	1961-2006	1981-2006	1990-2006
Spring	0.027**	0.034**	0.049	0.033
Summer	0.011*	0.036**	0.106**	0.147**
Fall	0.025**	0.041**	0.064	0.039
Winter	0.051**	0.045*	0.018	-0.119
Year	0.029**	0.038**	0.062*	0.032

Description: *- 95%- confidence, **- 99%- confidence or statistically significant

summer equation output was 95-99% statistically significant, for the other seasons output was not even at 95% confidence level as seen in **Table 2.2** next page.

Clearly, the number and duration of hot days is increasing dramatically. According to the 64 stations which were simultaneously working on the results of coefficient equation of the observed monthly mean data of temperature in different seasons, during the period of 1975-2007, temperature increased by 5-8^{o}C in the eastern part of the land and Great lakes deppresion.

Number of increased hot day is more than 95% statistically reliable in most of the regions except stations located in the high mountainous areas (**Figure 2.10**), while in most areas of the steppe and Gobi-desert zone, it is 99% reliable.

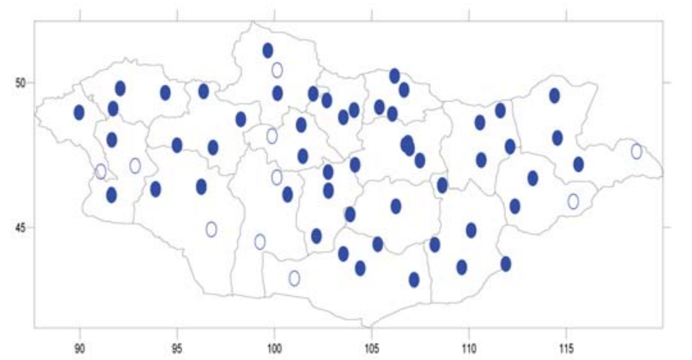


Figure 2.10. Statistics Persuasive of Coefficient Equation of Number of Hot Days (in bright color if more than 95%- reliable)

The highest temperature records between 1940s to1990s were broken in the last few years. According to the study, after 1991, the highest temperature occured and recorded in the 58 stations, out of 60 stations.

Table 2.3. Coefficient Results of Linear Equation of Total Precipitation of Different Seasons

	Equation of Linear Trend a-Coefficient			
	1940-2006	1961-2006	1981-2006	1990-2006
Spring	-0.032	-0.027	0.416*	0.554*
Summer	-0.127	-0.475*	-1.433	-5.288**
Fall	-0.059	-0.087*	-0.485*	-0.712*
Winter	0.009	0.0.25	0.106*	0.129
Year	-0.206	-0.564*	-1.416	-5.572**
Warm season	-0.250	-0.617*	-1.523	-5.518**

Description: * - 90%- reliable, ** - 99%- reliable.

Precipitation Amount Change

Linear trend analysis has been used to analyze the trends of the observed monthly mean data of precipitation in different seasons and different periods including 1940-2006, 1961-2006, 1981-2006 and 1990-2006. The results of coefficient equation total precipitation of different seasons are shown in **Table 2.3**.

About 95% of total precipitation falls in warm seasons and less than 3% of total precipitation falls in winter. According to **Table 2.3** winter precipitation has increased and warm season precipitation has slightly decreased. **Figure 2.11** shows warm season precipitation trend.

Precipitation changes in Mongolia can be classified by stations: since 1961 Altai mountain region, Altai Gobi and in the eastern part of the country has increased, and in all other regions has decreased by 0.1-2.0mm/ year.

The central region of Mongolia has been observed to have the most precipitation decrease where 95% reliable precipitation decrease was observed. In Gobi Altai, precipitation has been observed to increase with 95% reliability.

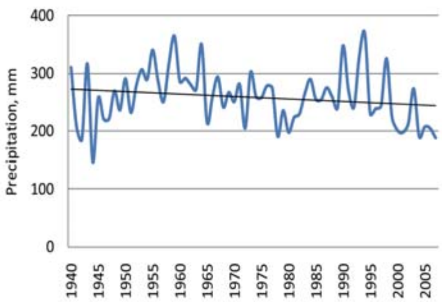


Figure 2.11. Warm Season Precipitation Trend

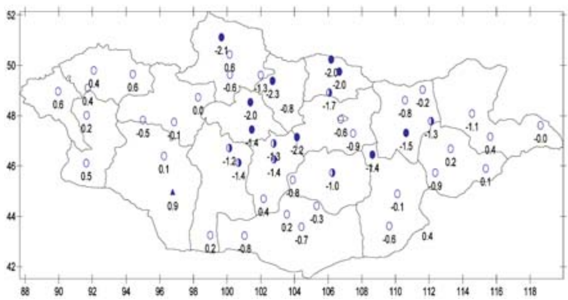


Figure 2.12. Coefficient of Linear Trend Equation of Warm Season Precipitation Change

Note: Description: colored circles indicate more than 95%- reliable, half-colored 90% reliable, non-colored circles indicate precipitation decrease and triangles indicate increase.

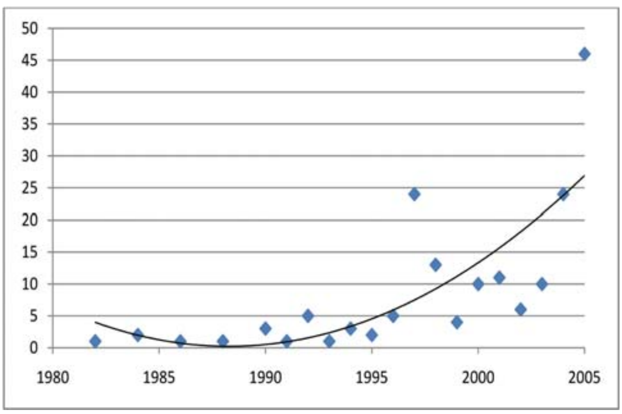


Figure 2.13. Natural Disasters Related with Atmospheric Convection

One of the indications in precipitation change is increasing amount of thunderstorms during the vegetation period. According to the observation, the result of Arvaikheer weather station, the number of thunderstorms amount has increased by 18% between 1979-1996. Although the observation period is not so long, it is one of the indications in precipitation change.

Besides the increasing trend in percentage of thunderstorms during the vegetation period, the maximum amount of precipitation in a day tends to increase as well. However, there is no statistically significant trend in the maximum amount of precipitation in a day.

As precipitation intensity increases, the extent of damage caused by it also increases. As a result of extreme events (atmospheric convection) such as thunderstorms, flash floods hail, etc., damage has significantly increased during the past 20 years and caused human death and economic losses. Natural disasters have increased by a factor of 2 in 20 years (**Figure 2.13.**)

Climate Extreme Indices Change

Changes in climate elements are important in climate change and variability study. Climate extreme indices change study has conducted for the first time in 2003, using weather stations data for the 1961-2001 periods. Daily maximum and minimum temperature and 27 indices of temperature and precipitation recommended by the Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI) were analyzed to identify the change in trend.

There are available data for 1961-2007 period for 23 stations where 12 out of 27 indices fit in the Mongolia country situation. Data above and below the mean 4 sigma ([mean ± 4*standard.deviations]) interval are used for quality check. Linear trending has been used to analyze 47 years of variability in western, central, eastern, southern and desert regions which created each of the region's mean data as seen in **Table 2.4**.

Due to global warming, the number of hot days (su26) increased by 16-25 days, number of cold days (fd-5) decreased by 13-14 days, and vegetation growing period (gsl) increased by 14-19 days. Night temperature which is higher (Tx90) and lower (Tn10p) than 90 and 10 percent provision, is more intense than day temperature. **Figure 2.13** shows

Table 2.4. Climate Extremes Indices

Abbreviation	Name	Description	Unit
Fd-5	Cold day	Year Tn (lowest temperature of the day) <0^{O}C	day
Su26	Hot day	Year Tx (highest temperature of the day) >26^{0}C	day
Gsl	Vegetation growing period	Average temperature in the first half of the year Tmean>5^{0}C and average temperature in the second half of the year, at least 6 days Tmean<5^{0}C	day
Tn10p	Cool night	Tn<10 percent of the day	day
Tx10p	Cool day	Tx<10 percent of the day	day
Tn90p	Warm night	Tn>90 percent of the day	day
Tx90p	Warm day	Tx>90 percent of the day	day
wsdi	Indicator of hot days	Tx>90 percent of the day, at least 6 days	day
csdi	Indicator of cold days	Tn<10 percent of the day, at least 6 days	day
sdii	Index of day	Annual total precipitation divided ratio days with precipitation	mm/ day
R95p	High precipitation	Annual total precipitation RR>95th more than supply	mm
R99p	Very high precipitation	Annual total precipitation RR>95th more than supply	mm
prcptot	Total amount of precipitation	Total amount of precipitation of days with precipitation	mm

correlations between changes in numbers of days with extreme maximum and minimum temperatures with 90 and 10 percentiles. **Figure 2.14** shows trends of number warm (a) and cold (b) days with 90 and 10 percentiles for 1961-2007.

Number of hot days (Wsdi) increased by 8-13 days and number of cold days (Csdi) decreased by 7-11 days.

Precipitation rate decreased in the most of the regions except western part of the country. Slightly trend of increased precipitation is observed in some areas.

Table 2.5. Change Trend of Climate Extremes Indices

Index	Western region	Central region	Eastern region	*Gobi region*
su26	16 (7…26)	25 (17…30)	20 (6…29)	*20 (6…29)*
fd-5	-14 (-5…-22)	-22 (-12…-32)	-13 (-4…-19)	*-14(-12…-17)*
Gsl	14 (9…23)	19 (9…25)	9 (6…16)	*14 (7…19)*
tx10p	-6 (-2…-11)	-6 (-4…-8)	-3 (-2…-3)	*-5 (-3…-7)*
tx90p	8 (4…12)	9 (7…12)	7 (7…9)	*7 (5…10)*
tn10p	-10 (-5…-15)	-10 (-4…-14)	-8 (1…-16)	*-9 (-6…-13)*
tn90p	10 (7…18)	14 (9…17)	10 (5…10)	*11 (9..12)*
Wsdi	12(3…23)	13 (10…17)	12 (8…14)	*8 (6…12)*
Csdi	-11 (-4…-25)	-7 (-1…-14)	-8 (0…-18)	*-7 (-5…-10)*
r95p	3 (-35…19)	-23 (-37…8)	-25 (-1…-39)	*-21 (-3…-45)*
r99p	1(-17…13)	-4 (-22…22)	-2 (-7…40)	*-7 (-27… 3)*
Prcptot	5(-35…48)	-49 (-10…-71)	-55 (-18…-86)	*-44 (-14…-70)*

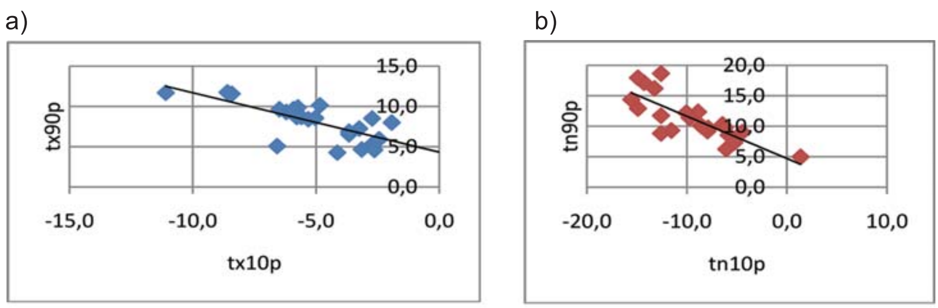


Figure 2.14. Correlations between changes in numbers of days with extreme maximum and minimum temperatures with 90 and 10 percentiles at selected stations.

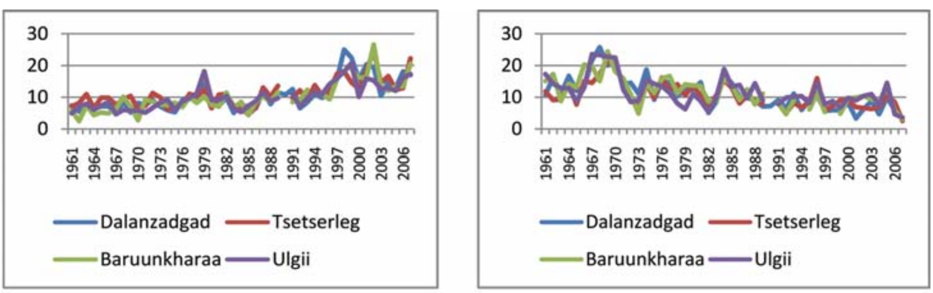


Figure 2.15. Trends of Number Warm (a) and Cold (b) Days with 90 and 10 Percentiles

2.2.4 Climate Change Projections

Model selection

Mongolia's future climate changes until 2100 are determined on the base of the A1, A2 and B1 scenarios of GHG Emissions (SRES) using biochemistry models.

Currently, developed countries are using these models for global scale study, and the results, time frame, space of the study are varied in different countries. In the framework of Fourth Assessment Report of the IPCC, study of climate change future scenarios were conducted using 24 models from 17 centers. 12 models which used A1, A2 and B1 scenarios of GHG Emissions were selected and evaluated by their accuracy of their studies on mean annual temperature and total precipitation amount of Mongolia in the period of 1971-1999.

Towards that objective, some statistic measure such as spatial correlation coefficient, standard deviation and variance coefficient are estimated between model output and NCEP/CMAP reanalysis data in terms of how regional climate has been reconstructed (**Table 2.6**). Here, the reanalysis data is not real geographical distribution of the climate variable, but it is most realistic (perfect) atmospheric state data set which is combined with construction of different climate element fields and dynamic models output. Reanalysis data has a warm bias in winter and cold bias in the summer in terms of seasonal temperature over Mongolia **[2]**. However, at present, this data is only available on digital climate dataset for mapping.

According to the evaluation, temperature standard derivation is between 1.26-3.44^{0}C, coefficient of space correlation is between 0.67-0.96, precipitation correlation coefficient is between 0.37-0.93. These sets of criteria created an opportunity to select accurate model to analyze future climate scenario of Mongolia. ECHAM5-OM, HadCM3, CM2, CCSM3 and CGCM2 models analyzed climate of Mongolia more accurately and in the future these models would work more accurately. All models showed increased total annual precipitation amounts. However, the standard derivation was not calculated by all models.

Table 2.6 Evaluation of Climate Models

Meteorological stations	Center abbreviation	Model abbreviation	Standard temperature derivation	Temperature variation coefficient	Temperature correlation coefficient	Precipitation correlation coefficient
1. Bjerknes Centre for Climate Research, **Norway**	BCCR	BCM2.0	1.51	2.29	0.95	0.75
2. National Meteorological center, **France**	CNRM	CM3	1.84	3.39	0.94	0.75
3. Common-wealth Scientific and Industrial Research Organization, **Australia**	CSIRO	Mk3.0	2.12	4.44	0.86	0.75

4. Max Planck Institute for Meteorological, **Germany**	MPI-M	ECHAM5-OM	1.26	1.59	0.96	0.91
5. Meteorologisches Institut der Universitat Bonn,**Germany** National Institute of Meteorological Research, **Korea** Max Planck Institute,**Germany**	MIUB, METRI, M&D	ECHO-G	2.29	5.24	0.87	0.37
6. Geophysical Fluid Dynamics Laboratory, **USA**	GFDL	CM2.0	1.66	2.75	0.93	0.92
7. Institute of Numerical Mathematics, **Russia**	INM	CM3.0	3.44	11.84	0.75	0.81
8. L'Institut Pierre-Simon Laplace, **France**	IPSL	CM4	3.13	9.79	0.67	-0.81
9. National Institute for Environmental Studies, **Japan**	NIES	MIROC3.2 medres	2.22	4.92	0.88	0.85
10. Meteorological Research Institute, **Japan**	MRI	CGCM2.3.2	1.94	3.74	0.91	0.90
11. National Center for Atmospheric Research, **USA**	NCAR	CCSM3	1.62	2.62	0.94	0.87
12. UK Meteorological Office, **UK**	UKMO	HadCM3	1.51	2.30	0.94	0.93

Climate Change Projections

In the Fourth Assessment Report of IPCC, three green house gas (GHG) scenarios (A2, A1B and B1) have been selected based on global socio-economic future trends. According to the estimation, corresponding values for these scenarios for average GHG concentration in the atmosphere would reach levels of 840, 720 and 550 ppm by end of this century, respectively.

The statistic assessment of the models shows that standard deviation of temperature between reanalysis data and simulated climate is 1.26-3.44^{0}C; spatial correlation coefficient is 0.67-0.96, and 0.37-0.93 for precipitation as respectively. Hence, above three statistic measures are chosen as main criteria to select best model, which might be reasonable to predict future climate change of Mongolia.

If the model is chosen based on these criteria, HadCM3, ECHAM5-OM, CM2 and CGCM2 have comparable minimum errors when simulating regional climate of the country. This nevertheless gives confidence for future climate change projection. Currently, all models overestimate annual total precipitation; however, the standard deviation has not been considered.

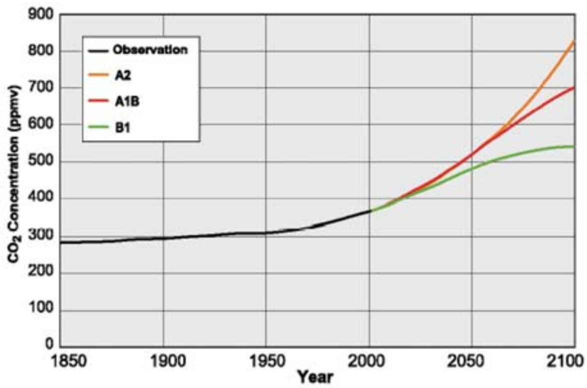


Figure 2.16. Observed (1850-2000) and Future CO_2 Concentration in the Atmosphere

The geographical distribution of the annual mean temperature and total precipitation are shown by some output of the models used and the reanalysis data in **Figure 2.17**. Here, the annual mean temperature and total precipitation averaged by 1971-1999 and 1979-1999 periods, respectively.

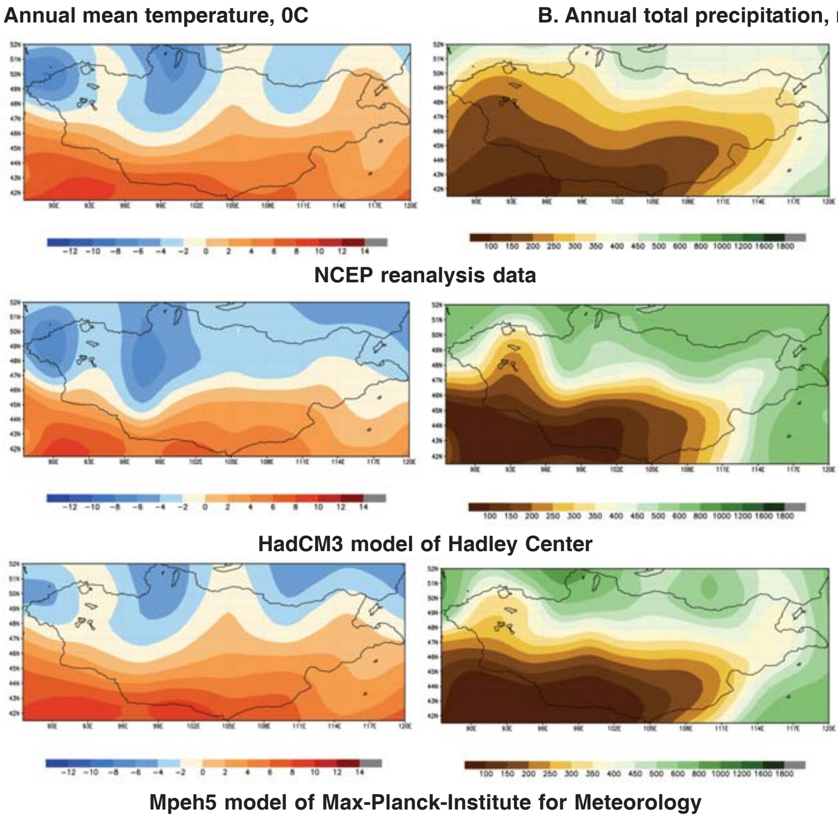


Figure 2.17. Geographical Distributions of 1971-1999 Mean Climate Represented by Reanalysis Data and Model Simulation

Climate Change Projection of Multi-model Ensemble

A dynamic process of the earth atmosphere is chaotic. To account this property of air into the atmospheric dynamic model, a special ensemble technique is used in the modelling framework. The ensemble members of model output are produced using perturbation of initial condition for the model (in other words, to increase number of model output under the same physical parameterization and dynamics). After getting result for each of the ensemble members, output is averaged by their numbers which in the process, could improve the accuracy of results.

Therefore, the average of above models output or multi-model ensemble output would improve the projection of the climate change of Mongolia.

The changes of winter and summer temperature and precipitation are estimated under A1B GHG scenarios and their results are shown in **Figure 2.18 - 2.19.** Here, a total of 12 climate models output is used in the estimation of annual mean temperature change and out of these, 6 models (MPI-M, GFDL, NIES, MRI, NCAR, UKMO) (with their spatial correlation higher than 85% according to previous statistical assessment) are used in the estimation of annual total precipitation change.

A climate baseline for Mongolia was selected for 1980-1999 which is the same as that used for AF4 IPCC. The change value is considered as year-to-year from 2000 to 2099 as compared to the values of the baseline period. Their geographical distribution is mapped in the beginning (2011-2030), middle (2046-2065), and end (2080-2099) of this century. The air temperature and precipitation change are expressed as Celsius degree unit and percentage which relative to baseline climate as respectively. There is high probability that the model systematic errors

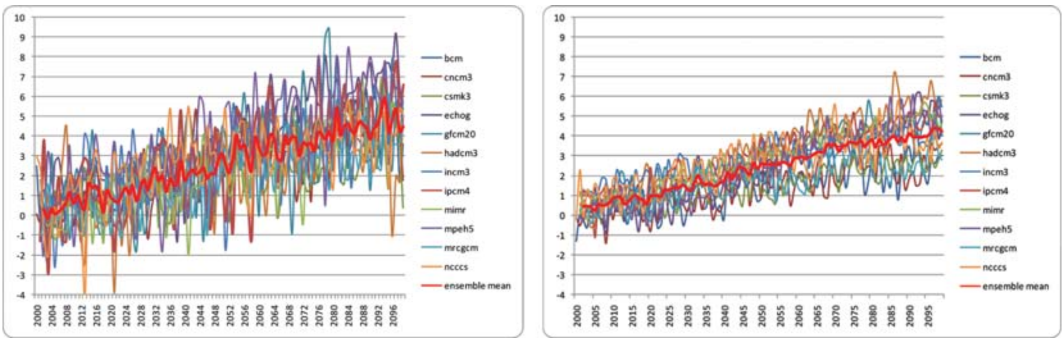


Figure 2.18. a) Winter and b) Summer Temperature Change Trends of Mongolia according to Estimation of A1B, GHG Emission Scenarios, ^{0}C, 2000-2099

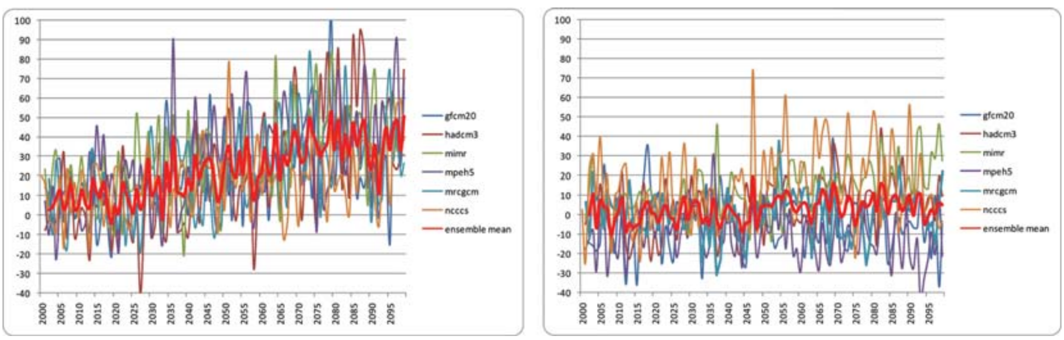


Figure 2.19. a) Winter and b) Summer Precipitation Change Trends of Mongolia according to Estimation of A1B, GHG Emission Scenarios, ^{0}C, 2000-2099

can be excluded in that arithmetic process. On the other hand, different output of models might be shown uncertainty of dynamic models (actual model dynamic, physical parameterization, integration scheme etc), therefore, it is indicating a possible interval of change for temperature and precipitation of the country.

According to estimation of the winter temperature change, most models give high change and amplitude, in other words, giving high variable results year to year. But their values will be varied by less than 6^{0}C in terms of change of trends and increased by 2.6^{0}C in 100 years. In summer, it is the opposite. The amplitude is low and values will be varied by less than 4.5^{0}C, and increased by 2.4^{0}C in 100 years (see red line in **Figure 2.18**). It is indicating that air temperature will be increased more significantly than summer season.

Intra-annual winter precipitation increase is less than 50% and its value will be increased nearly 23% in 100 years, and summer precipitation is changing less than 20% and its value will be increased only 3% (see red line in **Figure 2.19**). Relatively, winter precipitation will be increased faster than summer precipitation. If looked at on a time series, it will be gradually increased up to 2070 and then stabilizes henceforth.

Generally, the climate of Mongolia is anticipated that winter will become mild and summer become drier based on overall climate change assessment. Dryness, as expressed by percent, will be more intensified due to high evaporation and small increase in summer precipitation as compared to the normal climate.

This study result is mainly based on global GHG emission scenarios. Ecosystem changes due to human activity of local people (pasture and land degradation, soil erosion associated with mining activities, etc.) are not considered yet. But a biophysics feedback mechanism among the climate system components (including atmosphere, land, ocean, crysphere and biosphere) shows negative and positive feedback effects to regional climate. For instance, land cover/ vegetation is being degraded, when the regional temperature is increased and precipitation is being decreased.

Figure A2.4.1 (a) and (b) and A**2.4.2 (a) and (b)** in **Annex 2.4** show the geographical pattern of changes for winter and summer seasonal temperature and precipitation, respectively. These are estimated by multi-model ensemble technique in corresponding to three periods as mentioned above.

About temperature fields, eastern Mongolia will be more warmed in the winter season compared to other regions. The western part of the country will be relatively warmed in the summer season, in opposite directions.

According to geographical pattern of precipitation change, the precipitation will be increased in central and eastern part of Mongolia in winter as well as in eastern and south-eastern part in summer. Decrease in precipitation is projected at 10% in the western Mongolia.

Climate Change Projection of Hadley Center Model, HadCM3

Based on statistical assessment of the global climate model, the best model with minimum error has been used in determining climate change future scenarios for Mongolia. The climate variability change value is estimated based on period-wise averaging for 2011-2030 (beginning), 2046-2065 (middle), and 2080-2099 (end of century) periods versus the baseline climate values for 1980-1999 (according to FAR, IPCC).

Projections on the values of temperature and precipitation are estimated by area averages for the region, which covers the area between 41.5-52^0 latitude and 87.5-120^0 longitude. Also, annual and seasonal changes are determined for each GHG scenario (A2, A1 and B1) and the resulting values are shown in **Table 2.7.**

Table 2.7. Future Climate Change Projected by Hadley Center Model, HadCM3

Period		Temperature Change , ^{0}C			Precipitation Change, %		
		2011-2030	2046-2065	2080-2099	2011-2030	2046-2065	2080-2099
Annual	A2	1.0	2.7	5.0	2	9	15
	A1B	0.9	3	4.6	0	7	16
	B1	0.8	2.1	3.1	3	6	11
Winter	A2	0.7	2.3	4.2	14	19	55
	A1B	0.2	2.5	3.8	0	23	41
	B1	0.2	1.6	3.0	7	14	32
Summer	A2	1.1	3.1	6.3	-2	4	7
	A1B	1.4	3.6	5.6	-4	3	11
	B1	1.2	2.7	3.7	2	0	8

Table 2.7 shows that intensity of warming in summer season is higher than winter and its amount are 1.1-1.4^{0}C in 2011-2030, 2.7-3.6^{0}C in 2046-2065 and 3.7-6.3^{0}C in 2080-2099 periods, respectively. Winter temperatures will be increased by 0.2-0.7^{0}C, 1.6-2.5^{0}C and 3.0-3.8^{0}C in corresponding same periods as well.

Generally, precipitation will be increased; however, there is small decreasing in summer seasons in 2011-2030 according to A2 and A1B GHG scenarios. The precipitation in summer season will be increased by less than 10%, which is smaller than winter precipitation increasing as compared to their climate normal. The summer precipitation will be decreased by 2-4% in 2011-2030, increased by 0-4% in 2046-2065 and 7-11% in 2080-2099 periods. The winter precipitation is projected to increase by 0-14%, 14-23% and 32-55%, corresponding to the above mentioned periods as well.

Due to climate change effect, it is anticipated that winter is becoming milder and snowy, while summer is becoming hottier and drier even though there is small increase of precipitation based on overall climate change assessment.

Projected time series of temperature and precipitation are shown in **Figure 2.20 - 2.22**. As seen here, the climate change time series values within 1900-1999 period as well as projected time series within 2000-2099 are being given by depending on world population growth, socio-economic and technology development.

The amplitude of winter temperature and precipitation change is relatively higher than summer season (**Figure 2.22**). It is indicating that winter is becoming milder and snowy and there is high probability of climate anomalous phenomena (harsh winter, heavy snow etc). In summer season, warming is continuously intensified and precipitation will be increased by less than 20% (**Figure 2.22**).

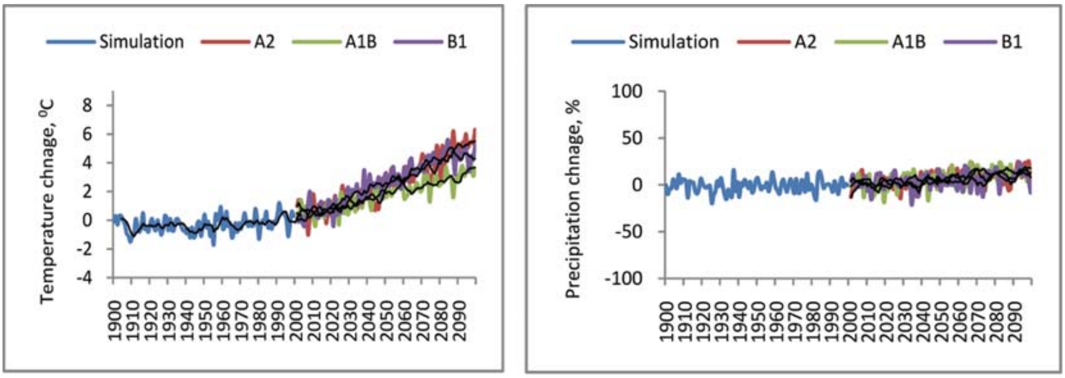


Figure 2.20. a) Annual mean temperature and b) Annual total precipitation time series estimated by HadCM3 model, 1900-2099

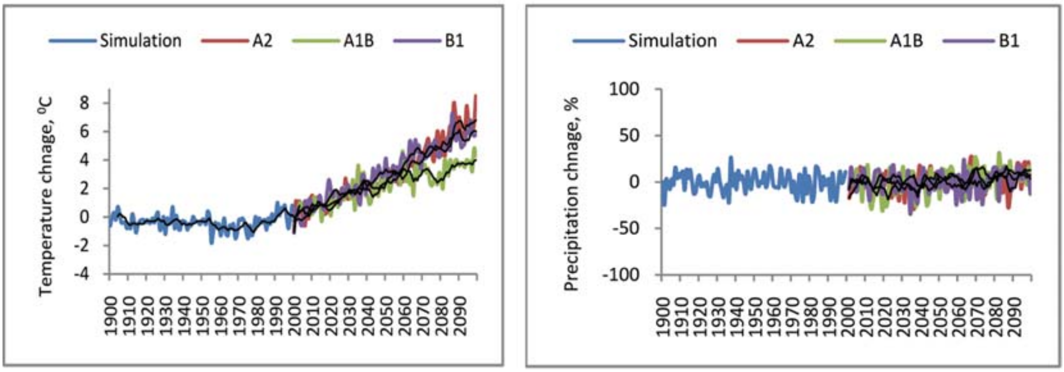


Figure 2.21 . a) Winter Mean Temperature and b) Winter Precipitation Time Series estimated by HadCM3 model, 1900-2099

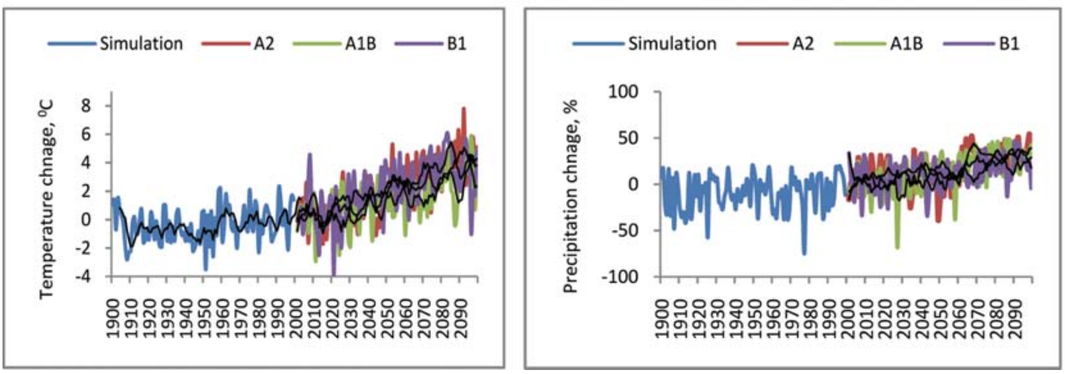


Figure 2.22 a) Summer Mean Temperature and b) Summer Precipitation Time series estimated by HadCM3 model, 1900-2099

3 Assessment of Impacts and Vulnerability

3. ASSESSMENT OF IMPACTS AND VULNERABILITY

The impacts related to climate change in Mongolia are discussed below with respect to the biophysical environment and economic sectors. Against this background, the vulnerability of these sectors are also assessed. The results of researches in these fields of investigation have been very voluminous. The following sections summarize the salient findings of the impact assessment. Further information were also gathered and included as separate annexes to provide supplemental insights.

3.1. Impacts on Biophysical Environment

Protecting our environment, fighting against climate change and reducing the vulnerability of natural and human systems to actual or expected climate change effects are the greatest global issues that need to be addressed today. Dramatic climate change will lead to severe damage to an already notable lack of geographical balance in land surfaces, plants, animals and micro-organisms, water, soil organisms and the biosphere in general. One must primarily consider the potential overall impact on human populations which share the same habitat.

Mongolia is very sensitive to climate change due to its geographic location, sensitive ecosystems and socioeconomic condition. As a result of climatic variability and the impacts of climate change, in the last forty years, Mongolian ecosystems have been notably altered. These changes have affected desertification, water supply and natural disasters. These changes affect the environment and lead to financial, environmental and human losses.

However, global warming could bring some benefits to countries that endure harsh weather like Mongolia. These benefits include, for example, milder climates and more pleasant temperatures which will lead to a decreased need for energy consumption. However, the benefits are outweighed by the drawbacks for our country. As the global temperature rises, atmospheric circulation patterns are likely to change with alterations in the frequency and seasonality of precipitation. This will cause a variety of secondary effects such as increased severe weather events, and potential effects upon the biosphere. These will affect our health, comfort, life style, economic activity and the environment in negative way. Therefore, we need to enhance the beneficial impacts and reduce the adverse impacts of climate change. Developing a plan in a timely manner to adapt to and cope with climate change using technology, information, skills, infrastructure, access to resources and management capabilities can simultaneously advance sustainable development and equity. In other words, as a sustainable development plan is implemented, the country is responsible for the formulation and implementation of an adaptation plan which can promote equity and development in our society and an economy that is more sustainable and that reduces our vulnerability to climate change.

3.1.1. *Ecosystem Shifts and Landscape Changes*

The geographic center of Mongolia is located at approximately latitude 46° 00 N and longitude 105° 00 E. It occupies only about 10° in latitude (from north to south) but in this relatively small range the geography changes significantly from Central Asian desert to Siberian forest. Therefore, it is difficult to evaluate the processes that alter landscapes and the potential landscape shifts that may result from climate change.Climate change affects not only temperature (for example, climate change will affect the probability of total temperature rising by 10^{o}C), but also landscapes, droughts and downpours, and changes to ecosystems including plants and vegetation spreads.

New climate conditions only reveal the potential for the alteration of ecosystems. However, these conditions are not sufficient to prove how one kind of species adapts to changes or transform to another species.

There are 3 methods to evaluate plant reactions to climate change, ecosystem changes of biomes and the dynamics of these biome changes. First, gap models evaluate the dynamics of biomes using plant reactions to climate change. These models concentrate on the vegetation uniqueness of plants and competition and other interactions between individual plants. Gap models often use long-term evaluations of forest ecosystems.

The second method is based on bioclimatic models which emphasize the empirical correlation between vegetation cover and climate parameters. One of the models representing this method is the Holdridge Lifezone Classification Model which incorporates the following indicators into the system: mean annual biotemperature, annual precipitation, and ratio of annual potential evapotranspiration to mean total annual precipitation.

The Gregory-Budyko table shows the radiation balance of global land surfaces and the relationship between the index of dryness and plant vegetation spread. The Lettau formula explains the average annual temperature, total annual precipitation and productive period of vegetation cover. Bioclimatic indices are often used to estimate the redistribution of vegetation zones and the corresponding changes of these zones. However, this model cannot calculate long-term prognoses.

The third method is a type of mathematical-based model that includes the formation and separation processes of the ecosystem. This type of model uses microorganisms and photosynthesis as its main data. These models are called ecosystem models. Some of the models representing this method are CENTURY, TEM, EBM and CASA.

In summary, the following assessments in ecosystem and landscape changes are made using different techniques;

1. Land Surface Changes Using Satellite Data

In 1995, the Mongolian National Research Center conducted an analysis using NDVI data for the years of 1992-1993 from the NOAA satellite to evaluate the land surface of Mongolia. In 1997 and 2002, the National Remote Sensing Center repeated the project to collect and validate satellite data for land surface changes. (**Figure 3.1 and 3.2**)

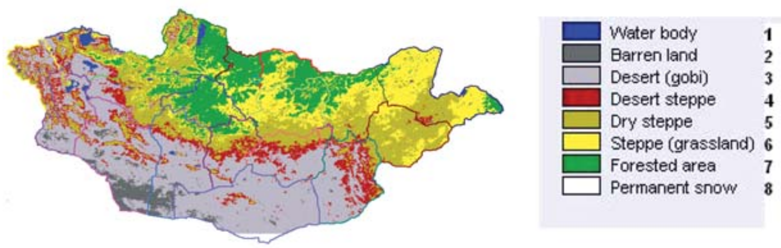


Figure 3.1. Land Surface Image in 1992

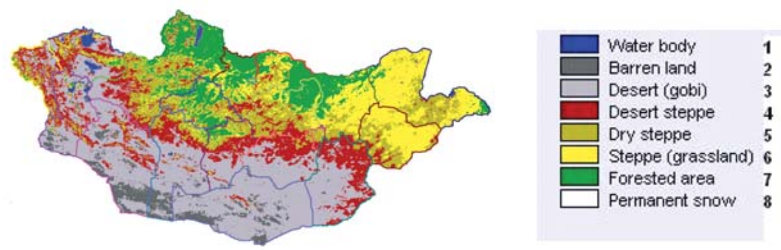


Figure 3.2 Land Surface Image in 2002

A comparison of the 1992 and 2002 figures, which were taken 10 years apart, reveals that the land surface has changed significantly; desert area has increased and forest area has decreased. In 2006, the land surface was evaluated by utilizing MODIS satellite data which has 16 times better resolution than the NOAA satellite data. Accordingly, water surface decreased by 38% from 1992 to 2002, but in 2006 the water area figures increased. Due to the higher quality satellite resolution, small lakes and ponds could be observed in the 2006 data which were not observable before. Areas without grass (or barren) increased by 46% from 1992 to 2002. By 2006, this barren area almost tripled, while during the same period forest area decreased by more than 26%.

2. Vegetation Zones Using the Entire Biological Product

Biological product is the main criterion for representing the vegetation zones. In order to calculate the effects of precipitation and temperature on biological product, or net primary productivity (NPP), and vegetation zone percentages, we varied the amount of temperature and precipitation.

Table 3.1 shows the current percentage of the total area of Mongolia occupied by each vegetation zone (as represented by NPP) and the changes to these percentages for various changes in precipitation and temperature.

According to the table, NPP>296 C h/m^2, which represents the taiga zone and a larger area, does not change when the temperature changes, but it changes when precipitation changes.

According to the HadCM3 model, taiga forest (NPP>296 C h/m^2) is expected to increase. This is especially noticeable in the years of 2020 and 2050. However, it does not mean trees will grow naturally. There is the possible advantageous condition for trees to grow if biomass increases and there is no effect of human activity. In 2080, forest-steppe is likely to turn into steppe. But version SRES A2 shows that the warming rate would be slow and as a result the process of forest-steppe turning into steppe would be slow as well.

The steppe zone (NPP=131-250C h/ m^2) is likely to be pushed by the semidesert zone from the south and decreases significantly. Due to climate warming, the semidesert zone will push the steppe zone to the north, especially in 2080. In 2080, forest-steppe and steppe areas decrease; this is caused by a lack of rainfall and an increase in temperature in the growing season (June, July, September). Even if, the amount of precipitation increases up to 1.6-2.7 mm, temperature is likely to rise 4-7^{0}C which will cause evaporation and make the air dryer.

The percentage of desert zone (NPP=60C h/m^2) tends to expand to the north. Although the amount of precipitation is expected to

Table 3.1. Change in the Percentage of Natural Zones when Temperature and Precipitation Amount Change

NPP,C h/m^2	Amount of Landscape Change, %					
	Precipitation Change %			Temperature Change, ^{0}C		
	-10	+10	+20	+1	+3	+5
>296	-51	+43	+82	+4	+7	-8
251-295	+9	-3	-9	-5	-33	-54
131-250	+6	-12	-20	-15	-8	-20
61-130	-22	+8	+22	+11	-10	+2
<60	+50	-34	-55	+19	+83	+179

increase, semidesert and desert zones are not decreasing; they are likely to expand. In other words, the increased amount of precipitation is still not enough for rapid evaporation.

3. Vegetation zones using degree of dryness

One of the criteria that defines an ecosystem is the degree of dryness. There are many indices that describe dryness. In this research, the degree of dryness is represented by the ratio of total annual precipitation to annual potential evaporation [Hare 1993].

As the climate warms, the total amount of annual precipitation also increases, but semidesert and steppe zones move to the north and the degree of dryness tends to increase more. These changes will be observed more in 2070-2099.

Based on calculations of the degree of dryness from future climate change scenarios, vegetation zones will move to the north and semidesert and steppe zones will likely expand. Therefore, the northern part of the country is considered to be a sensitive area. This does not mean that one zone will transform into another one immediately.

In conclusion, the northern part of the country tends to become dryer steppe, but if permafrost melts rapidly, then moisture in the soil will increase. Consequently, the drying process will occur over a long period of time. In other words, the drying process will affect plants when the moisture from the permafrost declines. However, the percentage of the desert zone will not increase extensively. The increase in the total amount of annual precipitation will reduce the aridity of the climate in this zone.

More detailed discussion on the techniques in evaluating land surface changes e.g. vegetation zones from a plan can be seen in **Annex 3.1**.

3.1.2. Permafrost

In Mongolia, the permafrost is located above the 43^0 N latitude, and 63 percent of the total territory of Mongolia has permafrost soil. Permafrost soil is deep underground soil with a temperature that is constantly at or below the 0^0 C for two or more years. Depending on its distributional features, there are seven types of permafrost, including continuous, discontinuous, common patchy, rare patchy, occasional, non-constant (permafrost that is formed once in a couple years) and seasonal (**Figure 3.3.**).

In the northern part of Mongolia, the total area with permafrost soil increases and continuous permafrost prevails.

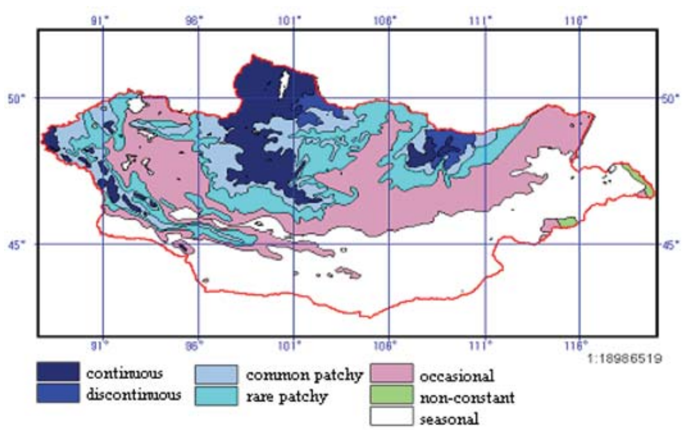


Figure 3.3. Distribution of various types of permafrost in Mongolia, 1968-1970

Current Change in Permafrost

Over the past 30 years, a seasonal thawing in the active soil layer in the permafrost region has increased by 0.1-0.6 centimetres in the Khentii and Khangai mountains and by 0.6-1.6 centimetres in the Khuvsgul Mountains. The seasonal permafrost level in the active soil layer in the eastern part of Mongolia has decreased by 10-20 centimetres over the last 90 years.

In the mountain in Khuvsgul *aimag* of 29.5 meters or the Terkh Valley, the permafrost is aboout 36 meters. However, the annual average soil temperature has increased by 0.05-0.15^0 C in the Selenge River Basin, by 0.05-0.10^0 C in the Khentii Mountainous Region and by 0.10-0.15^0 C in the Khuvsgul and Khangai Mountainous region.

Also, permafrost phenomenon such as thermocarst, solifluction, thermoerosion has occurred intensely over the last 50 years. As a result of thawing permafrost, a hollow forms in the land. This phenomenon has been observed in the Darkhad depression, the Chuluut River basin and around the Batsumber soum area. The thermocrast process advances approximately 5-10 centimetres per year and, in some places, reaches 20-40 centimetres per year.

Solifluction is observed near the Terkh Tsagaan Lake due to permafrost thawing in Toim Hill in the Khuvsgul aimag **(Figure 3.4)**. Moreover, the solifluction process is occurring intensely on the side of the mountain. The annual speed of solifluction is approximately 2 cm.

Figure 3.4 Solifluction Formed next to the Khangai Mountains (August 2003)

Future Change Trend of Permafrost

It is difficult to determine the actual size and distribution of permafrost. One widely used method to determine permafrost distribution uses air temperature; however, there are differences between soil and air temperatures. Many of the other models used to determine permafrost distribution and depth typically are based on soil physics or heat diffusion, which require extensive information on soil physics and water heat. However, this information is not always available and therefore, can create challenges in using these models. Therefore, the method that uses the air temperature to determine the permafrost distribution is preferred.

How much water will be released from permafrost thawing? The World Permafrost Research Association compiled data on the water content of permafrost and glaciers in the northern hemisphere. According to this information, the water content in permafrost in Mongolia is not higher than 10%, which means that there is 10 grams of water in every 1 kilogram of soil. In other words (if we assume that the water contents in the permafrost soil is less than 10%), the thawing of 1 square kilometre of permafrost that is 1 meter deep will release 1,000 cubic meters of water. Therefore, the land where the size of permafrost is shrinking will have increasingly moist soil, and that may have a positive effect on pastureland. However, when the soil has sufficient moisture, the shrinking permafrost will negatively impact the pastureland and buildings. Moreover, the rising moisture levels in the soil will increase underground and surface water levels; therefore, the rivers and streams will be rich in water during the permafrost thawing process. However, afterwards, when the moisture in the soil evaporates, the source of surface and underground water will diminish and negative effects will be evident, such as drought.

More information on permafrost and the methodology for calculating permafrost index and other information on the permafrost concern can be seen in the **Annex 3.2**.

3.1.3. *Glaciers and Snow Cover (Cryoshpere)*

> ***Cryosphere***
>
> *The cryosphere integrates "the components of climate system which are ice, snow, frozen soil including permafrost lying under the land surface and the ocean." An assessment of the impact of climate change on the cryosphere with respect to the snow cover has been ongoing since the mid-1990s; and the study of the impact of climate change on the ice caps and ice began a couple years ago.*

Snow Cover

Snow cover plays an important role in the environment: namely, it provides insulation to protect the deep soil that remains frozen, acts as a water source for herdsmen, wild and domestic animals during the winter, and nourishes the rivers and streams in the spring. However, if there is heavy snowfall, a white *zud* occurs, which results in no food being available for the herds. Conversely, if no snow falls, a black zud occurs, resulting in a lack of drinking water for herds. B. Erdnetsetseg analyzed the trends of some indicators of snow cover in Mongolia over the last 30 years and attempted to predict, using the world climate models, possible changes in snow cover.

The current changes in snow cover indicators. The change in the average depth of snow cover over the last 30 years shows that the snow cover depth is decreasing in the northern mountainous region of Mongolia; however, the snow cover depth tends to increase in the eastern and southern steppe and the Gobi desert region. In the northern mountainous and eastern part of Mongolia, it has been observed that the annual precipitation tends to be increasing, or in other words, the depth of the snow cover has resulted in a small increment. Moreover, the date of the first snow in the fall (0.54, 0.74) has advanced, and the timing for forming stabile snow cover (0.19, 0.28) also has advanced.

It has been observed that the date of snow melting in the spring tends to occur a little earlier in the northern mountainous part of the country (-0.08), and a little later in eastern Aimags (0.10). Moreover, the level of snow fall tends to be smaller in the southern semi-desert and desert region and the expected time frame for snow fall has been advanced to early fall. This region usually does not accumulate snow cover and the general tendency of rare incidents is –0.30, 0.05. The tendency of having snow in late spring and early summer in the southern (-0.41) and eastern (-0.26) parts of the country has been decreasing, but in the northern part (0.02) of Mongolia, the likelihood of having snow later in the season has been increasing.

In *Future Trend of Snow Cover,* R. Mijiddorj (2002) has postulated that the zero mean line of annual radiation balance basically overlaps an average air temperature of 0^{o}C. Thus, it is possible to draw a borderline between having snow cover for more than 50 days and less than 50 days in the country.

Using the IPCC scenarios of greenhouse gas emissions SRES A2 and SRES B2 and climate model HADCM3, the change of location of the 0^{0}C isotherm of annual average air temperature has been calculated for the years of 2020 (2010-2039), 2050 (2040-2069) and 2080 (2070-2099). The results for NPP are depicted in **Figure A3.3.1a** and **Figure A3.3.1.1b,** respectively, in **Annex 3.3**. According to the maps, the total amount of land that will have negative annual average temperature (or having snow cover for more than 50 days) has tended to be smaller. Similarly, the results for degree of dryness are depicted in **Figure A3.3.2a** and **Figure A3.3.1.2b,** respectively, also in **Annex 3.3**.

Currently, 62 percent of total area of Mongolia is having an annual average temperature below 0^0 C. However, as demonstrated by the SRES A2, SRES B2 scenarios, the coverage area will decline to 43-46% in 2020, 31-35% in 2050 and 27% in 2080 (**Table 3.2**).

Moreover, B. Erdenetsetseg discovered that the number of days having a daily average temperature below 10^0 C is directly correlated to the number of days with snow cover (correlation coefficient 0.82) and that a strong correlation exists between the temperature change in the fall season and the timing of formulation and melting of snow cover. Moreover, in the areas where the number of days with a daily average temperature of less than -10^0 C is 100 days or less, no permanent snow cover forms. Based on the above assumptions and the scenarios used in determining the future climate trends, B. Erdenetsetseg has predicted the future trend of snow cover. The future change has been calculated by overlapping the distributional change of number of days with -10^0 C degree or below with the mean line of 0^0 C.

According to **Tables 3.3a** and **3.3b**, currently one expects to have between 100-120 days with snow cover over 30% of the country's land (annual average temperature is less than 0^o C), 120-140 days with snow cover over 37.5% of the country's land, and 140 or more days with snow cover over 32.2% of the country's land. This does not mean that either snow will melt or snow cover will form once the daily average temperature passes above or below the -10^0 C point. However, it can be understood to be the threshold temperature for the preservation of snow cover in the areas with permanent snow cover, particularly, deep in the forests, wild lands and distant pasturelands.

Table 3.2 Land Coverage Area that is below or above an Annual Average Temperature of 0^0 C as it is Calculated using HADCM3 (as a % of entire country)

GHG Emission Scenarios	T^0 C	current	2020	2050	2080
SRES A2	< 0^0 C	62	46	31	27
	0^0 C <	38	53	68	73
SRES B2	< 0^0 C	62	43	35	27
	0^0 C <	38	57	65	73

Table 3.3a. Percentage of Land where the Air Temperature is less than -10^0 C of Daily Average Temperature, Calculated by HADCM3 Modelusing SRES A2 Scenario

Number of days	Current	2020	2050	2080
<50	0	0	0	0
51-100	0	0	0	0
101-120	30	34.1	32.2	28.6
121-140	37.5	35.9	50.5	58.3
140<	32.2	30	17.3	13.1

Table 3.3b. Percentage of Land where the Air Temperature is less than -10^0 C of Daily Average Temperature, Calculated by HADCM3 Model Using SRES B2 Scenario

Number of Days	Current	2020	2050	2080
<50	0	0	0	0
51-100	0	0	0	0
101-120	30	34.2	32.2	29.2
121-140	37.5	35.9	50.5	57.4
140<	32.2	29.8	17.3	13.4

In the future, the total area having snow cover between 100-120 days and 120-140 days will increase slightly, but the coverage area with snow cover for 140 or more days will likely decrease by 20 percent. This means that some areas currently having more than 140 days of snow cover per year will only have 120-140 days of snow cover, and some areas with 120-140 days of snow cover per year will shift to having only 100-120 days. Thus, the total coverage area with snow cover generally will decrease. However, climate change may not strongly affect the areas where the permanent snow cover has formed over longer periods of time.

In terms of the timing of the snow cover formation, the coverage area that typically has snow cover before November 11 or from November 12 to 21 will decrease in 2020, 2050 and 2080. However, the total area having snow cover formation between November 22 and December 11 tended to increase. Therefore, one can conclude that the third week of November is the most probable time for snow cover to be formed (2050-2080). The permanent snow cover will form in the largest territory during the second ten days of October in 2020 and 2050, and the third ten days of November in 2080.

Currently, the melting period of the permanent snow cover, which is calculated based on the average air temperature of –10^0 C, is during the last ten days of February and in March. However, in the years of 2020, 2050 and 2080, the snow melting period will be advanced by 20 days according to the estimations based on the SRES A2 and SRES B2 scenarios by HadCM3 model.

During the observation period, the level of glacier melting is 54 cm in 2004 and 89 cm in 2005 and the sum of daily average air positive temperature is 96.2 ^{o} C and 181.6^o C, respectively. From here, the melting parameter was calculated as 0.49 cm/ ^{o}C per day (2005) and 0.56 cm/ ^{o}C per day (2004). D. Davaa has calculated the vertical distribution of air temperature increase using multiyear information collected at Ulaangom upper air observation station centre and has concluded that 0.0 ^{0}C isotherm has been elevated by 531.3 m between 1976-1993.

Table 3.4 Vertical Distribution of Change in Air Temperature

Height, m	Current change	Future change		
		2010-2039	2040-2069	2070-2099
940	1.9	2.3	4.2	7.0
1,490	1.1	1.4	3.3	6.2
3,050	0.7	1.0	2.9	5.8

According to the calculation of the temperature change, the glacier melting in Tsambagarav Mountain will increase by 131 cm in 2010-2039, 371 cm in 2040-2069, and 739 cm in 2070-2099. Accordingly, there is a high chance that snow cap with about 50 meter depth will completely melt by 2040, with an 100 meter depth will completely melt by 2050-2060, with a 200 meter depth will completely melt by 2070-2080, and with a 300 meter depth will completely melt by 2090. More details on glacier and snow cover assessments can be seen in **Annex 3.3**.

3.1.4. *Water Resources*

Mongolia has limited water resources. Mongolia has 599 cubic kilometres of water, including of 500 cubic kilometres in lakes and 90 cubic kilometres of salt water. In particular, its glaciers contain 62.9 cubic kilometres of water, and there are 34.6 cubic kilometres of water in surface and underground water sources. The total water consumption in the country is only about 0.5-0.7 cubic kilometres. According to the surface water inventory conducted in 2003, there are 5,565 rivers and streams, of which 683 have dried up; 9,600 springs, of which 14,84 have dried up; and, 4,193 lakes and ponds, of which 760 have dried up during the last few years. However, the 2007 water inventory reveals that 852 rivers and streams out of a total of 5,128 have dried up; 2,277 springs out of a total of 9,306 have dried up; 1,181 lakes and ponds out of a total of 3,747 have dried up; and, 60 springs out of a total of 429 have dried up. Even though the country's water consumption is extremely low, changes in the river basin areas and its vegetative layer, as well as business activities affect the water resources and quality.

Based on the correlation between the flow and the average altitude of a river basin area, which includes many different environmental factors such as geological formation, forest, soil and vegetation, annual precipitation, mountain location, and river basin formation, Mongolia has been divided into 13 major water basin areas: (1) the Uvs Lake basin; (2) the Khovd River basin; (3) the basin of the Bulgan, Uench and Bodonch Rivers; (4) the basin area of the rivers originating in the Gobi-Altai Mountains; (5) the basin of the Zavkhan, Chigestei and Bogd Rivers; (6) the basin of the Baidrag, Tui and Taats Rivers; (7) the basin area of the Chuluut, Tamir and Orkhon Rivers; (8) the Shishkhed River basin; (9) the Delger River basin; (10) the Eg River basin; (11) the basin of the Yeruu and Onon Rivers; (12) the basin of the Kherlen, Tuul and Kharaa Rivers; and, (13) the Khalkh River basin. Mongolian lakes are usually located in the middle or at the end of the rivers in the above mentioned basin areas. The lakes are fed by the rivers and function to harmonize a river's downward flow. The effects climate change has had on the above-mentioned river basin areas are being researched. There are unpredictable direct and indirect impacts of water flow, resource and quality on animals and vegetation.

Change in Water Discharge/Flow

The first study and observation on river water level and flow was conducted in 1942. Since then, 108 hydrological river stations and posts and 15 observation posts at lakes have been established in Mongolia. From these observation posts, researcher P. Batima selected for observation the 20 longest running rivers, which differ from each other by their geographic location, their climatic conditions and the size of the area for water collection.

According to this research by P. Batimaa, the water flow and discharge has not changed in the past 40-60 years. In other words, there has not been any trend showing either an increase or decrease in the volume of the surface water. The annual change in river water flow is shown in **Figure 3.5**. As demonstrated in Figure 3.20, surface water flow increased from the mid-1970s until the 1990s and then precipitously dropped beginning in 1993 and 1994. However, the river discharge and water level has changed noticeably.

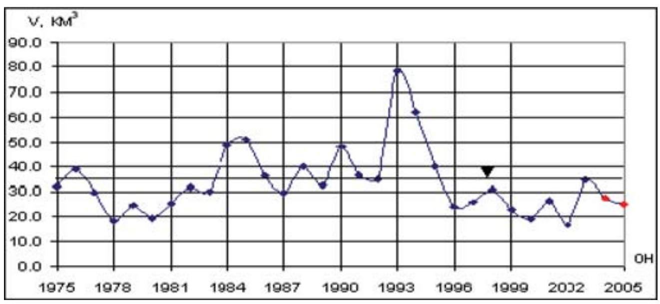


Figure 3.5. Multiyear Information on Mongolian Surface Water Resource

Changes in Ice Phenomenon

According to research and studies conducted in the past few years, changes are occurring with respect to the formation of ice on rivers and lakes, including the timing of the ice cover's formation and deterioration and the thickness of the ice. For example, the date that the ice cover forms on the surface of rivers and lakes is later in the year, and the change in this timing is different from one area to another depending on the local climate conditions.

To determine the volume of river flow in Mongolia, while assuming the current and future ratios between evaporation is constant, the intensity parameter of precipitation has been identified as 0.40 in the Arctic Ocean Basin, 0.27 in the Pacific Ocean Basin, and 0.5 in the Central Asian Internal Basin. Based on climate scenario results, the future trend of the change in river flow has been identified as follows**.**

According to the SRES A2 scenario, the river flow will increase by 10 millimeters in the Khentii Mountains by 2020, and by 2-5 millimeters in other mountainous regions, but will decrease by 2 millimeters in other regions such as mountain valleys, steppe and the Gobi region. This decrease is nearly 10 times lower than the amount of evaporating water. Even though there will be some increase in water flow in Mongolia, the evaporating water volume will be several times greater. Therefore, there is a tendency towards droughts in the river basin areas.

Further information on the snow and ice situation assessment for Mongolia can be seen in the **Annex 3.4.**

3.1.5. *Natural Disaster*

There are many different, even contradicting definitions of the term disaster that can occur in the economy, society and environment, including natural disasters. In addition, many terms that are widely used in risk management can be understood having different meanings when referring to a disaster.

A definition of natural disaster includes human fatality and property damage, but damage to the environment and cross border social and economic damages are not counted. However, when the natural phenomena create natural disasters, it usually causes socio-economic damages and also environmental degradation. The environmental degradation also negatively impacts society and the economy. Therefore, those phenomena that negatively affect the environment should also be counted as natural disasters. In practice, Mongolia counts a sudden increase of rodents, forest fires and steppe fires as natural disasters. Therefore, environmental degradation, in addition to large sum property damage, should be included in the UN's definition of natural disaster.

Frequency of Natural Disasters

According to data collected since the 1970s, Mongolia has experienced approximately 25-30 atmosphere related natural phenomenon, and of these almost one-third caused natural disasters and five to seven billion Tugrug in damage for the government and the society. Since the mid-1990s, excluding droughts and zuds, temporary hard weather conditions caused 10-12 billion Tugrugs in damage every year, which is due in large part to lack of protective mechanism against natural disasters, or improved statistical data. **Figure 3.6** shows the frequency of atmosphere related natural disasters that occurred in Mongolia over the past 20 years. The data compiled in Appendix 3.4 demonstrates that there is a trend showing an increased frequency of severe weather conditions and natural disaster occurrences; however, this observed change is insufficient to determine the precise increasing trend.

With regard to human fatality, continuous strong snowstorms (6 hours or more of snow) that cover a large territory are the most dangerous. During this type of storm, herders who are usually in the pastureland with their herds are especially vulnerable. For example, on from April 16 to April 20, 1980, a strong snowstorm, with up to 40 m/s of speed, continued for 60 hours and caused 43 human deaths (during the socialist era, the statistics on damage was not open to public) and

800,000 animal deaths. No information has been collected on whether wind speed or disaster frequency has been affected by climate change. However, information is available on the frequency of droughts and zuds and on other types of atmospheric convection causing hazardous phenomenon (heavy rains, squalls, thunderstorms, and big hails) covering small territory.

The frequency of heavy rain is increasing when compared to the occurrence of rain; thus, the volume of rain per day is increasing. [**3**] For example, according to the data collected at the Arvaikheer station from 1979-1996, the frequency of heavy rain increased by 18% when compared to the total precipitation in warm season. Since the convection intensity is increasing, the frequency of socially and economically harmful phenomenon, including flashfloods, thunderstorms and hailstorms, has increased by twofold.

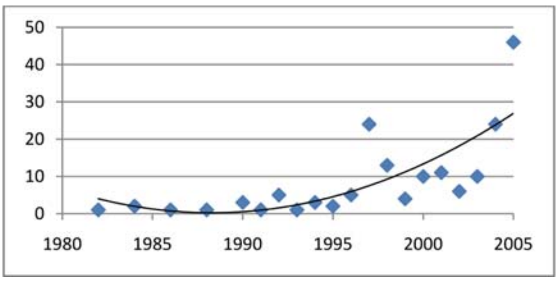


Figure 3.6. Multiyear Tendency of Atmoshperic-Convection-Related Natural Disasters

Drought is a natural disaster that causes a significant amount of damage to the economy and soceity. Drought usually occurs in dry, semi-dry and less moist areas. However, no uniform method exists to determine what exactly constitutes a drought and how to evaluate whether a drough occurred. Since there is no common understaing of droughts, the information received from areas with droughts usually differs. Moreover, it is important to differentiate between dry, semi-dry and less moist conditions from drought conditions.

More information on the nature of natural disasters and drought and the assessment methodologies for drought phenomenon are included in the **Annex 3.5.**

3.1.6. *Desertification*

Desertification extremely affected by climate change and human activity has become one of significant risk to the modern mankind. In accordance with the UN Convention to Combat Desertification (Paris 1994) desertification is defined as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic change and human activities. Characteristic of land has been defined by soil, water, plant, and other biomass as well as terrestrial biocapacity containing ecological and hydrological process of ecosystem.

The most prevalent human activity in Mongolia that can potentially induce anthropogenic land degradation augmenting desertification risk is animal husbandry, characterized be livestock grazing. In addition, mining activities and transportation sector have considered as technogen degradation. According to observation results performed on the territories of Mongolia, Inner Mongolia in China and Baikal region in Russian Federation, the intensity of livestock impact on pasture in forest-steppe and steppe regions causes the reduction of hydrophytes plants and growth of xerophyte plants. Therefore, the total vegetation productivity will significantly decrease by 1.4-7.0%. [**4**]

Current Situation of Desertification

Mongolia is one of the most arid countries in the world. Surface land is very vulnerable to the desertification. Data base results of the meteorological - stations has shown that proportion of the overall precipitation and evaporation is being varied by 0.04:0.78 and only in the highest mountain and greyhound area, it is above 0.65. On other hand, traditional grassland animal husbandry of Mongolia has been highly defended from natural condition and pasture during 4 seasons. Therefore, desertification has become one of the extremely specific natural disasters in Mongolia. According to some data sources, 70 % of the grassland in Mongolian territory has been affected by decertification. [**5**]

The study conducted by using of land and satellite monitoring in the Institute of Geo-ecology concluded that the 78,2% of territory of Mongolia has been affected by middle and high rate decertification **[6]** (**Figure 3.7**).

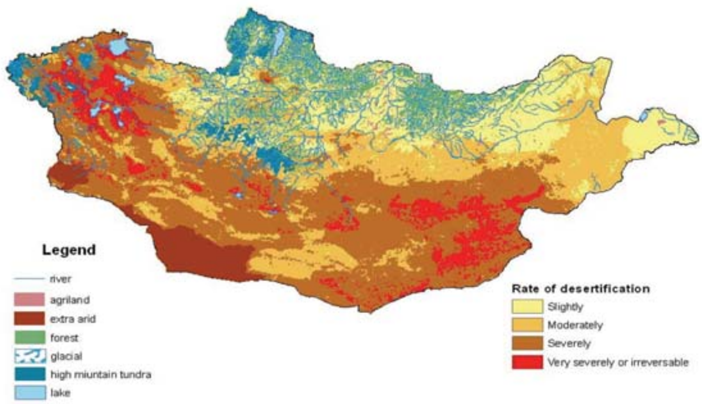


Figure 3.7. Dispersion of Desertification in Mongolia (A.Khaulenbek 2007)

Consequently, desertification impact assessment study results such as 20-30% decreasing of a pasture grassland growth during the last 40 years and livestock vulnerability rise, due to the pasture degradation has shown that desertification issue shall be considered at the National Security Management level. *The Desertification Future Tendency*

In the 21st Century, global climate change will intensify and it will obviously occur in Mongolian territory, which located at coldest continental area. Climate projections were estimated by HADCM model using greenhouse gas emission scenarios of SRES A2 and SRES B2. Evaluation outcomes shown that territorial monthly average temperature of warm season expected to increase by 1,2-2,3^{0}C in 2010-2039, by 3,3-3,6^{0}C in 2040-2069 and by 4,0-7,0^{0}C in 2070-2099. In particular, in the High Mountain and steppe zone, it would be significantly warmer.

The precipitation variability would be approximately ±4% or 6-17 mm during 2010-2039 and expected increase by 7-8% /27-33mm/ over 2040-2069, and in 2099 the growth rate will be decreased again. In other words, it has observed that precipitation would not be increased by pursuing the significant temperature growth in the 21st Century.

Thus, predicted intensive temperature increase is in the western areas, precipitation decreases are in the central regions and its increasing tendency would be observed in the eastern part of Mongolia. Air temperature increase in warm season would cause an expected increase of territorial annual evaporation by 100 mm over 2010-2039, 185 mm in 2040-2069, in comparison to 1990s level. In other words, this is 6-10% more than previous period increase. This means that drought intensity and ecosystem degradation is expected to activate due to climate change in the 21st Century. However, the predicted annual precipitation would be slightly increased, the negative natural changes as aridity increases, vegetation and desert-steppe zones migration north ward, associated with climate warming is expected to occur. These trends would be observed intensively in 2070-2099.

More information on these possibilities and factors that could have a deeper understanding of this important climate change phenomenon can be seen in the **Annex 3.6**.

3.1.7. *Dust and Sand Storms (Yellow Dust)*

Dust storms were started to be observed at the meteorological stations of the National Meteorological Services since 1936. On the basis of former Soviet Union monitoring methodologies, it has categorized three definitions of dust events which are the following: 1) floating dust, 2) drifting dust; and 3) dust storm. Visual observation error caused by the surrounding dust can cause inaccuracy in the records at the meteorological stations. A system of differentiating dust events uses distance synoptic visibility, as shown below:

Table 3.5 Definition of Three Types of Dust Events

Type	Wind	Visibility	Atmospheric Condition
FD (floating dust)	Low	1–10 km	Suspended
BD (drifting dust)	Strong	1–10 km	Turbid
DS (dust storm)	Strong	<1 km	Turbid

Over recent decades, it is widespread practice to determine the dust-related events using satellite and ground-based monitoring by measuring the dust particles in the atmosphere. During the dust storms, dust particles in the atmosphere are heated by the solar radiation which causes additional heating that is known as Voeikov phenomenon. The phenomenon of dust and sandstorm unpleasantly impacts the animal husbandry and becomes a factor of the pasturing destruction. Particularly, dust storm occurrence in the low temperature has significantly affected livestock pasturing and herder's outdoor activity.

As a result of frequent sandstorms, accumulated dust over the animal wool decreases wool quality and complicates its processing. The sand movement over the dune landscapes causes various other negative impacts such as sand encroachment on the roads and urban areas, damage to the monuments and memorials, and abrasion of the building chalk leading to falling off due to the constant impingement of the dust particles on building surfaces.

Geographical dispersion studies of annual average amount show that dust storm occurrences took place for less than 5 days a year in Khangai, Khovsgol and Khentii mountainous areas; in the desert areas, 30-37 days; and in the Great Lake Depression, 10-17 days (**Figure 3.8** and **3.9**).

Three major regions, namely, Altain farther Gobi, Red lake of Umnugobi and Zamiin Uud areas are identified as high frequency zones for dust storm occurrences. In addition to this, the dust storm occurrence and its geographical dispersion is closely related to geographical dispersion of days with massive wind and the surface soil characteristics of the country. In other words, sandstorms frequently occur in the regions with strong winds.

Further information on the dust and sand storms assessment for Mongolia can be seen in the **Annex 3.7.**

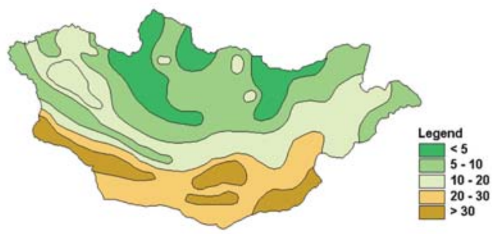


Figure 3.8 Geographical Distribution of number of days with Dust Storm

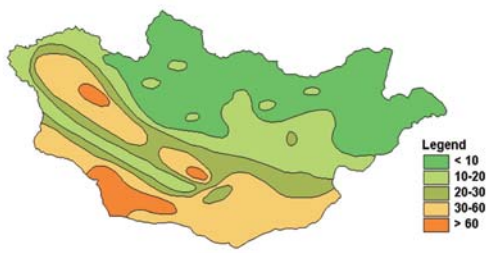


Figure 3.9. Geographical Distribution of number of days with Drifting Dust Storm

3.2 Impacts on Economic Sectors

3.2.1. *Animal Husbandry*

The extreme climate and weather condition have dramatic impacts on animals and the livestock sector in Mongolia which has harsh dry continental climate. Climate change, through pasture alteration, indirectly influences animal husbandry productivity and efficiency. On the other hand, the climate change could also be advantageous to animal body heat preservation and breeding. Mongolian livestock adapted properly to the natural climate condition and has maintained high productivity level when in open pastures that depends on normal climate and weather conditions. Negative impact of changing grassland and weather situations, especially during harsh winter and spring seasons, will definitely reduce productivity and quality, and would result to possible loss of livestock.

Models are used to simulate the animal weight gains in the winter-spring and summer-autumn periods and pasture resource conditions also taking into account their dynamics and weather conditions. Also, they define livestock climate change vulnerability in accordance to pasture biomass and climate changes. In addition, climate database analysis has conducted for accurate assessment of climate impacts on livestock fat, energy, fertility and productivity. The mathematical models are used to identify indicators on pasture stress and graze interrupt.

Due to the climate change, the increasing number of very hot summer days circumstantially influents on the animal grazing summer condition. For instance, livestock daily average pasture grazing interruption occurred in June-July by 0.8 hours (48 minutes) and it has extended by 0.2 hours (12 minutes) during last ten years period in comparison with previous ten years. In addition, a number of days with more than three hours interruption of grazing time have been increased by about seven days during the past 20 years. Particularly, it had significantly increased since the beginning of summer in 1990.

Climate change impact on animal husbandry

Many integrated factors are being influenced to the livestock and its main parameters as animal fat, live-weight change. It would be impacted on the growth, reproduction, productivity and vitality. Consequently investigation on weight change trend has became a key issue, includes many problems on climate and ecological changes.

These results show that recent climate change effects on pastoral livestock primarily negatively which leads to reduce of livestock productivity and impact on economic efficiency of animal husbandry. Due to the climate change, for last 20 year period sheep, goat and cattle hair cutting times have been shifted ahead by about a week.

Future climate change impacts on animal husbandry [**9**]

The Climate models such as HADCM3, CSIRO, ECHAM were used for future data analysis of temperature and precipitation amount for 2010-2039 /2020/, 2040-2069 / 2050/, and 2070-2099 /2080/ to estimate future climate change impacts on animal husbandry. Also, the climate change impact on pasture growth was estimated by the CENTURY model with consideration of future trends on time and space.

Model of estimation on Mongolian sheep live-weight change in winter-spring time" and the model of estimation on Mongolian sheep live-weight change in summer-autumn (May-Oct) (Tuvaansuren 2000) assess the influence of the Mongolian sheep life cycle, energy exchange for live-weight, with consideration of the sharp climate change, pasture and climatic condition. Models have analyzed the sheep daily life cycle process, through its energy balance by using of seasonal pasture and weather data base. Constant quantative indicators such as pasture and climate impacts, inticators identified their seasonal and regional defferences, and variable daily grazing and climatic measurements have been used in this model.This means that weight changes were calculated based upon enviromental condition.

Weight changes are calculated taking into account the basic parameter of particular sheep breeding average weight. There are approximatly 20 various sheep breeds in Mongolia which leads to different average weight parameters during spring, autumn seasons. Estimations were made using the parameters of long-term average of summer pasture maximum growth, ewe autumn weight, copulation period and daily weather database from 37 meteorological sations representinging different ecological zones of Mongolia.

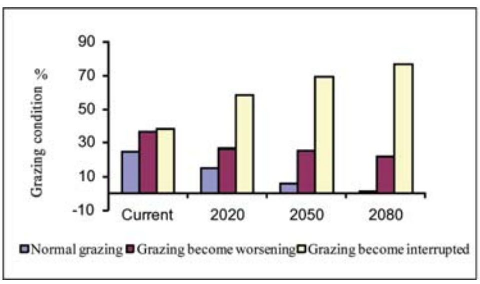
During evaluation of climate change impacts on Mongolian sheep, there was estimated sheep's summer-spring weight variability, considered, firstly, changes on air temperature by 1-5^{o}C and pasture grass maximum growth by 30, 20, 10, 0, -10, -20, -30 percent based upon database from a dozen of meteorological stations representing different ecological zones. According to the observation, Mongolian sheep achieve avarage weight gains at 16.5 kg, which is 45% of what is achieved in summer-automn period.

Assessment of Future Condition of the Mongolian Sheep Grazing

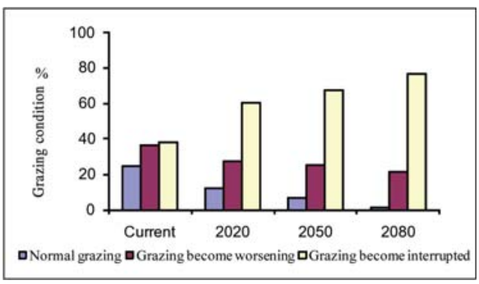
Grazing condition in summer season. The hot air temperature during summer-autumn period significantly impacts on the sheep grazing, which ultimately leads to livestock birth condition, fat, fertility and productivity. Animal stimulus lessens and daily pasturage duration decreases, due to the reduction of animal gaze on pastures in very hot temperature. When regional average mean air temperature rises up to 20-22^{o}C, then pasture grazing of Mongolian sheep is interrupted and its grass intake decreases. The HADCM3, ECHAM, CSIRO models have estimated regional climate change on continues effective warming and hot temperature, particularly in 2020, 2050 and 2080 that would causes to stress and interruption on Mongolian sheep pasturing.

Outcomes estimated by modeling. Changes in graze interruption, due to extremely hot summer temperature are shown in **Figure 3.10a** and **Figure 3.10b** (SRES A2 and B2 scenarios by HADCM3 model).

In accordance with climate warming, regional variation affect as the extremely hot summer temperature rise negatively impacts on the sheep pasturage condition, shown as pixel dots on the map of Mongolia in said figures. According to the both scenarios SRES A2 and B2 sheep summer grazing pasture



a) HADCM3 SRES A2 Scenario



b) HADCM3 SRES B2 Scenario

Figure 3.10. Projected Changes in Grazing Condition due to Climate Change

Table 3.6 Forecast of conditions of sheep pasture by HADCM3 model (%)

	Recent	HADCM3 by SRES A2			HADCM3 by SRES B2		
		2020	2050	2080	2020	2050	2080
Normal	25.139	15.13	5.67	1.56	12.24	6.90	1.56
Difficult	36.596	26.81	25.25	21.80	27.47	25.47	21.80
Prevents	38.265	58.06	69.08	76.64	60.29	67.63	76.64

interruption territory increases in the 21st Century. For instance, the duration of normal gazing time in summer occupies 25% of total pasture time then it will decrease by almost two times in 2020. However, present interruption time of gazing on pasture is 38%, it would be significantly increased up to 53-58 percent in 2020 (**Table 3.6**). The analysis shows that within any geographical zone, daily intake of Mongolian sheep would be decreased because of changes on pasture biomass and hot temperature condition. Besides this tendency observed that can cause to extend territory of regions with hot climate condition.

Calculations show that regional areas with condition of sheep graze interruption, daily time would be increased by 60% in 2020, and then it would reach to 70% in 2050 and 80% in 2080.

Further information on the assessing climate change impacts in animal husbandry for Mongolia can be seen in the **Annex 3.8.**

3.2.2. *Arable Farming / Agriculture*

The network of measuring and assessment of agro-meteorology and agro-climate in Mongolia was first established in 1959. The rate of harvesting within the agricultural regions in Mongolia fluctuates year after year, depending on the weather precipitations. The diagram below shows fluctuation of wheat harvesting rate for many years.

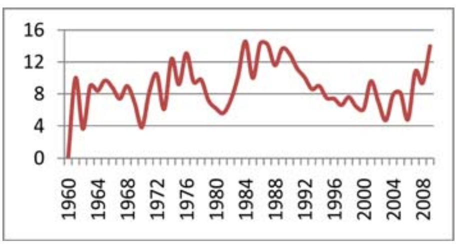


Figure 3.11. Spring Wheat Harvesting Rate Fluctuation for Many Years

From the above it is seen that starting from the 1960s – the time of massive cultivation of wild lands until 1980s harvesting rate per hectare was increasing, the fluctuation was minimal, especially at the beginning stage. But during the last twenty years the harvesting rate decreased due to some possible reasons. Since 1990s because of shortage in financing and manpower the agriculture was almost abandoned, but aside from these factors, repeated droughts also contributed to such decrease.

According to the measurements made by the agro-meteorological station on the crop fields of the Khongor *soum* in the Darkhan Uul *aimag*, based on the specialized Institute of Agriculture, the wheat harvesting rate between 1986-2007 was decreasing by 0.28 centners/ha. Another factor, which aggravates decrease of harvests, is increase of number of extreme

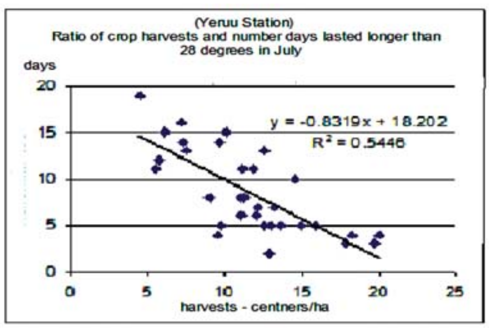


Figure 3.12. Ratio between Harvests and number of Days on July with air Temperature warmer than + 26 ⁰C

hot weather days that fall right at the time of blossoming of and pollination crops. The crucial time for crops falls on July when the air temperature rise up to +26 ^{0}C and warmer. From the diagram below see for the correlation between weather and harvests. [**10**]

Assessment of how the climate change and warming in the recent years affected timing of each stage of the wheat growth was tried to be performed.. According to the measurements taken by several stations, the time span for each stages of wheat growth seems to have shortened, but the findings are still being finalized. For instance, the stage between blossoming and fruiting took longer time by observation of 6 stations. It can be explained by extreme hot weather in July. The high coefficient of changes in speed of growing within the Khutag and Khalkhgol stations depended on frequency, quality and length of observation.

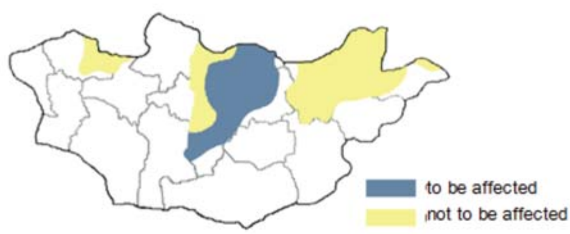


Figure 3.11. Spring Wheat Harvesting Rate Fluctuation for Many Years

Assessments of correlation between climate change tendencies and harvesting of cultivated plants was first conducted by Dr. Sh. Bayasgalan at the end of 1990s, where he used the scenario IS92a of increase of green house gases and models GFDL, CSIRO, CCCM, HADCM2, ECHAM4 and DSSAT 3.0 model for plants. **[14]** The estimations show that within the Central Agricultural region of Mongolia the harvests of wheat shall decreas by 19-67 %, though within the other regions harvesing rates shall get increased. As for potatoes harvests – there no significant declines shall be observed.

Additional information on results of some researches on climate effects on agriculture can be seen in **Annex 3.9.**

3.2.3. *Forestry*

A long term historical trend on environmental development of forest cover in Mongolia has shown that forest vegetation has been moderately substituted by plant vegetation. Besides this ecological impact, man-made negative impacts such as forest fire, logging and livestock production have significantly intensified the process of forest transforming into steppe, especially during the last 100 years. Thus, the tendency continues to be a decrease of boreal forest with spruce and cedar tree cover areas within the overall forest distribution. This change in composition of forest areas has been observed.

Over recent years, negative influences on forests, such as climate change, aridity, forest fire, harmful effects of human activities on biological systems, and harmful effects of insect and disease propagation have caused hotbeds of damaging activity that have led to critical injury. This injury is on the scale of environmental disaster. For instance, lightning in the mountain taiga is the main reason for forest fires occurring in the forest-steppe and boreal zones. A data source states that burned forest land comprises 3.36% of the total forest stock in Mongolia.

Depending on factors such as climate change, severe aridity, drought, forest-steppe fires, and non-technological timber harvesting, forest ecosystems are changing and generating less ecological benefits such as water regulation and soil protection. Insects that consume the leaves, conifer, seeds, cones, stems, and roots of vegetation in the forests have propagated.

Current climate change significantly impacts forest resources and growth. A general result of scenarios indicated by climate change assessments is that forest areas might decrease due to an expansion of the steppe and desert zones. More specific results include (The Mongolian Action Programme for the 21st century,1998):

- the high mountain tundra and taiga regions would decrease up to 0.1-5.0% in 2020 and up to 4.0-14.0% in 2050; and
- the forest-steppe area in Khangai, Khentii, Khubsgul and the Altai mountain regions will decrease by 3% in the first quarter of the twenty first century and by 7% in second quarter.

Additional information on results of some researches on climate effects on forestry can be seen in **Annex 3.10.**

3.3. Vulnerability and Risk Assessment

In the case of Mongolia, its fragile ecosystems, pastoral husbandry and very limited irrigated agriculture are extremily sensitive to climate change. As such, Mongolia's traditional economic sectors and its people's nomadic way of life are highly vulnerable to climate change. Mongolia is one of the few countries in the 21st century that has been able to sustain its nomadic way of life. Mongolia occupies a vast land and has low population density. On average, there are almost 20 heads of livestock per capita, and its herders are dispersed throught the country, following the nomadic way of life. Mongolians do not have an extensive experience with industrialized animal husbandry. Wool, cashmere and milk production are all being carried out naturally. Therefore, there is a lack of experience in investing in nomadic animal husbandry or upgrading the pasture quality. Accordingly, pastoral animal husbandry has a high probability of being affected by climate change.

A significant portion of the labor force in Mongolia is engaged in animal husbandry. Since the privatization of livestock in Mongolia, the number of herders has increased rapidly. In 1990, there were 147,508 herders and 74,710 herder families. By comparison, in 2000 the number of herders had increased to 421,400 and the number of herder families was 191,500. **[18]** However, during the periods of 1999-2000 and 2001-2002, when a harsh winter, known as a zud, occured in Mongolia, the number of livestock decreased significantly and the number of herders fell. By 2007, there were only 171,700 herder families, and 366,200 herders were engaged in animal husbandry.

The effects of climate change are most predominantly being seen by the pastoral animal husbandry sector in Mongolia because of the more frequent occurrence of drought and zud. The effects of climate change are evident in the animals' inability to gain the necessary live-weight during the grazing period because of the increase of number of extremely hot days, thereby causing a decline in daily caloric intake.

In other words, the zud can cause mass destruction of Mongolia's livestock,

Table 3.7. Correlation of Adult Livestock Mortality and Meteorological Factors (by types of livestock and linear and non-linear correlation coefficient)

	Total	Camel	Horse	Cattle	Sheep	Goat
S_{summer}	0.38	0.01	0.51	0.53	0.36	0.24
	0.64	0.18	0.79	0.87	0.61	0.35
S_{winter}	-0.52	0.04	-0.41	-0.36	-0.53	-0.56
	-0.59	-0.05	-0.46	-0.40	-0.61	-0.64
ΔS	0.60	0.01	0.64	0.63	0.59	0.52
	0.80	0.11	0.89	0.92	0.78	0.61

Note: 1st row – linear, 2nd row non linear correlation coefficient consequently affecting its environment and society. Therefore, one criterion for assessing the severity of a zud is the mortality of adult livestock.**[19]** However, apart from the livestock dying unnaturally during the zud, livestock deaths occur from a variety of other factors: cold summer rains; spring snowfall and windstorms; floods; wolf killings; and, lost livestock. All of these deaths are registered as livestock loss in general, and thus, exact data about livestock losses that result from zud is not available.

This Table clearly indicates that sheep and goat mortality S_{winter} is higher S_{summer} but in case of camel and cattle the situation is reverse, in total, camel and cattle are more vulnerable to zud.

In terms of pasture grazing patterns, due to biological differences, camel and cattle especially consume high growing vegetation; by comparison, sheep and goats, especially, which are active foragers, graze more intensively from top to the bottom of plants. Camels, three forth of which are native to desert regions, have adopted to survive during a one-year drought, and only in the case of several consecutive years of drought will a camel suffer from the lack of browse. Therefore, there is not much dependence on last year's vegetation yield. It is clear from the research results that the pasture yield has been reduced for the last forty years by 20-30 percent in all eco-regions,**[12]** the occurrence of drought is increasing,**[13]** overgrazing is increasing, the variety of plant species and yield **[17]** is declining, and the live-weight of sheep and goats has decreased during summer and spring seasons **[6]** in the forest steppe regions from 1980 to 2000, which can be explained by factors related to drought and desertification.

To investigate how vulnerability is changing due to the deterioration of pasturelands, the number of cattle stocks can be compared to the annual rate of perishing, reviewing the figures for the end of each year. The rate of perishing cattle stocks also can be compared to the rate of perishing of all the rest of the livestock. **Figure 3.14** below shows a comparison between the rates of perishing cattle stocks to those of sheep.

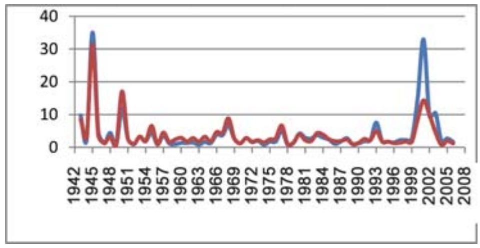


Figure 3.14 Comparison of the rates of perishing cattle stocks to all other animal stocks

From **Figure 3.14** above, it is visible that before the 1990s the rate of perishing sheep was much higher than that of cattle, but later, in 1990s, the figure has changed: the rate of perishing cattle stocks became higher that of the sheep. This dramatic change is a result of deterioration of pasturelands with higher grass. Cattle stocks were severely impacted. This fact can serve as a perfect indicator of droughts and the desertification process.

The vulnerability of pasturelands to climate change can be shown on the

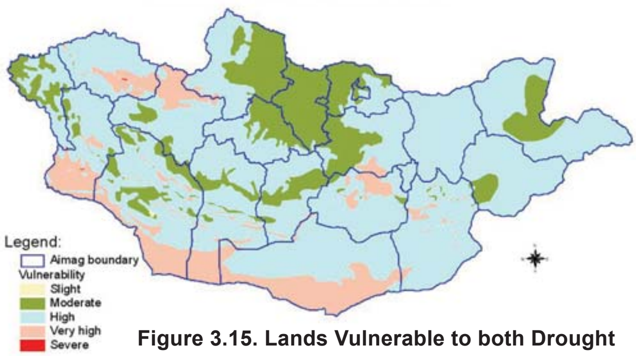


Figure 3.15. Lands Vulnerable to both Drought and Heavy Snowfalls

From the picture above, it is seen that nearly 90% of the total territory is vulnerable.

schematic figure, using the drought assessment method, which shows frequency and geography of droughts, both of so called “Black zud” and “White zud” (two forms of harsh winter). (**Figure 3.15**).

Future Tendency of ‘zud’.

Upon review of the outcomes of the assessment models, it is visible that, due to the global warming, the trend in precipitation in the winter seasons is increasing. (In the summer season, the trend in precipitation is increasing by 4 % +10%). Air temperature is expected to warm up by 0.9 % +4.7^{0}C. The harsh condition of the winter season will not reach its critical point, but the droughts in summer season will reach an extreme.

Observing the S_{summer} of the 21st Century, droughts will reach the highest point, which is much higher than what has happened in the last 60 years. In connection with this, the figures of ΔS will get higher and the rate of perishing of the bigger cattle will exceed normal and by 2020 reach 12.0%, and by 2050 will reach 17.8%.

The animal husbandry experts assess that if the rate of perishing of the bigger cattle exceeds 5%-6%, a catastrophic lost of the regime of livestock reproduction will occur. In other words, the harsh condition of the zuds will severely diminish the possibilities of having pastureland husbandry. Finally, it may lead to the end of the Mongolian traditional way of animal husbandry as we know it that at one time was the very core of entire nomadic civilization.

Additional information on vulnerability due to climate effects can be seen in **Annex 3.11.**

Table 3.8. Assessment of the Future Trend of Heavy Snowfalls by Comparing Results of the zud Index to those of Perishing of Bigger Cattle (by the HADCM3 model using GHG emissions scenarios SRES A2 and SRES B2)

	SRES A2			SRES B2		
	2020	2050	2080	2020	2050	2080
S_{SUM}	1.83	2.44	4.84	1.72	2.15	3.62
S_{WIN}	-0.2	0.16	0.09	-0.05	-0.15	-0.325
ΔS	2.03	2.28	4.75	1.77	2.3	3.94
ΔN	12	17.8	66.5	12.1	19.1	47.5

4 Legal Framework of Climate Change Response Measures

4. LEGAL FRAMEWORK OF CLIMATE CHANGE RESPONSE MEASURES

In order to comply with the obligations and commitments under the UNFCCC as well as to address challenges relevant to climate change, Mongolia has developed its National Action Programme on Climate Change and the programme was approved by the Government on 19 July 2000. The action programme includes national policy and strategy to tackle with the climate change adverse impacts and to mitigate greenhouse gas emissions.

The Article 4.1(a) of the UNFCCC states that *"All Parties taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall: … formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol, and measures to facilitate adequate adaptation to climate change"*

The Millennium Development Goals-based Comprehensive National Development Strategy (MDG-based NDS) of Mongolia identifies that *"to create a sustainable environment for development by promoting capacities and measures on adaptation to climate change, halting imbalances in the country's ecosystems and protecting them"*. In addition, the NDS includes a Strategic Objective to promote capacity to adapt to climate change and desertification, to reduce their negative impacts.

4.1. National Action Programme on Climate Change

The Mongolia National Action Programme on Climate Change (NAPCC) is aimed not only to meet the UNFCCC obligations, but also to set priorities for action and to integrate climate change concerns into other national and sectoral development plans and programmes. The NAPCC is based on the pre-feasibility studies on climate change impact and adaptation assessment, GHG (GHGs) inventories, and GHGs mitigation analysis. This Action Programme includes a set of measures, actions and strategies that enable vulnerable sectors to adapt to potential climate change and to mitigate GHGs emissions. Starting point was that these measures should not adversely affect socio-economic sustainable development.

The implementation strategies in the NAPCC include institutional, legislative, financial, human, education and public awareness, research aspects, and integration into other national and sectoral development programmes and plans. Also, existing barriers to implementation were identified as well as possibilities to overcome such barriers. The programme also considered several adaptation measures for animal husbandry and rangelands, arable farming agriculture and water resources.

Research activities will be focused on systematic observation and monitoring of the climate system, development of climate scenarios, vulnerability and risk assessment, potential impacts on ecosystems and society, and possible measures to adapt to climate change and mitigate the GHGs emissions at the national level. Based on such comprehensive studies and analyses, the NAPCC should be updated and hence facilitate the implementation of Mongolia's strategy and policy on climate change.

It is recommended that a considerable amount of capacity building and institutional strengthening takes place. Education and activities to enhance awareness should be held for decision makers, technical experts, stakeholders, the general public, students and school children. It is necessary to organize periodically information campaigns, distribute informative leaflets and other materials at national, regional and local level and to use the media to inform and educate the society. Periodic review of the level of public awareness on the climate change is important to increase public participation in the GHGs mitigation activities. The options for informal education in the field of environmental protection include use of mass media (newspapers, television, radio) and organization of conferences and workshops for specialists, the general public and the press.

4.1.1. *Adaptation Strategy*

Sustainable development depends on close links between the environment and the economy. A significant portion of the economic activity has always targeted on natural resources such as pasture, animal husbandry, arable land and water resources. Today, Mongolia faces not only with the same problems in developing countries caused by the global climate change, but also has a specific concerns which raised from features of Mongolia's geographical and climatic conditions. For instance, melting of permafrost area, which covers more than 60 per cent of the territory of Mongolia, caused by global warming will effect very adversely on agriculture practices, water resources and infrastructure development like bridge and road constructions, buildings, etc. In addition, climate change would effect seriously on ecosystem, natural grassland, arable farming, pasture animal husbandry, water resources and soil quality. Therefore, adaptation problem will be a high priority concern rather than GHG mitigation problem for Mongolia.

In the immediateterm, but however government should have a more balanced approach in the long form for both strategies.

Even though, throughout the history, Mongolia agricultural activities such as animal husbandry and arable land development have adapted continuously to the risks associated with climate variability, the climate change requires the government efforts to increase the diversity of crops and innovate the technologies. Due to geographical shift in the agricultural land base, pasture availability and arable land development could be changed, and some farmers may benefit locally improved yields while others might suffer from high investment to adjust farming to climate change. Also, the climate change may raise the competition for water in water limited region which may affect the welfare of people. Therefore, government strategy for implementation of the adaptation measures in agriculture and water resource sectors should focus on the following main aspects:

(i) Education and awareness campaigns between the decision makers, agriculture people and public

(ii) Technology and information transfer to farmers and herdsmen;

(iii) Research and technology to ensure the agricultural development that could successfully deal with various environmental problems in the 21st Century;

(iv) Management measures by coordinating information of research, inventory and monitoring.

There are still many uncertainties in direct and indirect effects of climate change on natural resource base and agriculture components, in evaluation and development adaptation options, and in adaptation technologies. Adaptation technologies usually require large initial investments. At the same time, the final results and benefits of any adaptation measures cannot be getting immediately. It will require a long time and great efforts.

Above identified adaptation options will have significant benefit even climate does not change as predicted. Moreover, assessing the preference among these options in different sector is complicated task for policy/decision makers since there are multiple problems and objectives to be solved and meet. Therefore, a simple approach a *Screening Matrix* of adaptation option was used to examining the priority of measures. Selected adaptation options are assessed with certain criteria that are more desirable to indicate the conditions of adaptation options. Adaptation options are qualitatively ranked as high, medium and low against the criteria to indicate the preference. Low cost and low barrier are easier to implement. This screening is purely subjective and is not based on specific models such as integrated or economic, or certain quantitative analysis of the efficacy of adaptation options.

In general, adaptation options as (1) change in fertilizer amount, (2) education and increase of awareness of herdsmen and (3) conservation of natural water resources have high priority, more effectiveness and beneficial and easier to implement in terms of cost and barrier. Population control of animals according to pasture availability and river run-off regulation work appeared most difficult to implement having high cost and social barrier.

Further identifying adaptation strategies that could provide economic, social, technical and environmental sustainability and minimize uncertainties require continues study that includes a broad and comprehensive research agenda to develop the understanding of the climate system needed for effective decision making on climate change issues.

4.1.2. *Mitigation Strategy*

Although, the total emission of GHG is relatively small, Mongolia has developed its strategy and policy to abate GHG emission. The GHG mitigation measures are not only important to mitigate GHG emissions, but also these are necessary to improve efficiency of energy and heat use and introduce environmentally sound technologies in the sectors that are major GHG emitters.

The greenhouse gas mitigation policies should focus on:

(a) *Institutional integration:* As stated before the energy sector is the main source of GHG Emissions and energy problems are becoming increasingly complex and will require intersectoral coordination for comprehensive implementation of GHG mitigation policies. Responsibilities for policymaking and implementation of energy related issues are belonging to Ministry of Mineral Resources and Energy. But the leading organization in GHG mitigation policies is the Ministry for Nature, Environment and Tourism (MNET). It is important to make clear coordination between the ministries and responsible organizations to formulate GHG Mitigation policies and implement GHG Mitigation projects.

(b) *Prioritize funding:* The implementation of mitigation measures will require high levels investment. Since Mongolia is constrained by many economic problems, it is essential that funds will be more clearly prioritized at the national planning level, and that resources be allocated according to economic and technical criteria. In particular, resources should be allocated in such a way that funding is transferred directly to the acting organizations. Cooperating organizations should also be allocated some share of the funding.

(c) *Provide legislative base:* In order to assume the role of promoter and facilitator, the government should define the legislative and administrative frameworks.

Implementation of GHG mitigation projects usually requires a large initial investment in expensive, modern technologies. Certain economic and policy mechanisms will be critical for the implementation of mitigation options. One of the economic mechanisms could be the use of taxes, tax incentives, and subsidies to overcome the barrier of high investment costs. In this way, more efficient technologies, a less carbon intensive energy source, and better resource management practices may be implemented. The use of tax incentives in particular could be focused on the importation, purchase and leasing of energy-efficient equipment. Moreover, subsidies will be needed to fund activities such as:

- research and development of new technologies;
- provision of low interest loans;
- rebates for the purchase of energy efficient equipment;
- development of public education.

The mechanisms for developing a regulatory base should focus on:

- development of new regulations for energy efficiency standards and natural resource management practices;
- improved enforcement of existing regulations.

The technology procurement initiative is an important strategy to support the development of improvement of energy efficiency in energy supply and end-use sectors. Public education and close cooperation/communication of suppliers with users is a critical element in the implementation of GHG mitigation options in the residential and commercial building sector. This can be achieved by developing a wide range of educational tools, such as equipment efficiency labeling, informational booklets for homeowners and radio/television advertisements.

In addition to the extension of a country's national power grid, broad development of small-scale hydropower projects and a small wind and Photovoltaic (PV) Solar System will not only be important for the implementation of mitigation options, but also for the sustainable development in rural area. The main Policy Guidelines & Programs in energy sector related to GHG Mitigation policies are:

– Renewable Energy Law" approved in 2007
– Coal Program
– Mongolia Integrated Power System (MIPS)
– Mongolia Sustainable Energy Sector Development Strategy Plan (2002-2010)
– Mongolia National Renewable Energy Program approved in June 2005
– Liquefied petroleum gas (LPG) Program

4.2. The Millennium Development Goals-based Comprehensive National Development Strategy

The Millennium Development Goals-based Comprehensive National Development Strategy of Mongolia (MDGs-based CNDS) was approved by the Great Khural (Parliament) of Mongolia on 12 February 2008. MDGs-based CNDS defines in a comprehensive manner its policy for the next fourteen (up to 2021) years aimed at promoting human development in Mongolia, in a humane, civil, and democratic society, and developing intensively the country's economy, society, science, technology, culture and civilization in strict compliance with global and regional development trends.

The strategy identified six priority areas of development of Mongolia, of which the Priority Area 5 says that *"to create a sustainable environment for development by promoting capacities and measures on adaptation to climate change, halting imbalances in the country's ecosystems and protecting them*". In the Strategic objective 6 titled "*Promote capacity to adapt to climate change and desertification, to reduce their negative impacts*" of this priority area, the climate change adaptation activities and measures were identified.

These are:

- Undertake a science-based assessment of climate change effects and define their prospects, and implement a policy in line with the concept of sustainable development.
- Assess areas affected or are at the risk of being affected by drought and erosion due to environmental degradation and climate change, define their prospects, and enhance the capacity to adapt to the peculiarities of those areas.
- Choose and cultivate those sorts of grain, potato and vegetables, fodder plants which are sturdy and capable to adapt to environmental and climate change, develop new sorts, and introduce advanced methods and technology in crop-farming.
- Develop and implement a policy with regard to regulating the population and structure of livestock in accordance with pastures' capacity.
- Develop in combination both nomadic and intensive animal husbandries capable to adapt to environmental and climate change, which would be more productive and with good biological capability.

Increase public participation in the activities related to climate change and desertification, to defining and introducing adaptation measures, means to cope with climate change, to reducing their adverse impacts, expand the work on providing to the public related knowledge and information.

4.3. Other Climate Change Policy and Strategies

The Government of Mongolia has taken several steps to deal with environmental and natural resource issues. However, there is still no law or any regulation mechanism addressing climate change related problems. Some of the existing laws and regulations, especially the environmental protection laws, directly or indirectly relate to emissions of pollutants, including GHGs. One of the options for the allocation of GHGs emission limits among relevant sources and sectors is the introduction of emission permits. The allocation should be based on the inventories of the current emissions of the production units and on the assessment of GHGs mitigation potential.

Since 1992, the Parliament of Mongolia has passed several laws directed toward environmental protection including the State Policy on the Environment (1997), which forms the legal basis for the protection of the environment and Mongolia's natural resources. In 1995, the Mongolian Environmental Action Plan was presented. The plan of action outlines the country's priorities for environment and resource management. The Mongolian Action Programme for the 21st Century (MAP 21), the National Action Plan to Combat Desertification, the National Biodiversity Action Plan, the Action Programme to Protect Air, the National Action Programme to Protect Ozone Layer were developed. Especially, the MAP 21 includes concrete considerations and recommendations related to adaptation to climate change and mitigation of GHGs emissions. The Law on Air (1995) and Law on Environmental Protection (1995, 2007) are the main legal instruments for protection of air and environment of the country.

These policy documents should provide an environment for compliance with the goals of the NAPCC. However, in order to implement the adaptation to climate change and GHGs emission reduction measures, the establishment of special regulations or rules related to climate change response measures, especially GHGs mitigation measures, is required. In addition, national policies and strategies to mitigate GHGs emissions and to adapt to climate change should be reflected in the laws and other legal instruments which relate to the development of relevant economic sectors such as energy, coal mining, agriculture, industry, transport, infrastructure, etc.

Recently, The Ministry of Health of Mongolia implemented a project on “Climate Change and Human Health” with assistance of the World Health Organization. Within this project, a National Adaptation Strategy of the Health Sector was initiated.

At the moment, the legal environment for sustainable development is on the formation stage. The requirements for sustainable development will serve as a basis for the design and the implementation of laws that deal with the relations between nature, environment, society, and economy. In order to improve the legal structure for sustainable development, it is necessary to integrate and coordinate the environmental laws and sectoral action programmes and plans. In addition to passing new laws and amending existing environmental laws, other related laws need to be amended for certain sectors, particularly laws regulating different socioeconomic relations.

4.4. Institutional Arrangements

The implementation of the NAPCC requires a close coordination of policies for various sectors. Problems in Mongolia seem more or less recognized on sector levels, and they are being addressed to certain extent. However, there is a weak coordination of sectoral actions and the responsibilities are not clearly distinguished between sectors. Responsibilities for policy formulation and implementation are usually dispersed among several ministries and agencies such as agriculture, energy, local and provincial authorities. However climate change issues should be managed as a unity rather than sectoral. Integration does not mean that all responsibilities must be centralized, but that the responsibilities of all necessary activities are clarified and made explicit to all institutes and authorities involved. The implementation of the identified measures also requires good coordination among ministries and agencies. Other important issues are financial assistance and evaluation of achieved results.

The Government has established the inter-disciplinary and inter-sectoral *National Climate Committee (NCC)* led by the Minister for Nature, Environment and Tourism to coordinate and guide of national activities and measures aimed to adapt to climate change and to mitigate GHG emissions. High level officials such as Deputy Ministers, State Secretaries and Director-Generals of the main Departments of all related ministries, agencies and other key officials are members of the NCC. The NCC approves the country’s climate policies and programmes, evaluates projects and contributes to the guidance to these activities. In order to carry out day to day activities related to implementations of responsibilities and commitments under the UNFCCC and Kyoto Protocol as well as of the NCC, and to manage the nationwide activities, and to bring into actions/integration of climate change related problems in various sectors, the *Climate Change Office (CCO*) under the supervision of the Chairman of the NCC is planned to be established.

The responsible organizations for climate change measures and actions are the Ministry of Nature, Environment and Tourism (MNET), the Ministry of Mineral Resources and Energy (MMRE), the Ministry of Food, Agriculture and Light Industry and the Ministry of Foreign Affairs and Trade. The National Agency for Meteorology, Hydrology and Environment Monitoring, which is directly under the supervision of the Minister for Nature, Environment and Tourism, has been designated as an operational organization for climate monitoring and research

The Ministry of Mineral Resources and Energy and other relevant Ministries and agencies are responsible for the implementation of GHGs mitigation measures, improving the efficiency in the energy sector, and for proper operation and maintenance of the station and the distribution network. The mitigation measures have to be taken in power and heat generation, mining, building and construction and transport. The ministry and its central and local units also provide free or low-cost energy audits of buildings and production processes, and give advice for measures to reduce energy demand. In addition, these ministries and organizations should provide technical and expert support to projects and measures for waste utilization, the introduction of renewable energy and energy savings in the transport sector. The Ministry of Construction, Transport and Cities Development also is responsible for the prevention of damage to buildings, roads, bridges and other constructions by permafrost melting.

The Ministry of Food, Agriculture and Light Industry (MFALI) is responsible for the implementation of measures and projects to mitigate GHGs emissions from the industrial sector, and for measures to adapt to climate change in arable farming, animal husbandry, water resources and others.

Other government institutions, NGOs, the private sector, academic and education institutions should be involved in planning as well as in implementation activities. The responsibilities and involvement of a specific stakeholder would be different according to the options to be implemented. However their participation is essential. All relevant ministries, agencies, institutions, NGOs, and the private sector should also integrate the climate change concerns and problems into their planning and activities.

Since much of the actual implementation must be carried out at the local level of the farmers, herdsmen or communities, it is important that feasible and workable instruments are brought into action to influence local habits and traditions. Moreover, the knowledge and experience of herdsmen and farmers should be mobilized to get optimal results. It is important that national objectives and policies should be perceived as beneficial by the end users. Therefore, local communities must be involved at the earliest stage of planning possible to ensure their commitments. Monitoring of the implementation of the NAPCC at the local levels should be carried out by the local agencies of the Ministry of Nature, Environment and Tourism, the Centres of Meteorology, Hydrology and Environment Monitoring and the Local Governor’s Offices.

4.5. Integration Measures with Other Related Programmes and Plans

The NAPCC and the MDGs-based NDS is developed as an integral part of other national and sectoral action plans and policy documents. Therefore, the success of the measures and actions identified in the NAPCC will depend directly on the level of integration with these national and sectoral development and action documents. Climate change concerns and problems are not reflected directly in these policy documents. However, some of them include climate change matters. In case of absence of such climate change related issues in a policy document, these issues should be taken into account in implementing activities under these programmes or plans. Existing environmental regulations, sectoral development policy documents and other related laws need to be amended if this is required for adaptation or mitigation actions.

Passing new laws or amending existing laws, particularly policy or development programmes or plans guiding different economic sectors, and the development of an improved strategy document should follow national and sectoral strategies and policies related to climate change concerns.

5 Adaptation Strategies to Climate Change

5. ADAPTATION STRATEGIES TO CLIMATE CHANGE

Social and economic development of the country goes in harmony with its nature and climate. A minor change in climate severely impacts daily routine and causes the decline of industrial effeciency. Also, climate plays a leading role in the natural ecosystem. Climate change alters the water resources, soil fertility, plants and animal species. Mongolian pastoral animal husbandry has adapted to its environment and climate for hundreds of years.

The climate of our planet, including our subregion, has changed more recently than in the previous 2000 years. All these changes are induced by human activities. Now it is getting obvious that the world's climate will be changing in the next 10 years. Many experts believe that these changes will be greater than human civilization has ever experienced before. These climate and environmental changes in Mongolia will have an adverse affect on our lives. Now, we are facing challenges to provide sustainable development. This includes developing pastoral animal husbandry and agriculture effectively with an inadequate water supply in this changing situation.

The developing countries are committed to finding solutions to preserving sensitive ecosystems during this climate change. It is certain that any living thing cannot adapt to such an intensified change by its natural adaptive capacity. In the new millennium, we must develop social and economic systems that can adapt to climate-environmental change.

Mongolia is considered quite vulnerable to the climate change because of its geographical location and its traditional socio-economic systems. So, it is essential to include the current and anticipated changes and its' impacts while formulating long term national development concepts. Unless we change our strategy on land utility, animal husbandry and agricultural technology, the conventional methods and obsolete technologies used in 1960, 1970 we will be even more adversely affected.

5.1. Needs to Adapt to Climate Change

The total impact of climate change depends upon various features of the country including culture, geography, social and economic systems. To mitigate the impact of climate change, we must form a national plan. We must also evaluate the impact on our natural resources and economic system.

***Adaptation to climate change**: Adaptation to climate change refers to adjustments in natural or human systems to actual or expected climatic effects. This moderates harm and exploits beneficial opportunities. Adaptation can be distinguished as anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.*

***Policy on adoptation to climate change:** Adaptation policy on climate change refers to the activities taken by government in order to restrict and facilitate the vulnerability to climate change, its' fluctuation, extreme incedents, to lessen likelyhood of getting hit by such incedents through making legislative regulation, promotion and coordination.*

***Adaptation capacity:** Adaptation capacity refers to the systamatic ability to combat actual damages, to exploit beneficial opportunities and to resist expected damages occurred due to climate change.*

Currently Mongolia is facing the same climate change challenges that developing countries are facing along with the issues derived from its' geographical and environmental peculiarities. For instance, the melting of permafrost covered 60 percent of the territory, could be a quite negative impact on infrustracture, specifically on construction and agriculture. Also, climate change will affect on natural resources, animal husbandry, pastureland, agriculture and other socio-economic sectors adversely. Sustainable development of the country depends largely on how good the correlation between the activities taken on environment and economy. A good deal of the economy depends on the natural resources such as pastureland, animal husbandry and water resourses. It is stated in the UN Framework Convention on Climate change that: "Formulate, implement, publish and regularly update national and, where appropriate, regional programs containing measures to mitigate measures to facilitate adequate adaptation to climate change is essential".

To Mongolia, a country which is very sensitive to even a minor change in climate, the formulation and implementation of the policy on adaptation to climate change is not the only accomplishment of its obligation under the UN Framework Convention, but also the way to provide sustainable development of the country. It has been assessed (by Batima.P and others. 2005 and Batjargal. Z and others, 2000) the measurements to reduce adverse affects produced by climate change based on the estimation result of climate change impacts on environmental and economic sectors. It is not enough just to start such deals, but also it is necessary to keep continueing it updating and reviewing such activities coherently with climate and socio-economic development.

5.2. Adaptation Options and Measures

5.2.1. *Land degradation, desertification and decrease of land fertility*

Due to almost the whole territory of Mongolia being included in arid and semi-arid zone; desertification and land degradation could be assessed as to have fully encompassed Mongolia. We are addressing here land deterioration as the general concept, land degradation as the decline of soil fertility and desertification as grassland decrease, its scarcity and the process of grassland becoming sandy. The survey has identified that desertification encompasses the whole territory of the country. The least precipitation of a year occurs in May with 15-20 percent on a daytime in the semi desert steppe zone. Geomorpholigically active wind of 15 m/second and above occur 30-70 days in a year, of which 30-60 percent occur in March and 18.5 percent in autumn in semi desert and desert areas. Because of this situation, land stays without any plant cover around the year and stay almost barren. The length of time between defrosting of the soil and growing of the plant is long; hence, the surface of the land is being blown by the wind for a big portion of the year. This is aggravated if the land has thin or no snow cover at all, is arid, and exposed to strong winds. All these factors contribute to enhance land degradation.. The actions on adaptation to and mitigation of climate change can be carried out through the management improvement of land utility. For instance, because the vertical straws play important role in protection of soil from the adverse effects by wind and water, straws should stay intact. Also planting strip forest, frutescent and perennials help create vegetative coverage on the surface of the land.

Besides, the above mentioned measures, it important to implement the following activities in the first run.

1. Formulating legislative baseline to improve the utilization of pasture land based on the traditional pastoral animal husbandry.

2. Providing appropriate balance of grassland utility and agricultural management.
3. Building a water supply network and irrigation system
4. Improving road
5. Protecting and conserving saxaul and other forests and planting frutescent and perennials in the degraded land and arid land area.
6. Keeping traditional methods to protect nature and educating people on climate change

The first step towards the restoration of soil fertility is the creation of vegetative coverage on soil surface. After that, it needs to increase humus level by accumulating organic substances in it. In different places of the world, the only way used to restore soil fertility is enhancement of organic substances in the soil. The method to enhance organic substances is varied depending on the features of environment and climate. According to the survey in the central agricultural zone conducted by the Institute of Botany and Agriculture (by E. Otgonbaatar, 1991-1994), the “prior to” is the major incentive to increase the level of organic substance residues in soil, particularly leguminous plants are remarkably useful because of its rich green mass and capacity to increase nitrogen in soil by bulb bacteria multiplication. It plays a role both nitrogen and organic fertilizer in Mongolian brown soil, known as the lack of nitrogen. As an example, the level of nitrogen and humus in soil has increased after planting Lucerne on the arable of Boroo, in Zuunkharaa, for 3 years, which was considered infertile and out of use. (Dorj, 1999)

5.2.2. *Natural disasters and communicable diseases*

Asia, specifically Central Asia and Mongolia is considered the most susceptible to natural disasters considering the number of people who suffered from the occurrence of natural calamities. Due to climate change, the recurrence and scale of natural disasters are expanding in Mongolia. For instance, because of the decline of spring precipitation percentage by 17 percent in last 60 years, the occurrence of forest and steppe fire and its’ recurrence has increased tremendously. The damage of the fires is estimated by billions of MNT, excluding the environmental and human losses. There is a likelihood that the occurrence of steppe fire depends on the intensification of Al Nino or Southern fluctuation. So, it is vital to improve respondence capacity of government, government institutions and public towards hazards and preventive systems of natural disasters such as drought, zud (natural disaster caused by excessive snow), snow storm and flood and prognostic methods systematicly. Also, scientific approach has to be used in developing prognostic methods and assessing preferable instrument to evaluate and estimate climate change in Mongolia. It is of particular importance to decide whether 60 years of observation period or some other time factors will be appropriate in the prognosis, in anticipation of climate changing sharply and with some extreme hazards already expected to increase in the near future.

In some Asian countries, contagious diseases that spread through the wind are the main reasons of death and sickness. Also, variety of parasites, rodents and bats are the transmitters of diseases. The expansion and growth capacity of these animals are ranging. For instance, the fluctuation of the number and growth of field mouse in Mongolia, that destroy the pasture land hugely, could be mentioned. As for Mongolia, the diseases spread through the food are the main problem. Climate change aggravates the eruption and expansion of these transmitted diseases in direct or indirect way.

Mentioning some measures should be taken to prevent and to reduce the risk of expansion of communicable diseases and natural disasters are:

1. Undertaking a survey promptly regarding the influence of climate change on public and environmental health and making an evaluation on it, an activity which has never been undertaken in Mongolia before
2. Modifying and strengthening preventive and rescuing capacity of national meteorological and combating institutions against natural disasters.
3. Researching the area with high risks of forest and steppe fires and making a full evaluation on it and initiating the activities on educating public.
4. Modifying the preventive, protective and forecasting system of flood
5. Expanding the number of health organizations responsible for prevention of human and animal communicable diseases.

5.2.3. *Animal Husbandry*

Pastoral animal husbandry has adapted to climate change and its risks for centuries but the survey result reveals that climate change is accelerating so it is essential to take actions on future improvement of animal husbandry in correlation with climate change.

One of the key concerns in providing sustainable development of the country is the reduction and mitigation of negative impacts of climate change observed during the last 60 years on pastoral livestock sector. Animal husbandry adapts to environment and climate change through the biological adaptive ability of livestolk itself and is regulated by human creative activity with particular purpose. The half of the Mongolian population who live in the countryside and whose main source of livelihood is animal husbandry, are also those who provide food and fiber to the other half. Animal husbandry and its growth is assessed by the effectiveness of activities on food safety, rural development and well being of herdsmen and livestock, which are all tied and inseparable. So, it is necessary to consider these factors when formulating development strategies and methods of adaptation to climate change. To lessen the impacts of climate change is not being reached to the level that the current survey shows some vital adaptation measures to provide sustainable development of animal husbandry are have to be taken. Some measures are mentioned below:

A. *Regulatory and utilization measures regarding to pastureland*:
   - Improving pastureland management
   - Precipitating cultivated pastureland
   - Emerging brand new breeds of plants persistent to droughts and pests
   - Vegetating pasturelands
   - Improving pastureland irrigation system
   - Enhancing production and preparation of fertilizer
   - Legislating ownership of pastureland
   - Balancing the heads of livestock with pasture land capacity

B. *Methods of looking after and herding the livestocks:*
   - Improving the quality of bio-capacity of livestocks
   - Modifying hibernation and spring settlements for livestock
   - Expanding research and experiment on livestock effeciency
   - Enhancing artificial insemination techniques
   - Stabilizing the operation of veterinary
   - Preparing and training agricultural managers
   - Organizing variaty of trainings (online, local, abroad, specialization and etc.)

C. Improvement of livelihood of herdsmen:

- Introducing the technologies for processing the products of livestocks
- Maintaining household and partnership based industry
- Developing agriculture and animal husbandry in parallel
- Encouraging initiatives by herdsmen to run a farm
- Supplying herdsmen with renewable energy
- Maintaining the small and medium sized industry in countryside
- Improving commucation system in the countryside
- Improving the structure of livestock insurance
- Increasing export of meat and products from meat

D. Urban food supply:

- Expanding milk farms in urban area
- Expanding meat farms in urban area
- Expanding other auxiliary farms /swine, chicken, grocery etc.

One of the negative impacts caused by climate change is the animal weight decline and this issue should receive an attention. According to the survey it is obvious that the change in biomass of pastoral plants is the one factor that influences the worsening of livestock living condition.

One of the main issues of pastureland management is adjustment of the number of livestock heads and the component of cattle to pasture capacity. Implementing a policy on efficiency enhancement of pastureland and improvement of economic capacity is the more reasonable way of management. This approach should be consistent with the government policy and it is likely to be supported by herdsmen too, because they know the hardships of drought and zud.

The baseline of state policy on pasture land management is to establish a network of pasture land management. Its main contents are:

- providing legal basis and policy guidelines for more efficient pasture land management and relationship
- using pastureland properly
- preventing and protecting pastureland from negative effects caused by human induced activities and environment
- establishing monitoring network of pastureland evaluation, condition and classification
- imposing charges on pastureland use
- restoring degraded pasture lands

The first steps to implementing all these are by making the map on and an evaluation of degraded pasture lands by each provincial unit, developing the methods on improvement of degraded land and use of wild land, saving genes and enriching genetic fund of plants through the invention of new breed of plants most suited to the soil features.

So far, the best strategy to implement pasture land management policy is to run animal husbandry by traditional ways of choosing pasture land adjusted to each season and animal type. Somehow, there is a contradiction between the new trend of development and the traditional method of using pastoral resource. It is imperative to preserve the pasture land through the investment made by herdsmen themselves by increasing their awareness about the importance of pasture land, because pasture belongs to the state but the livestock is private.

Herders are concerned about the elimination and protection of livestock from parasites and diseases and the fund treatments for it. However, they have neglected the issue of preservation of pasture and enhancement of its capacity because they are not aware of or interested in how much amount of forage and fodder are eaten by their cattle from the pasture. The investment by herders could be made in 2 ways: a) *vegetation* of pasture; and b) *creation* (cultivation) of pasture. The efficiency of both methods depends on how good herders' ownership of pasture is guaranteed. There is a promising future if the herders make investment in pasture land cooperatively.

According to the theory "the tragedy of public ownership", the management of pasture land can improve only in the case of privatization. Up until now the ownership of pasture in Mongolia is determined by provincial boundary, but it doesn't mean that the issue of pasture land ownership is resolved. At present there are arguments and debates over the pasture land ownership rights and use in the countryside. Due to the increase of the number of herders 2.6 times and reached 554 thousand since 1989, it became and still is a challenge for new herders to obtain the land for winter stay. People who used the pasture during the socialist regime and privatized it later consider themselves the owners of the pasture, while others claim themselves the owners because their ancestors lived there before. Herdsmen with no hibernation or place to spend the winter, resolve this through the connection of relatives and social interaction. If pasture land ownership is affirmed and guaranteed legally, it makes possible for herders to unite and resolve the problems pertaining protection, improvement and usage of pasture land interchangeably, building cattle pen and stockyards on it and dig wells collaboratively.

Pasture degradation could be prevented through tax policy and using it in a reasonable way. Tax policy could be used as an incentive procedure that lessens the overload of pasture land near concentrated places and main roads through imposing more tax on, and not depending on the number of livestock heads per household or reducing the tax on livestock in isolated places not depending on the number of livestock per household. In the same manner, building of irrigation system and roads and providing assistance to improve the capacity of pasture land could be encouraged along with some form of tax incentives.

Sustainable development of animal husbandry of our country has been dependent largely on pastureland along with fodder supply. Producing more fodders and forages is the one way to adapt to climat change that causes animal weight decline and the reduction of pastureland harvest, the trend is expected to continue in the future.

Another main factor that causes pastureland degradation is water supply in countryside. Mongolia has a substantial source of ground and hypogene water. Gross water scale is 34.6 sq.km per year, which is ranked above the world average for water scale per person. There are more than 4,000 rivers and springs with total length of 67.000 km. (Surface water of Mongolia, 2000) in Mongolia and it enables to use 30 percent of pastureland in warm seasons, but irregular and inadequate locations make it hard to be used with its full effeciency. Water network is tight in mountainous region, but there are few rivers and not enough water resources in southern and southeastern part of the country. For centuries, Mongolians have been herding cattles alongside with rivers and ground water keeping a balance not overgrazing pastureland capacity.

Due to ground water scarcity and not expedient locations of wells, there are 10.7 million abandoned and unused hectares of pastureland. The most parts of it are in Khalkh Gol, South Gobi, Bayankhongor and Gobi-Altai provinces and southern part of Khovd province inward from the national border and isolated from the municipal administration. 50 percent of pastureland resources in Dornod province is not used and this is involved with water supply in a direct and indirect way. Because of wrong locations of the wells isolated from the must-be-used pastureland, some pasturelands are crowded with cattles and people in warm seasons and this impacts negatively on pastureland proficiency. In some places, where there is a poor management , oasis /water point/ itself turns out to be a reason of pastureland degredation. In other words, following the enhancement of water points and wells there emerge concentration of cattle and people and it causes the grassland become barren.

There is no doubt that if the lands with pasture resources are made usable through irrigation, building stockyards and cattlepen on it and reserving fodder and forages, this would contribute to stabilizing pastureland utility. In the southern part of the country, where there is a scarcity of pastureland, pasturelands are located in the middle of the provincial borders and are not used at all or used only in the year when there is a snow mantle. So, the exploration and development of pasture land resources should be focused on such area.

Since herders are not able to repair and maintain the wells themselves due to the lack of fund, it is necessary to provide herdsmen with portable, compact, small-sized, electricity and fuel efficient and easy to assemble water generators. One version to encourage herdsmen and individual's contribution into repairing and maintaining water points could be by letting them privatize water points by making affordable to them a long-term preferential loan. /Lkhagvadorj, 2002/ Introducing the mechanism of expense-sharing into livestock water supply is helpful to increase the effeciency of state budget expenditure and to encourage herdsmen to dig wells.

There are 210 countries in the world, of which 10 percent are developed, 30 percent is developing and 60 percent is underdeveloped nations. The most of the countries with pastureland of which 40 percent is agricultural land are underdeveloped. This means the key sector in their economy is non intensified animal husbandry.

In the new millenium and in the era of globalization and climate change, the new technology needs to be introduced into the animal husbandry sector to make it independent from environment and weather through renovation and improvement of conventional methods. Today, all states acknowledging and realize that it is impossible to provide sustainable development without providing a correlation of economic acceleration, human growth and natural resource utility. Mongolia has formulated and implemented sustainable development policy as the milestone of the state development conception.

It has formulated the base of settled and half-settled farming system in Mongolia which requires that the nomadic animal husbandry to be transformed into intensified animal husbandry. In the transition period into the market economy, assessing the future development approaches on animal husbandry is essential. Scientists and researchers consider the option to continue nomadic practice in animal husbandry in the countryside, but at the same propose that improved farming systems could be better employed in nearby populated centers.

Intensifying animal husbandry and "improving intensified animal husbandry" are basically implying the same meaning, but these two are differentiated by the means of realization. Intensification of animal husbandry refers to the increase of income enchancing the productivity of per livestock and alleviating expences on per head. However, improvement of intensified animal husbandry refers to the development of the more fertile and efficient animals and running animal husbandry based on intensified farming system independent from environment. In terms of that, farming system had already been introduced successfully into Mongolia resulting with the quality improvement of livestock and culturing of new breeds with high proficiency. Nevertheless, this type of system was largely dependent on state subsidy and external market development. However, the highly subsidized system is no longer fit in the free market economy. So, it is important to make a plan coherent with realistic view taken on intensive farming system corresponding to the current development trend.

In livestock breeding, we should use the method of short run efficiency. For instance, artificial insemination gives an opportunity to fertilize cattle and increase the number of heads with high quality in short term, thus improving the quality of cattle. This method is used widely throughout the world. Specially, artificial insemination is used in the sheep, cow, and swine farms as the main fertilizing method. According to the statistics, 100 million cow, ewe and sow are fertilized by artificial copulation and Dutch uses artificial copulation by 100 percent, Czech and Germany 80-90 percent and Japan and Netherlands 60-75 percent in copulating animals. The artificial copulation is the new trend and biotechnological approach used in animal husbandry

One of the ways to improve adaptation capacity of pastureland to climate change is to invent the new breed of fodder plants resistant to drought, cold, pests and diseases, to restore degraded land and to create cultivated pastureland. The invention of new breed of plant requires 12-15 years using conventional method, but it could be shorten 2-3 times using bio-engineering methods. Now there are only few new brands. The actions taken on the plantation of drought resistant wild floras are extremely insufficient and the creation of genetic fund and the issues concerning crop farming is stayed unresolved. There are around 2,000 breed gene samples of floras in the national genetic fund which is unsatisfactory.

No action is undertaken on improvement of regional pasture land. Therefore, the old technologies used now don't meet the requirements of climate change. The current and urgent priorities of scientific and government institutions are the building of adaptation capacity through the invention and cultivation of new breed of floras resistant to expected climate change, the creation of cultivated pastures and an introduction of new technology of restoring degraded lands.

For the last decade or since when herders privatized livestock there has been no progress in methods to utilize and improve pasture land and preparing fodder. The inept ones stayed without any livestock and now there is new terminology "poverty in countryside".

Both methods, improving livelihoods of herders through increasing the number of heads of livestock or "going through stream" are improper strategies. However, it is getting obvious from the projects and programs on pastoral and agricultural sector implemented by various international organizations that the procedures like encouraging herders to work collaboratively on family, group, relatives or provincial partnership basis or formulating development conception on providing sustainable growth of each herders' household are the more efficient approaches with proven successes.

Now there has been implemented many projects by variety of foreign organizations, funds and individuals aid on environmental and rural development in Mongolia. This is a very positive sign that the majority of the projects are targeted on the improvement of pasture land management and water supply. However, poor correlation, coincidence or repetition of activities result the low efficiency. Improving correlation between projects helps to spend state budget on the most needed sectors and project funds more efficiently.

5.2.4. *Agriculture*

Climate change impact will cause the noticeable reduction in the crop yield of the central region. So, adaptation to and prevention measures of climate change must be taken at agricultural sector level as well as the national with immediate start.

First of all, training and educating public and the people in the agricultural sector on climate change adaptation and mitigation measures are essential. Research on agriculture and animal husbandry should focus on the development of new varities of crops resistant to climate change. Possible counter actions to overcome climate change negative impacts should be the prior adaptation methods. Agricultural adaptation methods are mainly addressed to the state and private farming entities.

Reflecting the issues of adaptation to climate change on the national economic growth policy makes actions possible. The actions are to be taken at the national level on mitigating and reducing climate change impacts are:

- To plant perennials in abandoned crop fields unused since 1990. These, crops can absorb more CO_2, which is helpful to balance the reduction of minerals in crops due to climate change, particularly soil degradation
- To, process and convert dung, manure and wastes from swine and cow farms into organic fertilizer could be the one of the solutions. Due to climate change, it is anticipated the decrease of mineral substances in soil.
- To carry out research on planting wheat in winters
- To improve agricultural industry through establishing agricultural research institution focused on upgrading grain variety, agro chemistry, sowing, technology, agricultural equipments, marketing, pests and diseases;
- To improve the structure of information exchange between local and international agricultural institutions and farmers
- To modify infrastructure using market economy leverages
- To legislate land utility and land ownership
- To improve agricultural management
- To train farmers and cultivators on climate change
- To complete a project on developing irrigated agricultural system and replicate.

The measures that should be taken for farmers and entrepreneurs are described below.

Sowing period: The base of sowing period is determined by the favorable date to plant seeds. Considering the precipitation in July is the major factor for ripping cultivated plants, specifically wheat grain in Mongolia, sowing should be done as the precipitation season and seed sprouting period is coincided. In agricultural regions of the country, the spring sowing of wheat and potato are usually done in the first 10 days of May annually. However, due to the global warming, the season of sowing is likely to be altered and there should be carry out research and experimentation on early sowing. As research result shows, the most favorable time for sowing is 15-20 days ahead of the conventional sowing term. Hence, it should be done thorough calculation on it taking into account air temperature and precipitation period, which are leading factors of sowing, growing and ripping process of seed.

In other words, the current sowing system of 1-2 year should be changed into 4-5 year. In the case of sowing the wheat seed once in 2 years it is necessary to renew the seeds each time and fertilize the soil each year. As for potato, it is suitable to sow the potato once in a 2 year. It helps to increase the forage chemicals in soil and to become more fertile.

Changing the variety of seed: In order to improve adaptation capacity of seeds it is necessary to develop the new variety of seeds with adaptable characteristics such as early ripe and resistant to heat and diseases. Also, it is compulsory to start a survey on possibility of planting winter wheat, to assess its efficiency and overall expenses, to prepare qualified specialists and to provide required facilities.

5.2.5. *Water Resources*

Water is not only the component of the nature, but it also plays a leading role in restoration, protection and upgrading of ecosystem. Land utility and other human engaged activities are all regulated by water management. So, the most proper method to adapt to climate change of water sector is the formulation and stabilization of water resource management policy.

As it was mentioned in the previous chapter, land surface water resource tends to be enhanced during the first stage of climate change, however, but there is no sign of enhancement yet whatsoever in these years. This means people still face water scarcity problems. Building of the structures that regulate the flow of rivers and lakes are not only the means of adaptation to climate change but also the solution to the problems pertaining water shortage, overcoming of water scarcity, prevention from flood and so on.

Considering the current water situation and the anticipated impacts of climate change on water, it is necessary to implement the following activities:

A. Regarding to water resources:

1. Protecting head streams of rivers and waters
2. Maintaining to build the structures that regulate water flow adequately
3. Protecting the Khuvsgul lake preserved 96.3 percent of pure water resource of the country
4. Protecting the area of Great Lakes, which plays a leading role in the balance and supply of local water stream which is very sensitive to a minor change of climate
5. Improving the network system of water distribution

B. Regarding urban water supply:

1. Reducing the loss of water distribution and water transmission system
2. Metering industrial and household water utility
3. Introducing the water saving technology into households
4. Harvesting rain water and using it for non-food consumption such as car washing, lawn irrigation and waste removal
5. Maintaining promotional activities on water saving and protection

C. Regarding grassland water supply:

1. Encouraging local people's participation in digging wells, water holes and multiplying the number of irrigation system
2. Building up an oasis network based on the balance of pasture land and heads of livestock
3. Maintaining, equipping and restoring old wells and resolving the issues pertaining ownership of wells
4. Starting the research on possibility of effusing the flux of rivers flowing from the Arctic into steppe

D. Regarding to irrigation system:

1 Introducing water saving technologies such as low-flow showers, drip irrigation and night irrigation

2 Using the breed of seeds persistent to drought and requires less water

3 Improving current irrigation system making it more efficient

4 Improving irrigated soil fertility

5 Imposing a tariff on water

6 Improving the effectiveness of ground water utility

E. Regarding to water quality:
   1. Improving operational activity of water cleaning system
   2. Reusing waste water
   3. Improving control system of water protection and water sanitation
   4. Improving monitoring system of chemical and biological substances in water

F. Regarding socio-economic issues on water:
   1. Educating public with different social backgrounds on water protection and water sanitation methods
   2. Changing public attitude towards water resource, usage and protection
   3. Introducing water cleaning and filtering technology widely
   4. Implementing the policy on providing equality on water use
   5. Completing a thorough research on water circumstances during flood, cloudburst and deluge
   6. Improving methodology to prevent and protect from flood

5.3. Adaptation Mechanisms

5.3.1. *Implementation strategy of adaptation measures*

The current priority is not the issue of if it is necessary to adapt to climate change, but how adapt to. The major part of adaptation is targeted on studies and evaluations on climate change impact including evaluation on climate change impact, its' harm and risks and formulation of methods and measurements to mitigate it. Effecient methods and strategy are needed in the first run in order to implement adaptation policy on climate change. Implementation strategy must include the factors related to legislation, structure, finance, human resource, science and media coherently with other policies and strategies. Also, it is vital to assess subjective and objective impediments to implementation of strategy and to take into the consideration how it is corelated with other socio-economic demands while formulating methodology to overcome or facilitate these impediments.

Sustainable development of Mongolia is largely dependent on beneficient cooperation of environment and economy, while economy is having a great deal with natural resources such as pastureland, animal husbandry, agriculture and natural resource utility. Adaptation technology usually requires a considerable amount of investment at the first. On the other hand, the effeciency of adaptation measurements is not recognized in the short run, it takes tremendous effort and time to have a visible result.

Hence the first of all concerns are the following:

1. Organizing broad activities on climate change among decision making authorities, farmers, the people working in agricultural sector and entire nation such as public awareness campaign and many other kinds of trainings;
2. Providing herders and farmers with information and new technology;
3. Inventing technology and conducting surveys and studies oriented to resolve the issues efficiently and to provide sustainable agricultural development;
4. Taking management actions targeted on providing coherence between surveys, monitoring and information

Except funding, the major factor of successful implementation of adaptation procedures are ability, willingness and concerns of the people involved with realization process. The successful completion is guaranteed only when public participation in the action is provided. The herders, farmers and local communities are the first sectors to benefit from adaptation policy. Also, it is crucial the participation and assistance of experts and specialists in training, fertilization, selection and invention of new breed and irrigation construction. Now it is obvious the importance of taking actions on public awareness of climate change, government willingness to cooperate with NGO-s and public and to be supported by them and providing them with adequate information.

5.3.2. *Research, training and promotional campaign*

There is no socio-economic sector singled out of climate change. The main step towards to adaptation and enhancement of adaptation capacity to climate change is strenghening and intensifying the activities of agricultural and other sectors' research institutions and the capacity building of human resources. It is essential not only to start a study on climate change, its impacts and further attitudes, but also to keep it continueing and scrutinizing each sector and each sector's overall goals.

Climate change related studies and survyes are made by the Institute of Metereology and Weather and are conducted by experts and specialists in the fields of agriculture, animal husbandry, biology, botany, geography and cryopedology. Such surveys and studies are being done only in the framework of particular projects or programs and there is still no state regulation. Since there is not a single sector out of climate change impact, intersectional or sectional surveys should be done in the future. There is a much demand to prepare qualified specialists in each sector who can understand, evaluate adequately climate change as a systematic issue. To expand and intensify the studies on climate change and climate change monitoring, it is necessary to take certain actions on preparation, training and specilizing young researchers by getting them involved in local, international and occupational trainings and seminars, after the degree studies.

5.3.3. *Anticipated impediments to implementation of adaptation measures*

It is necessary to take into the consideration the possible impediments to implementation of adaptation methods. It is certain there will be specific difficulties and impediments while implementing the adaptation measurements depending on the geographical, geophysical and environmental features and the level of socio-economic growth of the country. The most possible impediments and its' ways to overcome are mentioned in the below:

At the organizational and structural level:

The impediments to some sectors are identified and the actions to overcome are being taken. Among the susceptible and vulnerable sectors to climate change, there are still obscurity, misjudgment and lack of practice and full awareness of the danger of actual and anticipated risks of climate change. There is a contradiction between ministries and government agencies due to the lack of interagency operational coherence and human resource, and germination and uncertainty of their responsibilities for adaptation of climate change lead to the loss and reduction of management efficiency.

Implementation of adaptation measurements requires cooperative and regulatory activities by various groups. Decision making and implementation responsibilities regarding to climate change are allocated to only government agencies such as the ministries of agriculture, environment, power energy or municipal administrations and it results in the overall efficiency of these actions. Climate change issues are not only the concerns of one sector or institution; it needs integration and collaboration and definite assessment of responsibility and duty line. It is compulsory to fund and maintain the activities with high efficiency, to formulate the present and future measurements of adaptation, to monitor outcomes and benefits, to improve coherence of government agencies and institutions actions while implementing planned actions.

At the financial level:

Insufficient funding is preventing realization of adaptation measurements. Furthermore, the gap between planning and realization process of the policy, for instance expensive means to implement adaptation measurements would be greater burdens on the realization process. Ssuccessful implementation is dependent on the reliable source of funding. Due to the banking system in Mongolia being weak and there is not enough accumulation in the state budget, it might be more beneficial to attract foreign investments and aids to implement adaptation measurements. To get financial and technical and technological assistance from outside world it must be taken additional activities aimed to broaden a cooperation with international banks and organizations at the national level.

At the social level:

Lack of individual's insightfulness, conventional way of thinking and attitude and information scarcity for the public are all considered as the impediments to realization process and to be overcome. The majority of the actions are taken by the people in the agricultural sector including herdsmen, so all measurements must meet their traditional and ethical requirements and must based on their practical experiences. Hence, consumers should benefit from the policies and strategies implemented at the national level, it is better to make the public involved in the policy or strategy formulating process from the beginning and make them realize their responsibility and role in it. All adaptation measurements can't be carried out at the same time. Overcoming impediments to certain implementation process help us to assess the most suitable means to overcome impediments to another process, thus we can save time, money and effort.

6 Mitigation Strategies to Climate Change

6. MITIGATION STRATEGIES TO CLIMATE CHANGE

6.1. Monitoring Atmospheric GHG

The carbon cycle is the great natural recycler of carbon atoms. Carbon forms the backbone of organic molecules from which all forms of life that we know have been built. In fact, they are micro-organisms that control most of the recycling of carbon and other elements on earth. Because organisms are affected by climate, the latter has an influence on the recycling, while some of the molecules involved in the recycling, such as carbon dioxide and methane, influence the climate through the greenhouse effect.

Very carefully calibrated measurements have confirmed that CO_2 is increasing in the atmosphere and that human activities are the primary cause. The evidence for a dominating human role in the CO_2 increase is extremely strong. The 36% increase in atmospheric CO_2 observed since pre-industrial times cannot be explained by natural causes. About half of this increase occurred in the last three decades. CO_2 levels in the atmosphere have varied naturally throughout the Earth's history. However, CO_2 levels are now higher than any seen in the past 800,000 years **[2]**. When the observed CO_2 increase in the atmosphere is added to the observed increase in the oceans, the sum is approximately equal to all of the coal, oil, and natural gas burned since the 19th century. Finally, the annual mean CO_2 abundance in the northern hemisphere is higher than in the southern hemisphere, and more so in recent years compared to the early years of atmospheric CO_2 measurements. This suggests a growing source of CO_2 in the northern hemisphere, which is in fact where most of the fossil fuel burning takes place. For the year 2006, the estimated global average CO_2 amount was about 381 parts per million (ppm). This gives us a value of about 808 Gton of carbon in the atmosphere. If we include the mass of the two oxygen atoms in each CO_2 molecule, the total mass of CO_2 would be 2960 Gton.

Ice cores have been collected from Antarctica and Greenland which contain information stored in the ice that can be used to reconstruct climates thousands of years ago. As snow accumulates on ice caps and ice sheets where temperatures usually remain below freezing year round, it lays down a record of the environmental conditions at the time of its formation. Over time the snow, buried under further accumulations, is compacted to ice, preserving the climatic information. Air bubbles trapped in the ice can be analyzed to reconstruct the atmospheric composition at the time when the ice formed. Measurements of the amount of GHG in these bubbles show that the "pre-industrial" amount of CO_2 in the atmosphere was about 280 parts per million (ppm), about 100 ppm below the 2006 value. **Figure 6.1** below shows results of CO_2 measurements of air trapped in ice cores taken at the Law Dome site in Antarctica, along with present day measurements at the GMD Mauna Loa Observatory in Hawaii.

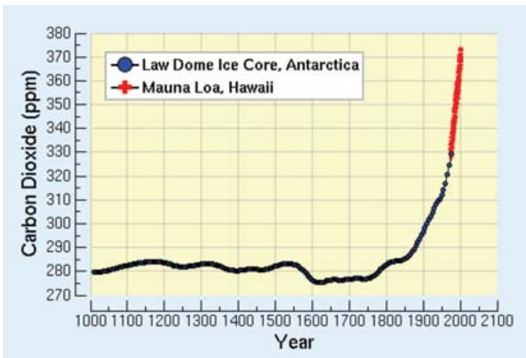


Figure 6.1. Results of CO_2 measurements (in blue) of air trapped in ice cores taken at the Law Dome site in Antarctica, along with present day measurements (in red) at the GMD Mauna Loa Observatory in Hawaii, USA.

Source: CMDL NOAA and Oak Ridge National Laboratory, Department of Energy, USA

6.2. GHG Measurements in Mongolia

In Mongolia, the actual concentration of GHG in the atmosphere is being measured at the Ulaan Uul located in Dornogobi *aimag* since 1992. This is a GHG monitoring site established jointly with the National Oceanographic and Atmospheric Administration, USA, for GHG measurement in the atmosphere. The site is located in the southeastern side of Mongolia at the Mongolian dessert-steppe region far from any anthropogenic sources.

The measurements show that the mean concentrations of major GHGs are higher than global average and increasing constantly during the observation period. In 2007, the annual average CO_2 concentration in the atmosphere measured at this station was 384.4 ppm. Long term changes of major GHGs measured in Mongolia are shown in **Figure 6.2**.

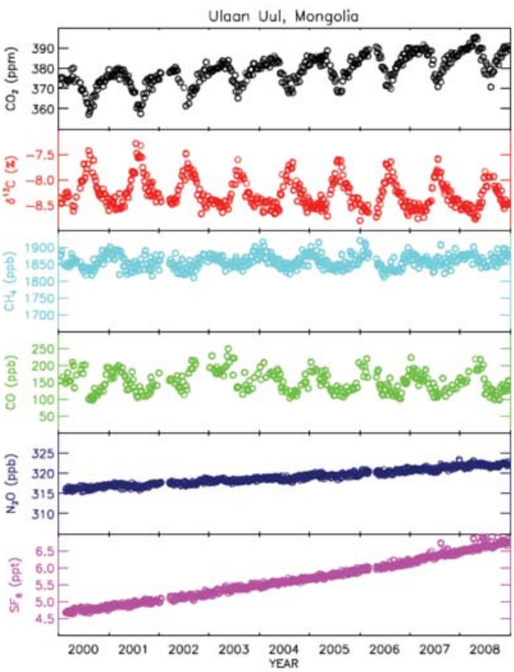


Figure 6.2. Long term Changes of Major GHGs Measured in Mongolia

In the **Figure 6.3**, the geographical distribution and long-term changes of CO_2 concentrations for 1992-2008 period are shown. Here, measurement results taken at the Ulaan Uul site are shown in red color.

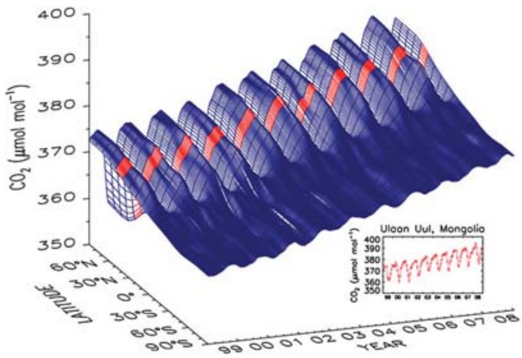


Figure 6.3. Geographical Distribution of CO_2 Concentration at Global and Mongolia Levels

6.3. National GHG Inventories

6.3.1. *Energy Sector*

The primary energy demand by sources is shown in **Table 6.1**. Among the energy sources, coal is the most important fuel in Mongolia. Its share in 2005 was 66.3%. Next was petroleum, which accounts for 22.7%. Share of hydro and other renewable energy was only 11%.

Table 6.1. Total Primary Energy Mix in 2005

Fuel type	*Volume, thousand toe*	*%*
Coal	1,895.0	66.3
Petroleum	648.0	22.7
Hydro and other Renewables	314.0	11.0
Total	2,857.0	100.0

Source: Energy Policy and Statistics in Northeast Asia. Country report for Mongolia, China, Korea and Russia, Dec. 2006. Korea Energy Economics Institute.

The Greenhouse Gas Emissions inventory for the energy sector has been prepared for the period between 1990–2006, considering emissions of the three main GHGs, namely, carbon dioxide (CO_2,) methane (CH_4), and nitrous oxide (N_2O), as well as the indirect gases carbon monoxide (CO), nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC), and sulfur dioxide (SO_2).

The inventory took into account the emissions resulting from fuel combustion as well as the fugitive emissions resulting from extraction of solid fuels. Activity data were taken from the coal balances and data on imports of liquid fuels, which are annually issued by the National Statistical Office, the energy balances prepared by the Energy Research and Development Center, energy data released by the Ministry of Fuel and Energy, and other relevant Ministries and organizations of Mongolia.

CO_2 emissions from solid fuel combustion for the period 1990–2006 are presented in **Table 6.2**, and were calculated using the sector approach. The table shows that most of the solid fuel or coal (60–80%) was used in the energy industry for generation of electricity and heat in power plants and heating boilers during the period 1990–2006.

The energy sector is the most significant source of CO_2 emissions in Mongolia. In 2006, CO_2 emissions from solid fuel combustion were 7,925 Gg, of which the energy industry, manufacturing industry, transportation, commercial, residential, and agricultural sectors emitted 79.8%, 3.8%, 2.1%, 2.7%, 8.5%, and 0.1%, respectively (See **Table 6.2).**

CO_2 emissions from liquid fuels mainly originate from combustion of imported gasoline, diesel oil, fuel oil, jet kerosene, and LPG. In 1990, CO_2 emissions from liquid fuels were 2,540 Gg and declined to about 1,000 Gg in 1995 and thereafter started to increase. In 2006, CO_2 emissions were 1,906 Gg which accounted for 19.5% of total of fuel combustion (See **Table 6.3**). **Figure 6.4** shows the CO_2 emissions by fuel type for the

Table 6.2. CO_2 Emissions from Solid Fuel Combustion, Gg and %

Years	Sectoral Approach							
	Energy Industries	*Manufac-turing Industry*	*Trans-portation*	*Commer-cial*	*Residen-tial*	*Agriculture*	*Other*	*TOTAL*
1990	6,074	1,576	156	412	838	217	259	**9,532**
	63.7	***16.5***	***1.6***	***4.3***	***8.8***	***2.3***	***2.7***	***100***
1995	5,444	974	132	293	190	38	314	**7,385**
	73.7	***13.2***	***1.8***	***4.0***	***2.6***	***0.5***	***4.3***	***100***
2000	6,123	284	100	314	278	4	136	**7,240**
	84.6	***3.9***	***1.4***	***4.3***	***3.8***	***0.1***	***1.9***	***100***
2005	6,346	154	137	258	499	25	151	**7,570**
	83.8	***2.0***	***1.8***	***3.4***	***6.6***	***0.3***	***2.0***	***100***
2006	6,328	289	165	211	677	11	244	**7,925**
	79.8	***3.6***	***2.1***	***2.7***	***8.5***	***0.1***	***3.1***	***100***

Table 6.3 CO_2 Emissions from Liquid, Solid, and Biomass Fuel Combustion

Years	Liquid Fossil		Solid Fuel		Biomass		TOTAL	
	Gg	*%*	*Gg*	*%*	*Gg*	*%*	*Gg*	*%*
1990	2,540.00	18.7	9,532.08	69.9	1,559.00	11.4	13,630.08	100.0
1995	1,020.2	10.0	7,384.93	72.2	1,825.00	17.8	10,230.1	100.0
2000	1,320.6	12.8	7,240.06	70.0	1,782.40	17.2	10,234.1	100.0
2005	1,703.7	15.5	7,569.86	68.9	1,713.10	15.6	10,986.7	100.0
2006	1,905.7	16.5	7,925.43	68.5	1,737.40	15.0	11,568.5	100.0

period of 1990-2006. The dramatic decrease in CO_2 emissions from fuel combustion observed between 1990 and 1995 was mostly due to socio-economic slowdown during the period of economic transition.

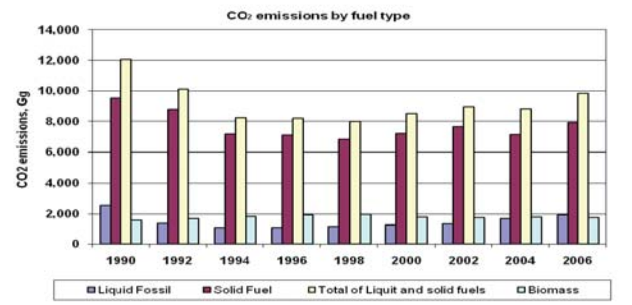


Figure 6.4. CO_2 Emissions in the Energy Sector by Fuel Type

CH_4 and N_2O Emissions. The sources of methane emissions in the energy sector arise from fuel combustion activities and fugitive emissions from coal mining. The main sources of N_2O emissions are fuel combustion activities in the energy industry and the residential sector. The values of CH_4 and N_2O emissions from the energy sector are relatively low. In 1990, CH_4 emissions from the energy sector were 18.38 Gg and decreased to 11.64 Gg in 1995. CH_4 emissions have been increasing since 1996 and reached 15.39 Gg in 2006. Fugitive emissions from coal mining accounted for 50% of CH_4 emissions from the energy sector in 1990, 42% of CH_4 emissions from the energy section in 2000, and 46% of CH_4 emissions from the energy sector in 2006. The N_2O emissions from the energy sector are very low and were about 0.19 Gg during the period 1995–2006.

Total CO_2, CH_4, and N_2O Emissions in CO_2-Eqivalents (eq) **Table 6.4** shows the total GHG emissions with CO_2 equivalents as the unit. By using the Global Warming Potentials (GWP) provided by the IPCC and its Second Assessment Report ("1995 IPCC GWP Values") based on the effects of GHGs over a 100-year time horizon, the CH_4 and the N_2O emissions were converted into equivalents of CO_2. As a result, the total emissions of GHGs from the energy sector were estimated at 8,561 Gg of CO_2 equivalents in 2000, of which CO_2, CH_4, and N_2O accounted for 95.49%, 2.84%, and 1.67%, respectively. It shows that the value of methane and the nitrous oxide emissions are very low and the predominant emission is CO_2 from the energy sector.

In order to identify the dynamics of GHG emissions and their comparative changes, the emissions from the energy sector are estimated for the period 1990–2006, as presented in **Table 6.4.** The results reveal that the total emissions were reduced from 12,529 Gg in 1990 to 8,710 Gg in 1995 and then increased to 10,220 Gg in 2006. This means that the emissions decreased by 30% in 1995 as compared with the figure in 1990 and the emissions in 2006 increased by 14.7% as compared with the figure in 1995.

Indirect GHGs (NO_X, CO, NMVOC) and SO_2 Emissions from Fuel Combustion Activities. In addition to the main GHGs, many energy-related activities generate emissions of indirect GHG. Total emissions of NOx, CO, and Non-Methane Volatile Organic Compounds (NMVOC) from energy-related activities from 1990 to 2006 are presented in **Table 6.4**. In 2006, about 44 Gg of NO_X, 226.58 Gg of CO, and 34.74 Gg of MNVOC were emitted from fuel combustion activities.

Fuel combustion activities are the most significant sources of NO_X. Within fuel combustion activities, the most significant sources are the energy industries and mobile sources. In 2006, the energy industries and transportation sectors accounted for 88% (energy industries: 47%; transport: 41%) of the NO_X emissions from fuel combustion activities in Mongolia. The major part of the CO emissions from fuel combustion activities come from motor vehicles. In 2006, the total CO emissions amounted to 226.58 Gg, 49% of which were

Table 6.4 Total CO_2, CH_4 and N_2O Emissions in CO_2-eq, Gg

Gas/Source	*1990*	*1995*	*2000*	*2005*	*2006*
CO_2	12,072	8,405	8,561	9,274	9,831
A - Fuel Combustion Activities	**12,072**	**8,405**	**8,561**	**9,274**	**9,831**
1. Energy Industries	**6,553**	**5,573**	**6,201**	**6390**	**6367**
2. Manufacturing Industries & Construction	**1,797**	**1,010**	**332**	**219**	**357**
3. Transportation	**1,773**	**899**	**1,205**	**1633**	**1874**
4. Commercial and Residential	**1,689**	**609**	**687**	**881**	**988**
5. Other (please specify)	**260**	**314**	**136**	**151**	**245**
International Bunkers*	31	23.0	7.0	15	13
CO_2 Emissions from Biomass*	1,559	1,825	1,782	1,713	1,737
CH_4	**386**	**246**	**245**	**299**	**324**
A - Fuel Combustion Activities	**191**	**147**	**148**	**159**	**174**
1. Energy Industries	**1.68**	**1.26**	***1.47***	***1.47***	***1.47***
2. Manufacturing Industries & Construction	**3.78**	**2.31**	***0.63***	***0.42***	***0.42***
3. Transportation	**7.56**	**3.78**	**5.25**	**5.88**	**6.72**
4. Commercial and Residential	**177.66**	**139.60**	**140.44**	**152.20**	**165.20**
B - Fugitive Emissions from Fuels	**195**	**99**	**97**	**140.1**	**150.36**
1. Solid Fuels	**195**	**99**	**97**	**140.1**	**150.36**
N_2O	**71**	**59**	**59**	**62.0**	**65.1**
A - Fuel Combustion Activities	**71.3**	**58.9**	**58.9**	**58.9**	**58.9**
1. Energy Industries	**31.0**	**24.8**	*31.0*	*31.0*	*31.0*
2. Manufacturing Industries & Construction	**9.3**	**6.2**	*0.0*	*0.0*	*0.0*
3. Transportation	**3**	**3**	**3**	**6.2**	**6.2**
4. Commercial and Residential	**28**	**25**	**25**	**24.8**	**27.9**
TOTAL	**12,529**	**8,710**	**8,865**	**9,635**	**10,220**

**These values are presented for informational purposes only and are not included in the total emissions.*

produced by transportation sector. Another large contributor to the CO emissions is the residential sector with small combustion equipment. In 2006, the residential sector produced 47% of the total CO emissions from fuel combustion activities.

The most significant sources of MNVOC from fuel combustion activities are mobile sources and residential combustion (especially biomass combustion). In 2006, road transportation and the residential sector accounted for 95% (road transportation - 59%, residential-36%) of the MNVOC emissions from fuel combustion activities in Mongolia. SO_2 is not a "greenhouse gas" but its presence in the atmosphere may influence on climate. SO_2 emissions are directly related to the sulfur content of fuel. The most significant source of SO_2 emissions in Mongolia is coal. But sulfur content of the coal in Mongolia is low. In 2006, almost 90% of the total emissions of SO_2 (45.84 Gg) was emitted from coal combustion activities.

Table 6.5. NO_X, CO, NMVOC and SO_2 emissions from the energy sector, Gg

Gas/Source	1990	1995	2000	2005	2006
NO_X	47.24	34.77	36.25	41.62	44.00
CO	250.79	178.92	199.11	211.47	227.0
NMVOC	38.75	26.18	29.96	32.23	35.00
SO_2	53.32	41.71	41.33	43.78	46.00

6.3.2. *Industrial Sector*

GHG emissions inventory in the industrial sector includes CO_2 and SO_2 emissions from cement manufacturing, CO_2 emissions from lime manufacturing, and NMVOC emissions from food and drink production. Other industries such as iron and steel are too small to calculate GHG emissions. In addition, there are also sources of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The present contribution of these gases to the anthropogenic GHG is small; however, because of their extremely long lifetimes, many of them will continue to accumulate in the atmosphere as long as emissions continue. In addition, many of these gases have very high global warming potentials.

Greenhouse Gas Emissions from Cement Production. In Mongolia, there are two large cement industries in Darkhan and Khutul. The Darkhan Cement Factory was constructed in 1968 as a state owned corporation under Czechoslovakian technical assistance with production capacity of 200,000 tons per year. The Hutul Cement Plant was constructed from 1982 with financial and technical assistance by former Soviet Union and started operation in 1985 with 2 wet kilns with a production capacity of 500,000 tons. But during Mongolia's transition period which began in 1991, the economy became sluggish and cement production decreased dramatically and remains in weak statue.

In the transition period, Darkhan Cement Plant was privatized to be owned by Erel Cement Factory. The Hutul Cement Factory is still a completely state-owned company and is having trouble responding to significant challenges and faces a critical management crisis, all of which have resulted in a rapid decline in cement production at that facility. Activity data for cement production is available in the Statistical Year Book of Mongolia. The emission factor for cement production is 0.4985 Gg of CO_2/ton of cement according to IPCC methodology. The GHG emissions from cement production are shown in **Table 6.6**. The CO_2 emissions have been reduced by 3 times from 1990 to 2006. The emissions of CO_2 from cement production in 2006 were estimated to be 70.19 Gg CO_2.

GHG Emissions from Lime Production. The CO_2 emissions from lime manufacturing for the period 1990-2006 are shown in **Table 6.7**. The CO_2 emissions from lime manufacturing in 1990 were 93.7 Gg and reduced to 27.4 Gg in 2004. But in 2005 the emissions were increased up to 73.9 Gg. The emissions of CO_2 from lime production in 2006 were estimated to be 55 Gg CO_2.

Greenhouse Gas Emissions from Food and Drink Production. The estimates of emissions from food and beverages were made for annual production of spirit, beer, meat, cakes, bread and animal feeds. The NMVOC total emissions in 1990 were 1,205 Gg and reduced to 806.5 in 2006. In 2006, 75% of total NMVOC emissions were from spirit production and 20% were from bread production.

Emissions Related to Consumption of Halocarbons (HFCs, PFCs) and Sulphur

Table 6.6 Greenhouse Gas Emissions from Cement Production*, Gg*

Year	1990	1995	2000	2004	2005	2006
CO_2	219.74	54.24	45.71	30.86	55.78	70.19
SO_2	0.13	0.03	0.03	0.02	0.03	0.04

Table 6.7. CO_2 Emissions from Lime Manufacturing for the Period 1990-2006, Gg

Year	1990	1995	2000	2004	2005	2006
CO_2	93.73	46.77	33.67	27.30	73.89	54.96

Hexafluoride (SF_6). For Mongolian condition, it was calculated potential product halocarbon emissions (HFCs) contained in various products such as refrigeration and air conditioning which are imported using Tier 1b methodology. The number of refrigerators and cars with air conditions were found from the Statistical Year Book of Mongolia. Quantity of material per unit (emission factor) selected from default factors in Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

6.3.3. *Agricultural Sector*

Methane emissions from enteric fermentation of livestock depend on livestock type, its weight, productivity and quality of forage. However, most Mongolian livestock are indigenous breeds that graze throughout the year on natural pastures with low productivity and small size as compared to other breeds of animals in the world. Additionally, the climate in Mongolia impacts the type of forage and the amount ingested by livestock annually and therefore emission factors for enteric fermentation have been developed for Mongolian specific conditions using Tier 2 by the working group on GHG Inventory.

Calculation of methane emissions from enteric fermentation for cattle, Gg. The methane emissions from enteric fermentation for cattle are calculated by using the country specific emission factors identified in **Table 6.8**. The results of the calculation of methane emissions from enteric fermentation for cattle are shown in Table **6.9.**

Estimation of Emission Factors for Livestock Except Cattle. The gross energy intake is calculated according to the same methodology as for cattle and the methane conversion factors for different type of livestock are assumed from the Table A-4 of the IPCC Reference Manual. The calculated emission factors are shown in **Table 6.10.**

Manure Management. Significant quantities of methane are emitted during the decomposition of animal manure. Under anaerobic conditions, methane-producing bacteria convert organic matter into methane.

Table 6.8. Country Specific Emission Factors for Cattle

Main categories of cattle	Fresh bred dairy cattle	Mature local dairy cattle	Mature non- dairy cattle (female)	Other non-dairy cattle	Calves
Emission Factor (EF)	65.26	47.99	43.56	32.09	0.21

Table 6.9. Methane emissions from enteric fermentation for cattle, *Gg*

	Mature fresh bred dairy cattle	Mature dairy cattle	Mature non-dairy cattle (female)	Other non-dairy cattle	Calves	TOTAL
1990	5.25	26.17	21.33	30.61	0.16	83.53
1995	3.35	31.85	22.39	36.58	0.20	94.37
2000	1.90	26.55	28.79	34.14	0.16	91.55
2005	1.42	19.12	15.93	19.52	0.12	56.11
2006	1.97	20.54	17.91	22.04	0.13	62.59

Table 6.10. Country Specific Emission Factors for Livestock Except Cattle

Livestock type	Sheep	Goats	Camels	Horses
Emission Factor (EF)	6.51	5.17	46.69	14.17

The quantities of produced methane are largely dependent on the type of manure management system and ambient temperature. Storing manure in lagoons or as liquid manure produces significantly greater quantities of methane compared to grazing on pasture or solid manure storage. The main producers of methane are cattle and swine. Sheep, goats, horses and poultry contribute only a comparatively small portion of the total emission of methane in Mongolia. The default emission factors are used for calculating methane emissions from manure management. The results of calculating methane emissions from manure management are shown in **Table 6.11**.

cultivation in Mongolia has been very short. Historically, Mongolia has imported all of its chemical fertilizers (ammonium nitrate, double super phosphate and potassium chloride), although since 1990 fertilizers have not been imported at all due to the existing economic conditions. Thus, chemical fertilizers are not applied to crops. Only very small amounts of fertilizer, i.e., sheep dung, have been used for vegetable and fruit crops.

Results of the calculation of GHG emissions from the agricultural sector are shown in the **Table 6.11**.

Table 6.11 GHG Emissions from the Agricultural Sector, Gg

Years	Methane Emissions from Domestic Livestock			Field Burning of Agriculture Residues			Cultivation of Soils
	Enteric Fermentation	Manure Management	Total				
	CH_4	CH_4	CH_4	CH_4	CO	NO_X	N_2O
1990	265.50	8.69	274.19	0.19	3.93	0.13	6.23
1995	282.30	9.30	291.60	0.08	1.69	0.06	2.93
2000	287.79	9.13	296.92	0.04	0.94	0.03	1.65
2005	249.23	7.40	256.63	0.02	0.50	0.02	1.49
2006	280.72	8.19	288.90	0.04	0.93	0.03	1.27

GHG Emissions from Field Burning of Agriculture Residues and Cultivation of Soils. Large quantities of agricultural residues are produced from farming systems world-wide. Burning of crop residues in the fields is a common agricultural practice, particularly in developing countries. It has been estimated that as much as 40 percent of the residues produced in developing countries may be burned in fields, while the percentage is lower in developed countries. For Mongolian conditions, residues were calculated from wheat and potatoes as these are the most the common crops in Mongolia.

Agricultural Soils. Emissions of N_2O from agricultural soils are primarily due to the microbial processes of nitrification and de-nitrification in the soil. The history of land

6.3.4. *Changes in Land Use and Forestry*

The IPCC Guidelines for National Greenhouse Gas Inventories include the following activities in this sector: a) changes in forest and other woody biomass stocks, b) forest and grassland conversion to cultivated land, c) on-site burning of forests, and d) abandonment of managed lands. Mongolian national inventory includes emissions and uptake of GHG from all of these sources except on-site burning of forests.

1. Changes in forest and other woody biomass stocks
2. Forest and grassland conversion
3. Abandonment of managed lands

GHG Emissions from Changes in Forest and Other Woody Biomass. To calculate the net uptake of CO_2, the annual increment of biomass in plantations, forests which are logged or otherwise harvested, and the growth of trees and stocks of woody biomass are estimated. Wood harvested for fuel wood and commercial uses is also estimated. The net carbon uptake is then calculated. The methodology for such calculations relies on the following estimates:

- total carbon content in annual growth of logged and planted forests;
- the amount of biomass harvested;
- wood harvested to carbon removed; and
- the net annual amount of carbon uptake or release.

Total forest area equals 18,291.8 thousand ha, only 8.1 percent of total area, which is why Mongolia is considered as a country with poor forest reserves. These forests include about 140 species of trees, shrubs and woody plants, 84.0% of which are coniferous and non-coniferous forest and 16.0% of which are Saxaul forest. In order to calculate the carbon uptake or removals, it is important to estimate the annual growth rate in “tons dm/ha/year” units for logged forests and “tons/1,000 trees/year” units for planted trees based on local and international data based analysis. On the basis of the research analysis from the Institute of Forestry at the University of Science and Technology, the annual growth rate for logged forests for Mongolia is generally accepted as 0.4 tons dm/ha/year.

Table 6.12. CO_2 Emissions from Changes in Forestry and other Woody Biomass Stocks

Year	Annual removal of CO_2 from biomass increment and forest plantation, Gg	CO_2 emissions from annual biomass consumption from Stocks, Gg	Total CO_2 annual emissions or removals, Gg
1990	-197.19	2269.15	2071.95
1995	-214.98	1,122.40	907.45
2000	-214.79	835.01	620.21
2005	-130.97	1,003.05	872.08
2006	-139.81	1,103.78	963.96

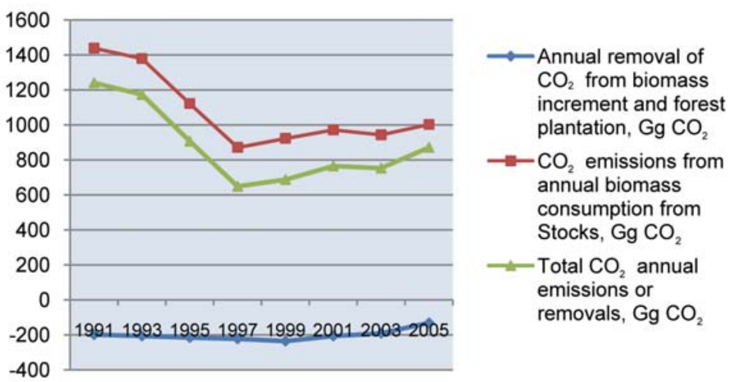


Figure 6.5. CO_2 Emissions from Changes in Forestry and other Woody Biomass Stocks

The calculation of GHG emissions from changes in forestry and other woody biomass stocks shows that the annual removal of CO_2 from biomass increment and forest plantation are much less than CO_2 emissions from annual biomass consumption from stocks.

GHG Emissions from Forest and Grassland Conversion. For Mongolian conditions, this section of inventory includes CO_2 emissions from grassland conversion and land use for industrial mining activities. There is no practice in Mongolia of converting existing forests to other land uses, such as agriculture. The history of land cultivation for agricultural in Mongolia is not very long. Mongolia began to cultivate considerable land area only after 1958 by converting grasslands into croplands for cultivation. The area of arable land continued to increase until the end of 1980s. For example, from 1958 to 1990 1,400 kha of grasslands have been converted.

The following coefficients for Mongolian conditions were assumed:

- Biomass before conversion - 0.35 tn.dm/ha;
- Biomass after conversion - 0 (even if all biomass is not fully cleared, the default value is 0);
- Fraction left to decay - 1.0 (by default value); and
- Carbon fraction in aboveground mass - 0.5 (by default value).

GHG Uptakes in Abandonment of Managed Lands. Activity data for calculation of CO_2 uptake from abandoned land is available from Mongolian grasslands used in statistics report and statistical yearbook of Mongolia. Abandonment of cultivated lands has accelerated recently as marginal lands have been taken out of production in the recent transformation period after the socialist system was converted to a market economy. Specifically, about 140 thousand hectares of land have been abandoned on average during the last 16 years. These abandoned lands only revert back to grasslands. The quantities of CO_2 uptakes from abandoned of managed lands, are given in **Table 6.13** for the entire GHGs inventory period. Analysis shows a significant increase of CO_2 removals caused by abandonment of lands for the GHG inventory period.

Total GHG Emissions from Changes in Land Use and Forestry. Total emissions from changes in land use and forestry were decreasing in the period from 1990 to 1993 and the balance became negative in 1994 due to the increase in abandoned lands. Total emissions were reduced rapidly from 1,887.4 Gg in 1990 to 74.42 Gg in 1993 and the removals are dominated from 1994. The CO_2 removals increased from 538.8 Gg in 1994 to 2,082.6 Gg in 2006 due to an increase in the amount of abandoned lands and a reduction in the rate of conversion to cultivated land (**Table 6.13**).

Table 6.13. GHG Emissions from Changes in Land Use and Forestry

Years	A Changes in Forest and Other Woody Biomass Stocks	Forest and Grassland Conversion	Abandonment of Managed Lands	TOTAL
1990	2,071.95	926.37	-1110.93	1,887.39
1994	1030.98	393.98	-1963.79	-538.83
1995	907.45	347.21	-2160.18	-905.52
2000	620.21	266.6	-2646.87	-1,760.06
2005	872.08	225.29	-3063.28	-1,965.91
2006	963.96	193.33	-3239.87	-2,082.58

6.3.5. *Waste Management*

Recent increases in urban population and an improving economy has amplified the need for municipal solid waste (MSW) management in Mongolia. The total generation of waste in UB was estimated at 552.8 tons per day. Of that total, it is believed that 321.6 tons of that waste (58.2% of the total amount) ends up in final disposal sites, while 21.4% of that waste is dumped illegally along the main streets in the suburbs or in open space. The recycling rate was calculated at 3.7%. More than half of it is collected and recovered by waste pickers either on the streets or at the disposal sites. It is expected that waste amounts will increase as the population grows and the economy expands. All waste collected in Ulaanbaatar is disposed of in three landfills (Dari ekhiin ovoo, Ulaanchuluut, Moringiin davaa) without any further processing. The management of municipal waste is emerging as a problem of prime importance.

Methane Emission from Solid Waste Disposal Sites. The Municipal Solid Waste (MSW) depends on number of urban population and MSW generation per capita. The number of urban population was available from the Statistical Yearbooks. There is the World Heath Organizations report where calculated that an individual in Ulaanbaatar city produce 0.334 kg solid waste a day. According to this source, the MSW generation rate is assumed as 0.334 kg/person/day. Fraction of MSW disposed to SWDS was assumed as 0.61 based on information and data collected from Ulaanbaatar City Service Office**. Table 6.14** shows the total annual solid waste from disposal sites. Methane emissions from solid waste disposal sites are shown in the **Table 6.15**.

Methane Emissions from Domestic and Commercial Wastewater Treatment. The calculations are for two basic types of wastewater treatment systems

- Domestic and commercial wastewater
- Industrial wastewater

In Mongolia, most domestic and commercial wastewater is treated by sewer systems with aerobic treatment. The methane emissions from solid waste disposal sites are calculated according to the IPCC guidelines. The calculation results for methane emissions from domestic and commercial waste water are shown in **Table 6.15**.

Methane Emissions from the Waste Sector. Total CH_4 emissions from waste were estimated at 4.59 Gg in 1990 and this amount increased to 6.55 Gg in 2006. During the period of estimations, about 38% of CH_4 emissions came from solid waste disposal sites and 62% came from waste water treatment (Table 6.15). In 2006, about 2.43 Gg of CH_4 were emitted from solid waste disposal sites and 4.12 Gg of CH_4 were emitted from waste water treatment. Of these wastewater emissions, about 55% came from industrial waste water treatment facilities. The trend for emissions shows that the annual emissions of CH_4 from solid waste disposal sites and waste water treatment have increased continuously year after year.

Table 6.14. Total Municipal Solid Waste Generated in the Cities (by urban population)

Year	Urban population of Mongolia	Solid waste generation per capita	Solid waste	Solid waste in disposal sites
	Thousand persons	*kg/day*	*thousand tons/year*	*thousand tons/year*
1990	1225.00	0.334	149.34	91.10
1995	1240.00	0.334	151.17	92.21
2000	1377.00	0.334	167.87	102.40
2005	1543.30	0.334	188.14	114.77
2006	1579.50	0.334	192.56	117.46

Table 6.15 Methane Emissions from Wastes

Year	Methane emissions from solid waste disposal sites		Methane emissions from domestic and commercial waste water		Methane emissions from industrial waste water and sludge handling		TOTAL	
	Gg	%	Gg	%	Gg	%	Gg	%
1990	1.86	40.52	1.43	31.15	4.59	28.32	4.59	100.00
1995	1.91	36.59	1.45	27.78	5.22	35.63	5.22	100.00
2000	2.12	37.13	1.61	28.20	5.71	34.68	5.71	100.00
2005	2.38	37.19	1.80	28.13	6.40	34.69	6.40	100.00
2006	2.43	37.10	1.84	28.09	6.55	34.81	6.55	100.00

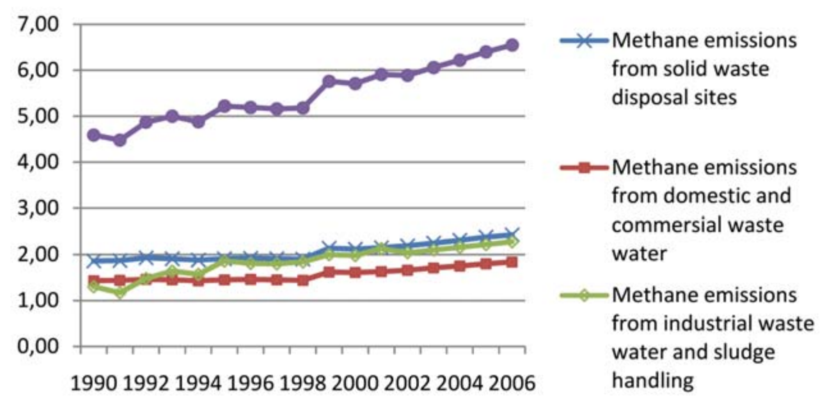


Figure 6.6. Trend of Methane Emissions from the Waste Sector

6.3.6. *Net GHG Emissions in Mongolia*

The total CO_2-eq emissions in Mongolia for the period 1990-2006 are presented in **Figure 6.7**. The calculation shows that Mongolia's net GHG emissions were 22,535 thousand tons of CO_2-eq in 1990. The net GHG emissions were reduced to 15,044 thousand tons in 1995. The reduction of net GHG emissions is mostly due to socio-economic slowdown during the transition period from socialism to a market economy. But during this period, the methane emissions increased due to an increase in livestock population.

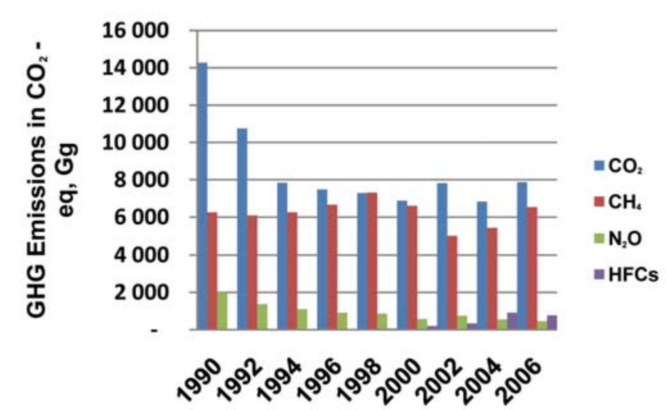


Figure 6.7. Total GHG Emissions in CO_2-eq by gases for the period 1990-2006

Figure 6.8 shows that carbon dioxide is the most significant of the GHG in Mongolia's inventory making up 50.4 % (7,874 Gg) of the total CO_2-eq emissions in 2006 followed by methane which made up 41.8% (6,529 Gg) of the total CO_2-eq emissions in 2006. The remaining gases (N_2O, HFCs) made up 7.8% of Mongolia's CO_2–eq emissions.

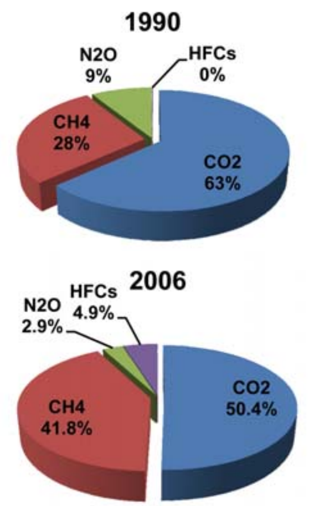


Figure 6.8. Total GHG Emissions in CO_2-eq by gases in 1990 and 2006

In addition to the main GHG addressed above, many activities generate emissions of indirect GHG. Total emissions of nitrogen oxides (NOx), carbon monoxide (CO), non-CH_4 volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) from 1990 to 2006 are presented in **Figure 6.9a**. The main indirect GHG is carbon monoxide which is emitted mostly from fuel combustion. In 2006, about 44 Gg of NO_x, 227.50 Gg of CO and

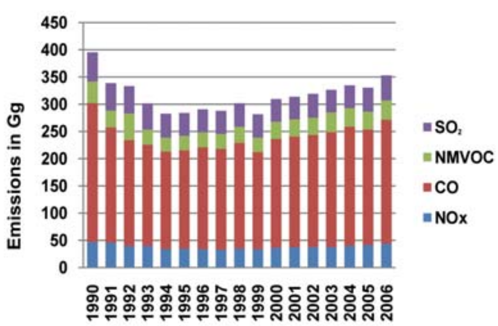


Figure 6.9a. Indirect GHG Emissions for the period 1990-2006

35.55 Gg of MNVOC were emitted from overall activities. Emissions of SO_2 are directly related to the sulphur content of fuel.

6.3.7. Sectoral GHG Emissions in Mongolia

In 2006, Mongolia's net GHG emissions were 15,628.00 gigagrams (=1,000 tons) (Gg) in CO_2-eq. The energy sector (including stationary energy, transportation and fugitive emissions) was the largest source of GHG emissions comprising 65.4% (10,220.09 Gg) of total emissions (**Figure 6.9b)**. The second largest source of GHG emissions was the agricultural sector (41.4%). For the changes in land use and forestry sector, the total CO_2 removals were more than total CO_2 emissions at 2,083.6 Gg (13.3%) in 2006 due to an increase in the area of abandoned lands and an reduction in newly cultivated land. Other relatively minor sources currently include emissions from industrial processes and the waste sectors.

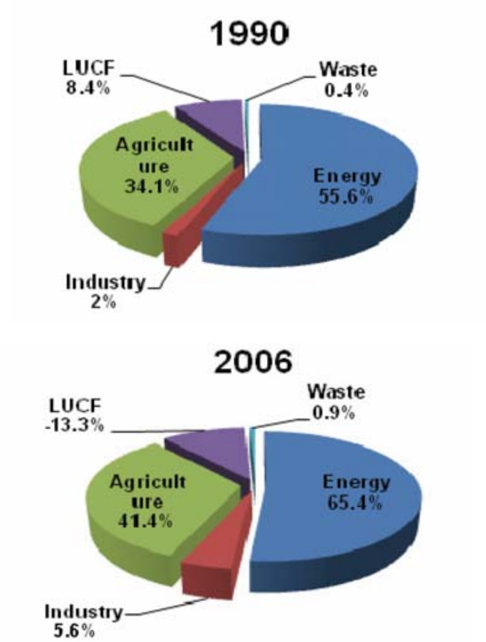


Figure 6.9b. Contribution to Total CO_2-eq Emissions by Sector for 1990 and 2006

Table 6.16. shows that the single largest emitter of carbon dioxide is the energy sector. In 2006, 98% of carbon dioxide emissions were from energy sector which includes all types of fuel combustion activities.

Table 6.16. Main GHG by sectors in 1990, 2000 and 2006

GHG source and sink	CO_2emissions	CO_2Removals	CH_4	N_2O	HFCs	CO_2-eq
1990	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**GgCO_2-eq**
Energy	12071.00	0.00	18.38	0.23		12520.08
Industrial processes	313.47		0	0	0.0104	327
Agriculture			274.38	6.24		7695
LUChF	2998.33	1110.93		0		1887
Waste			4.59	0		96
Total	**15383.61**	**1110.93**	**297.35**	**6.47**	**0.0104**	**22534.51**
2000						
Energy	8561.00	0.00	11.63	0.19		8865.36
Industrial processes	79.38		0	0	0.15	276
Agriculture			296.96	1.65		6748
LUChF	886.83	-2648.87		0		-1762
Waste			5.71	0		120
Total	**9526.88**	**-2648.87**	**314.30**	**1.84**	**0.15**	**14246.77**
2006						
Energy	9831.00	0.00	15.39	0.21		10220
Industrial processes	125.15		0.00	0.00	0.588	892
Agriculture			288.94	1.27		6462
LUChF	1157.29	-3239.87		0.00		-2083.58
Waste			6.55	0.00		137.55
Total	11113.54	-3239.87	310.88	1.48	**0.588**	15628

The main contributor to the total methane emissions is the agricultural sector contributing about 92-93% of the total methane emissions. The second biggest contribution comes from the energy sector with about 5-6%, while all other sectors contribute less then 2% of the total

Table 6.17. Total CO_2-eq Emissions by Sector for 1990 and 2006

Sectors	1990	1991	1992	1993	1994	1995	1996	1997	1998
Energy	12529	12214	10505	9882	8582	8710	8566	8371	8368
Industry	327	199	146	109	129	166	142	148	171
Agriculture	7695	7210	7006	6724	6932	6764	7167	7420	7659
LUChF	1887	747	466	74	-539	-906	-882	-1413	-881
Waste	96	94	102	105	102	110	109	108	109
Total	22534	20464	18225	16894	15206	15044	15002	14635	15426

Sectors	1999	2000	2001	2002	2003	2004	2005	2006
Energy	8451	8865	9063	9418	9023	9246	9635	10220
Industry	207	276	275	450	729	972	862	892
Agriculture	7716	6748	6040	5338	5240	5518	5854	6461
LUChF	-1356	-1762	-1347	-1386	-1788	-2112	-1966	-2083
Waste	121	120	124	124	127	131	134	138
Total	15129	14247	14155	13944	13331	13755	14519	15628

The total GHG emissions in Mongolia are comparatively low, but the per capita rate of GHG emissions is relatively high compared to other developing countries because of the cold continental climate, the use of fossil fuels for energy and the low efficiency of fuel and energy.

Table 6.18 Per capita GHG enissions in CO_2-eq

	1990	1995	2000	2001	2002	2003	2004	2005	2006
GHG Emissions in CO_2-eq, Gg	22534	15044	14247	14155	13944	13331	13755	14519	15628
Population, thousand persons	2103	2249	2407	2446	2475	2504	2533	2562	2595
Per capita GHG emissions, ton/ person	10.7	6.7	5.92	5.80	5.63	5.26	5.43	5.66	6.02

6.4. Mitigation Options and Measures

6.4.1 *GHG Mitigation Potentials*

Options and opportunities for greenhouse gas mitigation in Mongolia were identified during preparation of the Initial National Communication (1998 to 2000). These mitigation options were identified according to case studies and analyses of the inventory of GHG emissions and emission projections as shown in **Table 6.19**.

Table 6.19. Brief Description of the Studies on Greenhouse Gas Mitigation

Name of Project	Brief Description
U.S. Country Studies Project	The U.S. Country Studies Project for the energy sector and land use and land-use change and forestry (LULUCF) was the first study on GHG mitigation options. In the energy sector, long range energy alternative planning (LEAP) was used to estimate the amount of GHG emission reductions. In the LULUCF sector, the Comprehensive Mitigation Analysis Process (COMAP) model was used to identify mitigation options (1995-1996).
Asia Least-cost Greenhouse gas Abatement Strategy (ALGAS) Project	The ALGAS project identified the primary areas of GHG mitigation based on an inventory of GHG emissions and the results of emission projections. Following the identification of the primary areas, a list of potential mitigation options in the energy sector was developed. The list of options was screened using qualitative criteria. The EFOM-ENV, an energy sector optimization model, was used in correlation with a bottom-up energy demand accounting model, MEDEE/S-ENV, to develop a least cost scenario for the reduction of GHG emissions.
Climate Change National Action Program	The Climate Change National Action Program includes GHG mitigation studies. The aim of the mitigation assessment was to provide policy makers with an evaluation of those technologies and practices that can both mitigate climate change and also contribute to national development objectives. The main focus of this study was on the energy, transportation and forestry sectors.

Mongolia's Initial National Communication	Mongolia's Initial National Communication was prepared within the GEF Climate Change Enabling Activity in 2001. In compliance with its UNFCCC commitment, Mongolia conducted a mitigation analysis to provide policy makers with an evaluation of technologies and practices that can both mitigate climate change and contribute to national development objectives, and to identify policies and programmes that could enhance their adoption.
Climate Change Mitigation Measures: Assessment of Technology Transfer Needs in Mongolia's Energy Sector	The objectives of the Climate Change Mitigation Measures assessment are as follows: to make a baseline survey to identify the priority technology needs in the energy sector of Mongolia that are conducive to addressing climate change and minimizing its negative impacts; and to develop project outlines that meet technology needs in the energy sector most cost-effectively in order to implement the Climate Change Action Program.
Regional Cooperation on the Kyoto Mechanisms (CDM/JI)	Regional Cooperation on the Kyoto Mechanisms (CDM/JI): Enhancing the Environmental Cooperation in Northeast Asia in a New Dimension.The focus of this project is on sustainable development. Northeast Asia has a tremendous opportunity to cooperate in and benefit from the win-win situation afforded by the Clean Development Mechanism (CDM) and Joint Implementation (JI) systems set out in the Kyoto Protocol.

Energy Sector

The analysis of GHG emissions shows that most GHG emissions in Mongolia are from coal combustion. This means that GHG emission mitigation policy should focus on the reduction of coal use through coal substitution. In particular, there is considerable scope to replace fossil fuels by other clean energy resources such as renewable energy resources.

Renewable Energy Resources

Mongolia has considerable renewable energy resources including hydropower and solar energy. It has significant hydropower potential with 3,800 rivers and streams. Based on this potential, the number of small hydropower plants has been increasing during recent years. Large scale hydro plants are being identified.

Hydropower provides a clean alternative source of energy with no direct GHG

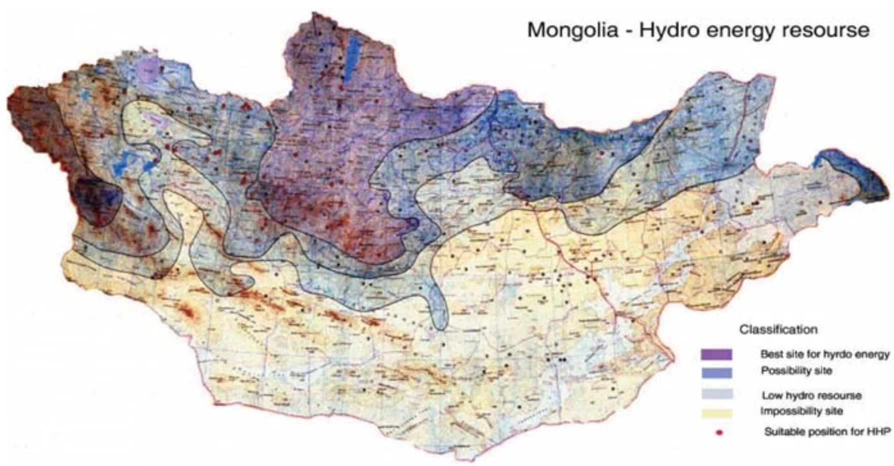


Figure 6.10. Map of Hydro Energy Resources in Mongolia

emissions. It contributes to the reduction of GHG emissions by displacing the electric power that would otherwise have been generated by coal-fired electric power plants. In Mongolia, two hydropower plants, one with a capacity of 11 MW and another with 12 MW, operate as approved Clean Development Mechanism (CDM) projects reducing GHG emissions and generating Certified Emission Reductions (CER).

Mongolia has considerable wind energy resources. In the steppe and Govi regions the annual average wind speed is 4 m/s. Forty-seven percent of Mongolia is classified as territory with the "highest possibility" for wind energy installations. In particular the southern provinces have wind regimes of 150 -200 W/m^2 with wind durations of 4,000-4,500 hours per year.

It has been estimated that more than 10% of the country has good-to-excellent potential for wind energy applications on a commercial scale. Several wind farm projects with 30–50 MW capacity in various areas of Mongolia are being considered. The objective of these projects is to generate electricity using wind energy sources and to reduce the need for electricity generation by the coal-fired power plants that currently supply the Central Grid of Mongolia, thereby reducing GHG emissions.

The total solar energy resources, evaluated as the annual solar radiation on the entire national territory, have been calculated to potentially achieve 2.2 x 10^{12} kWh. The potential solar energy varies from 1,200 kWh/m^2/y to 1,600 kWh/m^2/y in the different regions of Mongolia.

The installation of large scale, carbon free, renewable electricity, such as very large scale PV (VLC-PV) systems in the Govi region of Mongolia, may contribute to both protecting against air pollution and supporting regional development. It is possible to implement pilot research projects in the areas along the railways and consider VLC-PVs in the Mongolian Gobi Desert in the future.

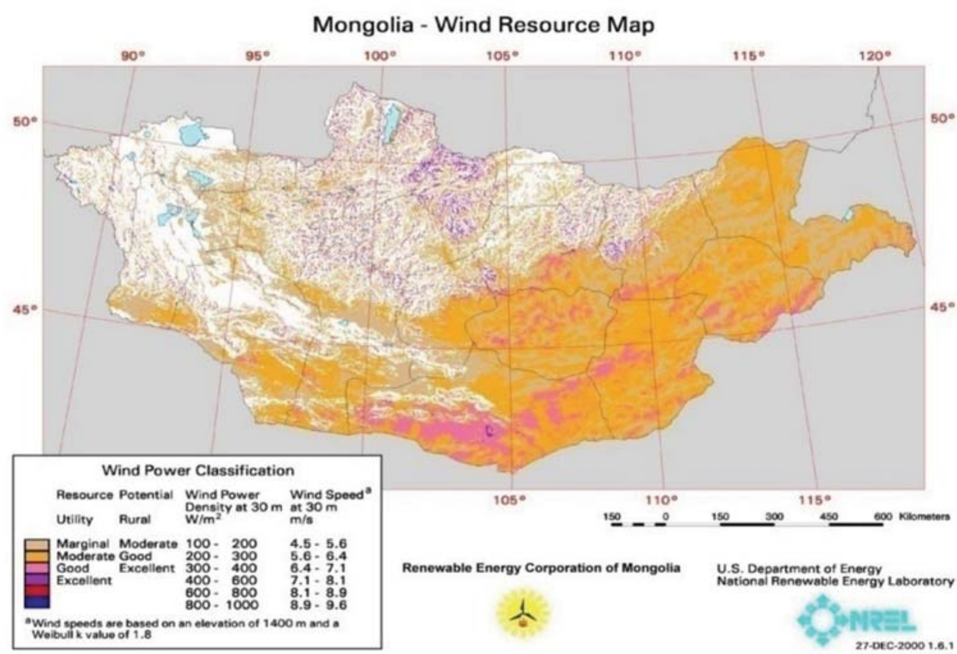


Figure 6.11. Map of Wind Energy Resources in Mongolia

Efficient Use of Traditional Energy Resources.

The primary mitigation potential for Mongolia is to use the existing traditional energy sources, such as coal, more efficiently. Coal is the most important primary energy source because Mongolia has large coal reserves, lacks natural gas and has insufficient oil reserves. There are around 320 coal deposits and occurrences (80 deposits and 240 occurrences) according to the Geological Information Center of Mongolia. Total geological coal resources are estimated at approximately 150 billion tons, including about 24 billion tonnes explored. **Table 6.20** shows the coal resources of Northeast Asian countries.

Figure 6.12. Map of Solar Energy Resources in Mongolia

There is significant potential to mitigate greenhouse gas emissions in the energy sector by increasing the efficient use of fossil fuels in power plants, increasing the use of heat-only boilers and encouraging energy efficiency practices by end-users. Space heating sustains the livelihood and economic activities during the harsh Mongolian winters. The winter season in Mongolia lasts eight months with minimum temperatures reaching -30 to -40^{0}C. District heating (DH) services were developed in the 1960s, and use Soviet-era technologies. A rapid increase in urban populations, fed by a large influx of migrants in recent years, has resulted in a proliferation of coal-fired heating stoves and small boilers in Ulaanbaatar and other cities, leading to large GHG emissions and serious indoor and ambient air pollution.

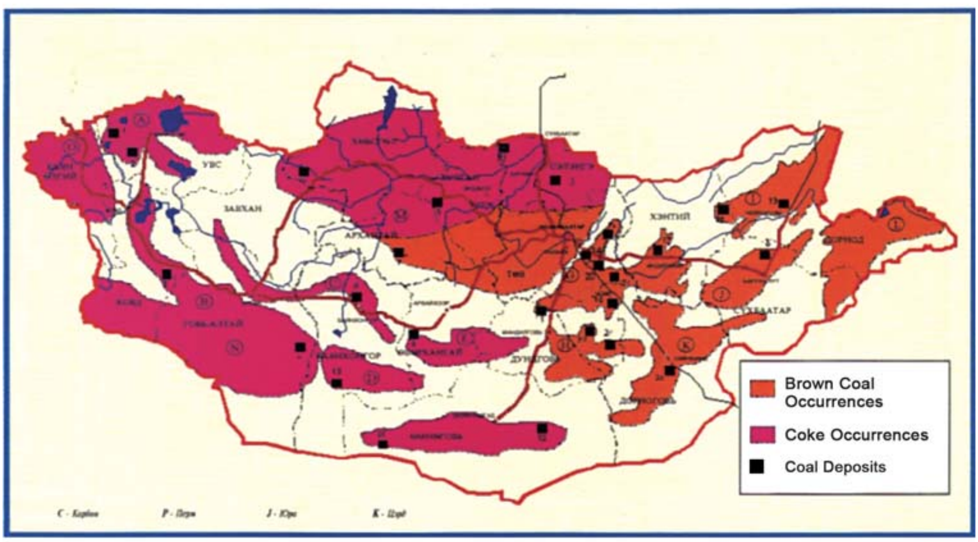


Figure 6.13 Coal Resource Map of Mongolia

Table 6.20. Coal resources of Northeast Asia Countries

Country's name	Explored resources, billion tons	% in world resources	Population, million people	Coal resources per Capita
Russia	157	15.7	142	1105.6
China	114.5	11.5	1318	86.9
Mongolia	24	2.4	2.6	9230.8
DPRK	0.6	0.06	23.3	25.8
Japan	0.36	0.03	128	2.8
Korea	0.08	0.01	49	1.6
World	998	100	6625	150.6

Non-Energy Sectors

The industrial sector is one of the largest energy consumers, using about 70% of the electricity supply and 28% of the heat produced. Industrial enterprises are small in number but relatively large in terms of production. For example, Erdenet Copper Mining Industry, which provides one-third of Mongolia's income tax revenue, accounts for about 36% of the country's electricity use and about 15% of the peak power demand.

According to the GHG inventory for 2006, the industrial sector contributes about 6.0% of the total CO_{2}-eq emissions. These emissions stem from direct industrial use of coal and diesel. The emissions originating from electricity and heat are attributed to the energy sector (supply, conversion and distribution). The preliminary estimates of future emissions show an increase of the share of CO_2 emissions from the industrial sector (i.e., the industrial share of total emissions from all sectors).

Forest areas occupy 8.1% (17.5 million hectares) of Mongolia's total territory. Most of the forests are located in the northern and central part of the mountain regions. According to the National Forest Law passed in 1995, the forest area is divided into three zones: special, protected and industrial. Special forests account for about 6% of the total forest area, including the upper forest boundaries and the protected areas of the National Conservation Parks. Protected forests account for 48% of the total forest area and include green zones, prohibited strips, saxaul, oases, small forest areas covering up to 100 hectares and forests on slopes greater than 30 degrees. Industrial, wood- and timber-producing forests account for 46% of the total forest area.

The Greenhouse Gas Inventory shows that annual CO_2 emissions from biomass stock consumption is much higher than annual uptake of CO_2 from biomass increment and forest plantation. In 2006, the annual uptake of CO_2 from biomass increment and forest plantation was 140 Gg. However, the CO_2 emissions from annual biomass consumption was 1.103 Gg, which equals 7.0 % of total GHG emissions in Mongolia. There is potential for GHG mitigation in forest areas by reducing biomass consumption and increasing forest plantation.

The agriculture sector, especially livestock, provides the main livelihood and source of wealth in Mongolia. The country's economy depends substantially on production and development in the agriculture sector. The main contributor of methane emissions is the agriculture sector, contributing about 92- 93% of the country's total methane emissions.

6.4.2. *GHG Mitigation Options*

Energy Sector

The energy sector of Mongolia is the largest contributor to greenhouse gas (GHG) emissions. The cold continental climate and the low energy content of Mongolian coal contribute to a high rate of carbon dioxide (CO_2) release when measured on a per capita basis. The estimate for national GHG emissions in 2006 is 15.6 million tons or roughly 6.02 tons per capita. This estimate is larger than that for per capita GHG emissions in the great majority of developing countries and exceeds the world average.

The country's pattern of energy use is determined by its economic growth, large land area, climate regimes, low population density and significant indigenous resources. Coal, the fossil fuel that emits the highest amount of GHGs per unit of energy, is abundant, with explored reserves estimated at 24 billion tons. Coal contributes the bulk of Mongolia's energy production (80%); this includes power generation and heat. Oil products (mainly diesel oil) account for the remainder. Currently, Mongolia has no domestic oil or natural gas production, and all oil products are imported, mostly from Russia. Petroleum products account for 19 percent of the total commercial energy use and are consumed mostly in the transportion sector. Apart from traditional biomass (fuel wood and dung), use of renewable energy is in the development stage in Mongolia. The non-commercial primary energy sources are fuel wood and animal dung. In households, wood and dung are used for cooking and heating.

The existing power sector of Mongolia consists of the Central Energy System (CES) with five coal-fired Combined Heat and Power (CHP) plants and local provincial energy service enterprises. Overall, the power sector of Mongolia has a net installed capacity of about 1,066.0 MW.

Extraction condensing turbines are used in the CHP plants. Part of the steam is extracted from the turbines to meet heat requirements (steam and hot water) and the remaining part of the steam flow is cooled and condensed by using cooling water. Isolated power systems range from 60 kW in the smallest systems to 7.2 MW diesel engine generators. Both hot water and space heating are supplied by heat only boilers (HOBs). Boiler capacities range from 0.4 to 10 Gcal/h. Due to harsh, cold climate conditions in winter, heat is an essential energy use. Heat supplies account for 40% of gross energy consumption.

The previous studies regarding the energy sector identified the following mitigation options:

1. *Energy supply sector*

- Increase renewable options
  - Hydropower plants
  - Wind farms
  - PV and solar heating
- Improve the efficiency of heating boilers
  - Improve the efficiency of existing HOBs
  - Install boilers with the new design and high efficiency
  - Convert steam boilers into small capacity thermal power plants
- Improve household stoves and furnaces
  - Modernize existing household stoves and furnaces
  - Implement the new design for household stoves and furnaces
  - Change fuels for household stoves and furnaces
- Improve coal quality
  - Coal beneficiation
  - Apply effective mining technology and facilities, including selective mining and dewatering system coal handling plants
- Improve CHP plants
  - Improve efficiency
  - Reduce internal use

2. *Energy Demand Sector*

- District heating and building environment
  - Make building insulation improvements
  - Implement improvements of district heating system in buildings
  - Improve lighting efficiency
- Industry
  - Improve housekeeping procedures

- Implement motor efficiency improvements
- Improve lighting efficiency
- Adopt technology changes (e.g., dry-processing for cement industry, etc.)

Regarding the GHG mitigation assessment for the energy sector, the most detailed analysis was done by the Asia Least Cost Abatement Strategy (ALGAS) project. The analysis includes the identification of the primary areas of GHG mitigation based on the GHG emissions inventory and projections of the inventory. Following the identification of the primary areas a long list of potential mitigation options in the energy sector was developed and screened using qualitative criteria. The energy flow optimization model for environment (EFOM-ENV), was used in correlation with a model for energy demand and energy efficiency for environment (MEDEE/S-ENV), to develop a least cost scenario for the reduction of GHG emissions. The analysis of the screening matrix showed that many of the potential options are not yet technically feasible in Mongolia. Options that consider efficiency improvements and utilization of unused potential are encouraged.

The options having the largest potential for GHG mitigation are listed below::

- Coal Beneficiation;
- Combustion Efficiency Improvement;
- Reduction of Station's Own Use (Existing Plants);
- Reduction of Transmission and Distribution Losses;
- Photovoltaics (PV);
- Small Wind Generators;
- Biomass Gasifiers;
- Small Hydroelectric projects;
- Cogeneration;
- Motor Efficiency Improvement;
- Fuel Consumption Efficiency Improvement;
- Efficient Coal Stoves;
- Efficient Lighting; and
- Building Insulation Improvement.

A taxonomy of options was developed through the screening of the potential mitigation options. Carbon dioxide emissions depend on fuel characteristics, and the most effective way to abate CO_2 emissions is through the rational use of energy. Therefore, mitigation options to reduce CO_2 emissions from the energy sector considered in the assessment may be grouped into two major categories: (1) energy conservation or efficiency improvements; and (2) substituting less carbon-intensive energy sources for those that are more carbon-intensive.

For each potential mitigation option, the following technical data/characteristics were developed.

- Scope and range of the application;
- Availability / commercial readiness;
- Potential for GHG mitigation/abatement;
- Current constraints in Mongolia that will inhibit the application of the option including financial, institutional, policy, information or other constraints.

Supply Side

Coal Beneficiation. Mongolia has substantial coal reserves. Coal will continue to be the most economic fuel for power and heat generation in the Central Energy System (CES) and for heat generation in provincial centers. There exists no provision for coal preparation at mine sites, and as a result there is no quality control in the supply system. Approximately 70 percent of coal is transported more than 150 km by railway on average. Coal quality often does not meet the minimum standard requirements, and in many cases, emergency situations at the power stations are caused by the low quality of coal. Better quality control at the mines and installation of "selective" crushers and screening equipment have been recommended to reduce the amount of rock and inert material transported to the power stations. Better management of mine drainage systems is necessary to reduce the moisture content of the coal. Coal washing at the mine site is now common in many countries.

Coal washing can be introduced at the biggest coal mines in Mongolia, which are Baganuur and Shivee-Ovoo. This option is technically feasible; there are few institutional barriers. This option is already included in the Mongolian Environmental Action Plan. The coal benefication plan will result in local benefits such as the reduction of ash disposal in residential areas, less SOx emissions and increased coal transportation efficiency. Combustion of high quality coal at the power plants will increase gross efficiency of power generation and reduce the station's own use.

Station's "Own Use". All the thermal power plants in Mongolia are designed for cogeneration; they provide base load electricity and hot water for district heating. Steam from industry is also processed for these purposes. The station's own use of energy is very high in thermal power plants. This high consumption of electricity for "own use" can be explained mainly by the low coal quality which results in much longer coal mill operating hours and by the high leakage losses in the pipeline which results in high electricity consumption by the pressurizing pumps. Investigations carried out to-date indicate that through the installation and proper maintenance of control equipment and improved housekeeping procedures, such as eliminating leaks, repairing insulation and recovering condensate and boiler blow down, savings in a station's own use of up to 5 percent of the gross generation can be achieved. This option is highly feasible, and in fact its implementation has already started. The emissions reduction impact of this option is assessed to be in the medium range, and its local benefits are considered to be high.

Electricity Transmission/Distribution Loss Reduction. The transmission system of the Mongolian Central Energy System consists of 220 kV and 110 kV overhead lines. The grid is connected to the Siberian and Russian grid by a 220 kV transmission line. The distribution system consists of 110 kV overhead lines that mainly feed secondary substations. Total line length of the 220 kV system is estimated to be about 2,000 km, and line length of the 110 kV system is estimated to be 2,500 km. Voltages of 35 kV, 10 kV, and 6 kV are used in distribution networks that supply industrial and distribution stations, while 0.4 kV are used in networks supplying residential and other public consumers. The electricity losses in both the transmission and distribution lines are high.

The reduction of losses in the electricity transmission/distribution system involves redesigning and/or rehabilitating the existing old transmission/distribution lines, installing more energy efficient equipment on poles and in power substations and replacing old and inefficient pole-mounted transformers. On the other hand, nontechnical losses could be reduced through strict monitoring and eliminating electricity theft.

District Heating System Losses. District heating systems exist in all major cities and towns in Mongolia. Existing district heating systems use constant flow technology which is not flexible. Losses in the heat distribution systems are high, and urgent measures, such as minimizing leakage, replacing valves and reducing radiation losses, are required. Building losses are also high and residential consumers have no means of regulating temperatures.

It is necessary to convert the district heating systems into a variable flow system which would result in a substantial reduction in peak demand. Results of the Ulaanbaatar Heat Rehabilitation Projects show that the total loss (end-use heat, hot water and thermal losses) could be reduced by 1,121 TJ/year.

This option is highly feasible in Mongolia. The emissions reduction impact of this option is high, and the local benefits can be substantial. A district heating system rehabilitation project has already been started in Ulaanbaatar.

Combustion Efficiency. This option considers the improvement of combustion efficiency in small boilers and furnaces. Small boilers and furnaces, usually owned by local governments, are supplying public facilities such as hospitals and schools, and because of obsolete technology and the lack of quality control and maintenance skills, the gross efficiencies of these boilers and furnaces are comparatively low, about 40 to 60 percent. Some independent study results show that the efficiencies of these boilers and furnaces can be increased up to 75 to 80 percent by simple retrofitting. Replacement of these boilers and furnaces by new modern ones is also a viable option.

Technologies and measures involved in this option include using high efficiency burners and combustion monitoring and control systems and improving basic housekeeping practices. It has been assumed that it is possible to increase boiler gross efficiency up to 80 percent with an average additional investment of $50/kW. This option is considered to be feasible. The Government of Mongolia has a policy of encouraging energy savings and resource conservation. The emissions reduction impact of this option is assessed as high, and its local benefits are also high.

Hydropower Development. A number of promising hydropower sites have been identified in Mongolia. Hydropower development is one of the best options for electricity supply to remote and limited demand consumers. Currently Taishir (11 MW) and Durgun (12 MW) hydropower plants are starting operations, and more than 20 hydropower sites have been identified, with capacities ranging from 5 MW to 110 MW. This option is moderately feasible in Mongolia. The Government of Mongolia has in place a policy to develop small and medium sized hydro projects. Therefore, the policy barriers are low. The emissions reduction impact of this option is high, and its local benefits are expected to outweigh the negative impacts.

Photovoltaic (PV) Solar System. Mongolia is located in a region with abundant sunshine, typically between 2,250 to 3,300 hours each year. However, the current information available for designing a solar energy system is not considered to be accurate or complete. Possible targets for the application of solar energy are the families of nomadic herdsmen. During the last ten years, different kinds of small solar-electric units have been introduced into rural households. PV power generation is a mature technology for small power applications. The PV market is currently very small, but the market growth has been 25 percent per year internationally. The PV systems have been shown to be the less expensive option when compared to small gasoline generators. At present, small-scale PV systems (10 to 1,000 W) are used in remote areas. It has been assessed that in Mongolia PV power systems are competitive with conventional energy sources for small power applications for nomadic families.

Wind Generator. The economic feasibility of this option for Mongolia is currently being assessed. Among renewable energy technologies, wind energy has proven to be the most competitive in terms of cost for the bulk power market internationally. Mongolia has very little experience with wind energy. There have been few systematic assessments of the potential of wind energy resources in Mongolia. According to the available meteorological data prepared by the National Renewable Energy Center, the annual average wind speed in the southeastern part of the country is in the range of 4 to 5 m/s. This is marginal in terms of the potential cost. As in the case of solar energy, there is considerable potential to supply nomadic livestock herders in the Gobi Desert with small portable wind generation systems. Renewable energy development is included in the Government Action Program as the principal way to provide electricity to remote areas and nomadic families. Turbine generators (100-150 kW) could be placed in provincial centers in the southern part of Mongolia. The most promising sites should get priority in order to establish the technical and economic feasibility of operating 100-150 kW wind turbine generators in parallel with existing diesel generators. Also, large scale wind farm projects could be implemented in Mongolia.

Bioelectricity System (Biomass Gasifier Technology). Bioelectricity has been shown as a potential and feasible option to meet all the current and projected electricity requirements of rural areas in the majority of developing countries. It is possible to install sustainable biomass-based electricity generation systems in island provinces, instead of installing expensive power generating assets to generate all the electricity required. Bioelectricity systems could be installed in any rural location where biomass can be grown and harvested. It is possible to set up electricity generation units having capacities ranging from 20 kW to several megawatts. Electricity can be generated year-round and 24 hours a day. The average electricity demand in remote villages in Mongolia is estimated to be around 150 to 250 kW. Approximately 50 remote villages located in the northern part of Mongolia, from a total of 384 rural villages, are potential candidates for the installation of biomass gasifiers.

End-use/Demand Side Energy Efficiency Measures

Lighting Efficiency Improvement. This demand-side management option concerns replacing inefficient incandescent light bulbs (ILBs) with energy efficient compact fluorescent lamps (CFLs). CFLs provide the same amount of light as an incandescent light bulb but use roughly 70 percent less electricity. Although CFLs are more expensive than ILBs, they are more economical on a life cycle basis due to savings in electricity costs. The economic feasibility of this option for Mongolia is currently assessed to be in the medium range due to the fact that it is financially accessible only to a limited number of consumers. Policy barriers are assessed to be low because the Government has a policy of encouraging energy savings. The emissions reduction impact of this option is assessed to be in the medium range.

Efficient Coal Stoves. Mongolia has a total of 526,000 households, 60 percent of which use small coal stoves. Each household in every soum (administration unit) and in the suburbs of cities uses 4 tonnes of coal and $2.5m^3$ of fuel wood annually. The final end-use efficiency of coal stoves is low, around 25 to 30 percent. It is estimated that the efficiency of coal stoves can be improved up to 45 percent by retrofitting existing stoves or by replacing them with efficiently designed ones. The local pollution benefit of this option is large, and it is this aspect which makes this option an attractive one. The emissions reduction impact of this option is assessed to be in the medium range.

Building Insulation Improvement. In Mongolia, all buildings have space heating installations. Almost 65 percent of the total energy demand of households and 90 percent of the total energy used in the service sector are for space heating. A study on heat losses found that nearly 40 percent of heat is lost from houses and buildings. The heat losses occur through windows, walls, and doors; design and construction of most multifamily buildings in bigger cities are very similar to buildings found in many places of the former Soviet Union.

A study of local building standards found that heat demand in multifamily buildings could be reduced by about 60 percent. The feasibility of this option for Mongolia is currently assessed to be in the high to medium range. Policy barriers are assessed to be low because the Government has a policy of encouraging energy savings. The emissions reduction impact of this option is assessed to be in the medium range.

Motor Efficiency Improvement in Industry. Industry is one of the largest consumers of electricity in Mongolia. Motors and pumps are the main consumers of electricity in the industrial sector. Existing motors and pumps are old, and their efficiencies are very low. An energy audit study for the principal industries shows that there is the the potential to improve motor and pump efficiency by more than 20 percent. The emissions reduction impact of this option is assessed to be high.

Vehicle Fuel Consumption Efficiency Improvement. Most vehicles operating in Mongolia are old and, therefore, unit consumption of fuel is high. The regular control of exhaust and fuel consumption does not exist. The results of various studies show that there is a potential to reduce unit fuel consumption by about 10 to 20 percent by installing simple devices, tuning engines, and performing proper regular maintenance. The feasibility of this option for Mongolia is currently assessed to be in the high range. Policy barriers are assessed to be low because the Government has a policy of encouraging energy savings. The emissions reduction impact of this option is assessed to be in the medium range. Local benefits of this option could be substantial.

Summary of Mitigation Options in the Energy Sector

To provide guidance in designing national climate change mitigation strategies, the ALGAS study generated cost of emissions reduction initiative (CERI) curves. CERI curves are developed to help policy makers and other interested groups understand the economic impact of choosing different sets of GHG mitigation policies and options. A CERI curve is estimated by determining the difference in costs between a baseline (reference) scenario and an alternative scenario; this difference is referred to as an incremental costs. These curves represent a projection of a country's future cumulative net GHG emissions over time without the implementation of a set of GHG mitigation interventions (baseline) versus with the implementation of a set of GHG mitigation interventions (alternative). An integrated approach was adopted in the energy sector using the EFOM-ENV model. The mitigation cost and mitigation potential for each of the GHG abatement options are shown in **Table 6.21**.

Table 6.21. Mitigation Costs and Mitigation Potential for each GHG Abatement Option

GHG Abatement Options	Incremental Mitigation Cost \$ / tonne CO_2	Mitigation Potential (Cumulative Emission Reductions) millions of tons of CO_2
Lighting efficiency improvement	-2.48	4.35
Building Insulation Improvement	-1.73	9.08
District heating system loss reduction	-1.71	12.74
Small Combustion Efficiency Improvement	-1.43	6.34
Vehicle fuel consumption efficiency improvement	-0.39	12.77
Electricity Transmission loss reduction	-0.33	3.31
Biomass energy system	-0.22	0.70
Motor efficiency improvement	0.31	21.53
Coal benefication	2.26	10.17
Wind power system	2.41	0.36
Photovoltaic Solar System	4.46	0.19
Hydro power Development	10.32	1.47

Source: ALGAS Mongolia, Manila Philippines, 1998

Industry Sector

The following GHG mitigation options (technologies) were selected on the basis of mitigation studies [20]

- *Motor efficiency improvements:* Motor systems use about 70% of industrial electricity in Mongolia. These motor systems are often less efficient than the ones in industrialized countries. Motor efficiency improvement technology includes using energy-efficient motors and variable speed drives; improving operation and maintenance; correcting previous over-sizing; and improving mechanical power transmission and efficiency of equipment that is driven. It is estimated that the electricity savings potential is 20% of the electricity currently used by industrial motors.
- *Good housekeeping practices and energy management:* Mongolian industry has significant potential for saving energy through improvement of energy use and management. The energy savings potential by "easy" savings (good housekeeping practices that minimize the use of heat and electricity and energy management) is 15-25 % with a cost recuperation period of less than 1 year.
- *Steam saving technology (steam traps, heat recovery, pipe insulation, etc.):* This technology includes the rehabilitation of steam systems, including the repair of steam traps, insulation and valves and the return of condensate. It is assumed that 30% of all industrial heat demand is steam consumption. Industry's steam savings potential is estimated to be 25%.
- *Introducing dry-processing in the cement industry*: Changing the wet-processing of cement to dry-processing saves a large amount of energy. This has been proven by the feasibility study, which was conducted within the framework of the Clean Development Mechanism project to reduce GHG emissions. It is estimated that 25% of all industrial coal is used for cement production. Wet-processing of cement requires 1,500 to 1,700 kcal/kg-cl of heating whereas dry processing may require 1,000 to 1,200 kcal/kg-cl. This boils down to a savings potential of 40% of the coal consumption in the cement industry.

The most attractive CO_2 emission reduction options are implementing good housekeeping procedures (including energy management), improving motor efficiency and using dry-processing for cement production. CO_2 emission reduction potentials for selected options are given in **Table 6.22.**

Table 6.22. CO_2 Mitigation Potential for Selected Options in Industry Sector

GHG Mitigation options	Energy saving potential in 2020, GJ/year	Total system cost reduc-tion*1000 US$	Cumulative CO_2 emission reductions, thousand ton	Specific mitigation cost, US$/ tonne CO_2
Motor efficiency improvement	4279.3	-7,473.00	5,540.00	-1.35
Steam saving technology	791.37	-7,346.00	1,370.00	-5.36
(steam traps, heat recovery,				
pipe insulation)				
Good housekeeping	2989.62	-330,098.00	5,670.00	-58.21
(including energy management)				
Dry process of cement production	3722.37	420.00	3,410.00	0.12
Total	11782.7		15,990.00	

** Difference between total system costs of alternative scenario and baseline scenario.Source: Greenhouse Gas Mitigation Potentials in Mongolia, Ulaanbaatar, 2000.*

Agriculture Sector

Traditional pastoral animal husbandry and cultivation of arable land are the major economic activities of Mongolian agriculture. Livestock production accounts for about 80% of gross agricultural output while arable land is limited to cereal crops (spring wheat, oats, barley and vegetables). Domestic livestock production is a major source of methane emissions in Mongolia and contributes 90-93% of the country's total methane emissions.

The total number of livestock at the end of 2007 was estimated at 40.3 million with 17.0 million sheep, 18.3 million goats, 2.4 million cattle, 2.2 million horses and 0.3 million camels. During the last three years, the livestock population has increased by 30 percent. Mongolia is one of the few countries with a pastoral nomadic economy with historical traditions of animal husbandry. Pastureland is the primary source of the forage and feed needed to support extensively managed livestock in Mongolia. One of the features of Mongolian animal husbandry is seasonal movement among different pastures so the manure of the animals is managed under aerobic conditions or just as a solid on pastures and ranges. Animal breeds are small and less productive than breeds in other countries.

Potential options are as follows:

- to limit the increase of the total number of livestock; and
- to increase the productivity of each type of animal, especially cattle.

Intensive, industrial, livestock production enterprises practically do not exist in Mongolia. Therefore, methods such as mechanical and chemical treatment of feed, production enhancing agents, covered lagoons and large and small scale digesters are not applicable in Mongolia.

Land Use and Forestry Sector

Forests are complex ecosystems capable of providing a wide range of economic, social, and environmental benefits. In addition to their economic importance, Mongolian forests play important roles in biodiversity and in the region's carbon budget –the balance between carbon release and capture. Because a considerable amount of carbon is temporarily stored in forests, they influence the accumulation of carbon in the atmosphere, both through emissions from fire, decay, harvesting and processing and through absorption and storage as they grow.

Mongolian forests provide many services in regard to climate change and other environmental problems, including serving as carbon sinks, sources of renewable energy, watershed protection and soil erosion protection. Many of these services have been lost, or will be lost, due to the extreme pressure exerted on Mongolia's forest resources.

The following major mitigation options are identified for the forestry sector:

- *Natural regeneration*
- *Plantation forestry;*
- *Agroforestry;*
- *Shelter belts; and*
- *Bioelectricity*

Among these options, agroforestry and bioelectricity have a high priority for meeting national environmental and socioeconomic development goals (ALGAS, 1998). The selected options were further assessed using the COMAP model to calculate the life cycle cost per tonne of carbon abated. The options were ranked from the lowest to the highest cost. While natural regeneration has the lowest cost per ton of carbon abatement (0.8 $/tC abated), agroforestry (0.9 $/tC abated) and plantation forestry (1.1 $/tC abated) options are very comparable in cost to natural regeneration. The shelter belt (2.0 $/tC abated) and bio-energy (2.4 $/tC abated) options showed relatively higher costs compared to the other options. **[18]**

Waste Management

Waste disposal is a mounting problem in Mongolia, not only in terms of GHG emissions, but also in terms of land use and sanitation, especially in Ulaanbaatar (UB). Almost half of Mongolia's population lives in the capital city. At present, the total amount of waste generated in UB is estimated to be 552.8 tons per day. Of this waste, 321.6 tons (58.2% of the total amount) is thought to be brought to final disposal sites, while 21.4% is dumped illegally along the main streets of suburbs or in open space. The recycling rate was calculated at 3.7%. More than half of it is collected and recovered by waste pickers either on the streets or at the disposal sites. According to population projections and the expected economic growth rate, the estimated amount of waste that will be generated in the future is as follows: in 2010, 588.2 tons/day; in 2015, 620.2 tons/day; and in 2020, 641.4 tons/day.

All collected waste in the city of Ulaanbaatar is disposed in three landfills (Dari-Ekhiin Ovoo, Ulaan Chuluut and Moringiin Davaa) without any further processing. The management of municipal waste is emerging as a problem of prime importance. The Ulaan Chuluut disposal site is the largest disposal site in Ulaanbaatar and has been the cause of various environmental problems for a long time. For the Municipality of Ulaanbaatar, the improvement of the disposal site in Ulaan Chuluut has been an urgent issue.

The Pilot Project for the Urgent Improvement of the Ulaan Chuluut Disposal Site is being implemented by the Japan International Cooperation Agency (JICA). The objective of this pilot project is:

- To establish a control and management system of collected waste in order to avoid illegal dumping;
- To dispose of waste at the designated area; and
- To rehabilitate the completed landfill area and conduct a sanitary landfill operation to the extent possible.

Mitigation of GHG emissions from the waste sector is generally not a high priority because the methane emissions associated with this sector are relatively low. However, the following mitigation options in this sector were considered:

- *Landfill methane recovery;*
- *Comprehensive waste management; and*
- *Alternative waste management, such as recycling.*

One of the major options for methane emission reduction is source reduction of solid waste and wastewater. The following options can be implemented **[19]**

1. *Recycling:* It is necessary to begin categorizing solid waste, for example, household bottles, plastics, paper, domestic as well as industrial ash, pipes, raw metal parts, etc.
2. *Storage and collection system:* The system currently in operation does not yield the same results for every area because the outcome depends on a number of factors, such as, the area size, amount of waste to be collected, available road space for the placement of containers, effective operation of collector vehicles, etc. Thus, raising the collection rate of solid waste from all areas (household, commercial, industrial and others) is the essential option for reducing gas emissions from waste.
3. *Incineration:* For solid waste, some experts suggest the use of a new incineration technology, a kiln with heat recovery. At present, most of the solid waste is burned in open dumping sites.
4. *Improve solid waste disposal facilities:* The quality and technical capability of containers and trucks for particular types of solid waste and/or for particular districts of Ulaanbaatar should be improved. For instance:

- In *ger* or the traditional Mongolian tent house areas: replace existing trash containers with changeable containers with a volume of 10-12 m^3, which will be carried by special trucks.
- In apartment areas: for sludge disposal needs, use containers with a volume of 2.5 m^3 and have an arm-roll and an automatic draw off system.
- For other areas: use containers with a volume of 12 m^3.

5. *Small projects:* In small communities, domestic waste is washed by rain water into streams and gutters or collected in ponds and in lowlands. This is becoming a problem in terms of gas emissions, environmental contamination and health risks. While a complex treatment system is not feasible in such cases, this problem can be solved by implementing small scale projects.

6.5. Implementation Possibilities of GHG Mitigation Projects

Greenhouse gas mitigation projects in developing countries could be implemented as clean development mechanisms (CDM). Mongolia is one of the potential host countries of CDM projects. Despite a small population and economy, Mongolia's GHG emissions are relatively large, due mostly to climatic factors (cold winters). In particular, there is considerable scope to use renewable energy resources to replace fossil fuels, to reduce fossil fuel input by replacing outdated heating equipment with more efficient heating equipment and to increase energy efficiency in industry. CDM can play an important role in the sustainable development of Mongolia's economy –CDM can help reduce pollution, make the economy more competitive, create employment and reduce poverty. The potential benefits to Mongolia from CDM can be relatively large, especially given Mongolia's climatic conditions.

In order to realize the potential benefits from CDM, Mongolia needs to attract CDM projects, either in the form of investment in projects or in the form of certified emission reduction (CER) purchases. In order to realize this potential, Mongolia should establish conditions that make it an attractive place for CDM projects.

Recently, several projects have been approved and registered as CDM. These are summarized (**Table 6.23**. and **Table 6.24**).

Table 6.23. Summary of Hydropower CDM projects in Mongolia

Name of Project	Type of Project	Expected CERs, CO_2-eq/yr	Project Status	Host Country and Organization	CDM Project Development Participants
Taishir Hydropower Project	Small scale hydropower project	29,600	Operational	Mongolia, Ministry of Fuel and Energy (MFE)	Energy Research and Development Center (ERDC)/ Mongolia Mitsubishi UFJ Securities Co., Ltd./ Japan
Durgun Hydropower Project	Small scale hydropower project	30,000	Operational	Mongolia, MFE	ERDC/Mongolia Mitsubishi UFJ Securities Co., Ltd./ Japan
The 220 MW Egiin Gol Hydroelectric Power Generation Project	Hydropower project	192,500	Delayed Impelement-ation	Mongolia, MFE	ERDC/Mongolia Mitsubishi UFJ Securities Co., Ltd./ Japan

Table 6.24. Summary of Energy Efficiency CDM projects in Mongolia

Name of Project	Type of Project	Expected CERs, CO_2-eq/yr	Project Status	Host country and Organization	CDM Project Development Participants
A retrofit program for decentralized heating stations in Mongolia.	Small scale energy efficiency project	11,904	The project has been partially carried out	Mongolia, Ministry of Nature and Environment	Mongol Zuukh XXI Ltd./Mongolia PROKON Nord Energiesysteme GmbH/ Leer, Germany
Energy efficiency improvements carried out by an Energy Service Company (ESCO) in Ulaanbaatar, Mongolia to replace old boilers with new ones	Small scale energy efficiency project	22,700	The project is under implementa-tion. 10 inefficient boilers have been replaced with energy efficient boilers	Mongolia, any ministry or organization	Open to any Ministry/ MongoliaMitsubishi UFJ Securities Co., Ltd./ Japan

CDM cooperation in Northeast Asia has a tremendous opportunity to benefit from Kyoto mechanisms by integrating their economic development and environmental conservation efforts. Northeast Asia is composed of both Annex 1 and non-Annex 1 countries, and all of the countries are already parties to the Kyoto Protocol. The realization of the mechanisms can take place entirely within a regional framework.

Japan, the world's leading industrialized nation, faces challenges in meeting its Kyoto targets. At the same time, the industrial structure and technology in most Northeast Asian countries is still dominated by inefficient, wasteful and polluting technologies and energy intensive machinery and equipment. Therefore, there is an exact match of supply with demand with regard to the development of Kyoto mechanisms in the region.

In order to realize the potential benefits from CDMs, Mongolia needs to attract CDM projects, in the form of either investment in projects or CER purchases. In order to realize its potential, Mongolia should establish conditions that make it an attractive place for CDM projects. Accordingly, the Mongolian Government has established the Designated National Authority (DNA) under the Ministry of Nature, Environment and Tourism. This is because without the DNA, Mongolia cannot formally approve CDM projects, and thus, the registration of CDM projects in Mongolia would be impossible.

The roles of the DNA are as follows:

- To act as the country's focal point for CDM projects;
- To facilitate project development;
- To provide technical guidance to companies;
- To approve projects;
- To conduct market studies and project identification;
- To implement a monitoring system;
- To spread awareness through domestic and international outreach efforts (e.g., organize meetings, workshops, conferences, etc. with relevant companies and organizations and provide relevant

Kyoto Protocol-related information to companies and other third parties);

- To conduct international outreach efforts to countries.

For the success of CDM development, the following activities need to be implemented:

- Focus CDM capacity building on policy makers and government officials, the DNA for CDMs, project developers, project financiers, NGOs, local communities and research organizations;
- Work with the private and financial sectors to identify CDM projects, formulate business plans, raise financial support and implement project activities;
- Establish a pipeline of CDM projects based on sustainable development, especially in the energy sector;
- Strengthen the network among researchers, policy makers, project developers and NGOs working on CDMs.

7 Technology Needs Assessment

7. TECHNOLOGY NEEDS ASSESSMENT

7.1. Technology Needs in Energy Sector

The priority goal of the energy sector is to reduce fuel consumption. In other words, the sector focuses on assessment of technological needs and aims to develop and introduce new advanced technologies which could meet the increasing demands for energy by burning significantly less fuel. About 40 percent of heat generated from fuel burning is lost and goes unutilized. From the study conducted, it was estimated that only 45 percent of heat generated from overall fuel burning is used inefficiently. Total heat loss structure is shown in **Figure 7.1** below. Over 70 percent of overall heat loss occurs at the production level and therefore developing boiler technologies that increase efficiency is very important.

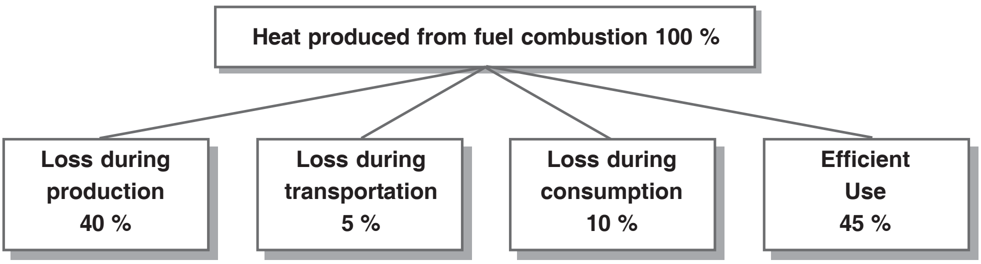


Figure 7.1 . Composition of Heat Losses from Overall Fuel Burning

Combined Heat and Power Technology

Combined Heat and Power Plant (CHP) produces approximately 98 percent of the country's electrical power energy. Although, Mongolia is rich in renewable energy sources of wind, solar and water, utilization of these sources has not reached an efficient level. Currently, small scale hydroelectric power plants produces electricity but only in quantities of less than one percent of total energy generation.

Coal Combustion Technology

There are two methods of burning coal:

1. *Burning coal on fuel beds is characterized by the relative directions of the flow of fuel and the air used for combustion. Combustion occurs in the furnace. This method is used in medium and small capacity boilers, furnaces and stoves.*
2. *Pulverized coal combustion systems are used with high capacity steam boilers of CHPs. The dominant method of burning pulverized coal burns it as a fine powder suspension in an open furnace.*

About 23 percent of total coal consumption is consumed by electrical power stations.

There are a number of advanced technologies suitable for the energy sector that are currently available:

1. Increased efficiency of energy production:
   - Technologies to produce electricity with less fuel;
   - Renewable energy technologies; and
   - Nuclear power technologies.
2. Introducing stoves with higher efficiency coefficients.
3. Utilizing technologies that minimize heat loss.
4. Lightening technologies that use less electricity.
5. Technologies that allow consumers who use the central heat system to control their own heat consumption. In other words, installing temperature control equipment with heat meters in each household and providing individual consumers with separate financial accounts.
6. Utilization of engines that use less electricity.
7. Improve the efficiency in the steam supply network.
8. Reuse condensed water from steam heat.

The measures mentioned below are essential to improving the efficiency of energy production and its sources:

1. To develop more efficient and cleaner technologies for power generation and distribution through the national electricity grid.
2. To gradually replace electric power plant and national electric grid equipment with more efficient, higher productivity and cleaner technologies and to stop using equipment that cannot be upgraded;
3. To build one of the below mentioned types of power plants/stations to improve the structure of energy network:
   - Hydropower plants with higher capacity;
   - Water-tank electrical power station;
   - Heat power plants of bigger capacity to operate with advanced techniques and technologies located next to a coal mining;
   - Wind power development.

7.1.1. *Electricity Supply*

The Mongolian Central Energy System (CES) is responsible for generation and distribution of electricity and heat throughout the interconnected grid and is the principal entity responsible for supplying energy to about one-half of the population of Mongolia. In recent years, electricity transmission lines hundreds of kilometres long were built under the public program to build a national energy grid for Mongolia. The grid covers areas where approximately 80 percent of the country's population resides. The Central Energy System provides about 90 percent of the total electricity needs of Mongolia. Combined Heat and Power Plants (CHP) generates 99 percent of the electricity and supplies 70 percent of district heating systems. The specific fuel consumption for electricity generation of CHP is shown in **Table 7.1.**

Table 7.1. Specific Fuel Consumption for Electricity Generation for CHP, gram. CE/ Kwh

CHP	Years									
	1980	1985	1990	1995	2000	2001	2002	2004	2005	2006
Average	398.0	370.1	347.8	435.7	420.8	408.6	414.3	389.5	378.4	366.7

The current level of specific fuel consumption for a CHP is 370-400 grams CE/ kWh, which shows that our technology is outdated. This level is still higher by 80-100 gram CE/kWh compared to Russian CHPs. The specific fuel consumption for electricity generation is a main criterion of the heat supply efficiency. CHPs operate often on coal and experts suggest using the technologies listed below to reduce the impact on the environment.

1. Fluidized–bed combustion technology;
2. Combined cycles and cogeneration. Advansed combined cycles, in which the gas turbine exhaust is used as a heat source for a steam turbine cycle, can achieve overall thermal efficiencies in excess of 50%.

The construction of the new CHP is expected to reduce severe air pollution in Ulaanbaatar significantly as a result of increased efficiencies as well as by reducing the number of stoves used for household and water boilers purposes, all of which will result in the reduction of GHG emissions.

Renewable Energy Sources

The Japan International Cooperation Agency has introduced the 'Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia". According to this plan, up to 20 percent of the country's electrical power will be supplied from renewable energy sources by the end of 2020.

Small hydropower development is one of the best technology options for electricity supply for remote and low-demand consumers. Up to date, two small hydro sites with a capacity of 11-12MW, two small hydro sites with a capacity of 1-2MW, and nine sites with a capacity of 110-500MW are operating.

Wind power generator systems. Small stand-alone wind power systems for battery charging can be used for low power and high quality applications such as lighting and telecommunications. The larger scale wind turbine generators with capacity of 100-150 KW have been operating in 15 provincial centers of the southern part of Mongolia.

Photovoltaic (PV) solar system. Solar home systems are easy to transport and can be used for low-power DC applications and even for low-power AC applications if the system includes a transformer. Almost half of 170,000 herder households use the solar panels of 50W and 40% of them use ones with 20-30W.

7.1.2. *Heat Supply*

District heating systems are in all of the major cities and towns in Mongolia. The efficiency of CHP boilers is low and new and advanced equipment to update old CHPs is needed to improve efficiency. Taking into account the outdated condition of steam boilers at the power plants, many projects have been implemented to improve their efficiency by installing new equipment. The results were positive and the reliable operation and efficiency of energy production was improved.

Medium Capacity Heating Boilers. There are approximately 20 steam and 30 HOB boilers with coefficient efficiency of h=0.7-0.8 in 13 provincial centers where district heating systems are available. Russian made heat boilers were installed during the period of 1980-1988 and many of these older systems are still in operation. Reconstruction and modernization of medium capacity heating (steam) boilers could be accomplished by implementing the following technologies:

- Installation of nuclear heat plant;
- Change the design of boilers, and introduce coal fluidized bed combustion technology;
- Change the design of boilers, and install steam boilers.

Small Capacity Hot Water Boilers. Approximately 10% of annual coal consumption is used for heating for more than

340 populated areas, including ger districts in the big cities of the country. Those outdated boilers with lower efficiency (0.4-0.5), installed during the socialist period provide heating for schools, hospitals, kindergartens and other public institutions. As mentioned above, boilers do not have optimum design and their efficiency coefficient is below average. Also, the absence of water treatment equipment in all boilers used across the country leads to quick deterioration of the boilers rendering them useless after 4-6 years. The reasons for the high level of heat price, which is about USD 20-30/GCal (in 2006), are as follows:

- Application Inefficiency. 600 to 715 kg of coal is required to produce one GCal of heat;
- At the present time, approximately 20 coal mines are operating at sites that are located 80-350 km and even as far as 480 km from urban areas. Transportation cost compromise about 60-80 percent of a total cost of coal.

Suggested options to increase the efficiency of small capacity heating boilers:

- Install new high efficiency boilers in areas which are not connected to the central power grid;
- Replace existing boilers located in soums that are over 150 km from coal mines and are connected to the central power electricity grid with electric boilers or heat pumps. This would result in a reduction of heat and coal consumption;
- Install water treatment facility to remove minerals from boiler water. Salt or other mineral chemicals such as calcium and magnesium are dissolved in untreated water, sometimes referred to as “hard water,” that is used in boilers and heating systems. As a result, a dense scale layer is formed in the boiler and heating pipes which results in lower efficiency of heat generation and a shorter life of the boiler and related facilities.
- Provide opportunities to both boiler houses and consumers to have heat meters and boilers respectively;
- Replace heating only boilers with lower efficiency with ones of higher efficiency; and
- Install oil or gas fired boilers.

Furnaces and Coal Stoves. About 55% of the population lives in cities and province centers, 14% in province units and settlements and 31% in the countryside, i.e. far from any settlement. 70% of the total population lives in gers and houses which utilize 330-360 thousand furnaces/stoves. Approximately 180 thousand furnaces/stoves in large cities and province centers only utilize coal for heating. The gers and houses in large cities and province centers annually use 4.3 tones of coal and 1.5 tones of wood for producing 6-7 Gcal of heat for heating and cooking. The efficiency of stoves in houses and gers are the same as 30-40% . The following proposed measures could increase efficiency of household furnaces and stoves:

- To use of pre-fabricated fuel;
- To use of electric heaters; and
- To move residents of ger districts into apartments.

7.1.3. *Distribution Systems*

The industrial sector is one of the largest energy consumers. It uses about 70% of the electricity and 28% of the heat that is produced. The transport sector primarily uses imported petroleum products. The total energy consumption of the transport sector was 551,000 tones in 2005. The residential sector is the largest consumer of commercially produced energy in the country. It consumes 11% of the coal, 48% of the heat and about 25% of the electric output. The energy use of the service sector has been increasing rapidly. The energy consumption of agricultural sector is comparatively low.

Electricity Distribution System.

Electrical power is primarily used by the following four main categories – motors, thermal electric equipment, lighting and electrical appliances. An assessment of technology needs for the electrical distribution system was conducted for each of these categories.

Motors and Drives.

Mongolia like the other developing countries is relying on motor systems to power the expansion of its industrial sectors. Motor systems consume about 70% of industrial electricity in Mongolia and these motor systems are less efficient than motor systems in industrialized countries. Electric motors and drives are generally oversized and badly maintained which leads to a significant decrease in their efficiency. This is particularly relevant for the milling and tanneries/textile factories because they utilize a high number of electric motors. Audits have measured the load of such machinery to be as low as 20-30%, typically resulting in efficiencies in the range of 50-60%. For efficiency to be achieved, this must be more than 80% for properly designed and maintained motor-installations. Technologies to improve motor efficiency include the following:

- Utilizing new energy-efficient motors;
- Improvements in the power factor;
- Use of variable speed drives;
- Correction of previous over sizing;
- Improved mechanical power distribution; and
- More efficient driven equipment.

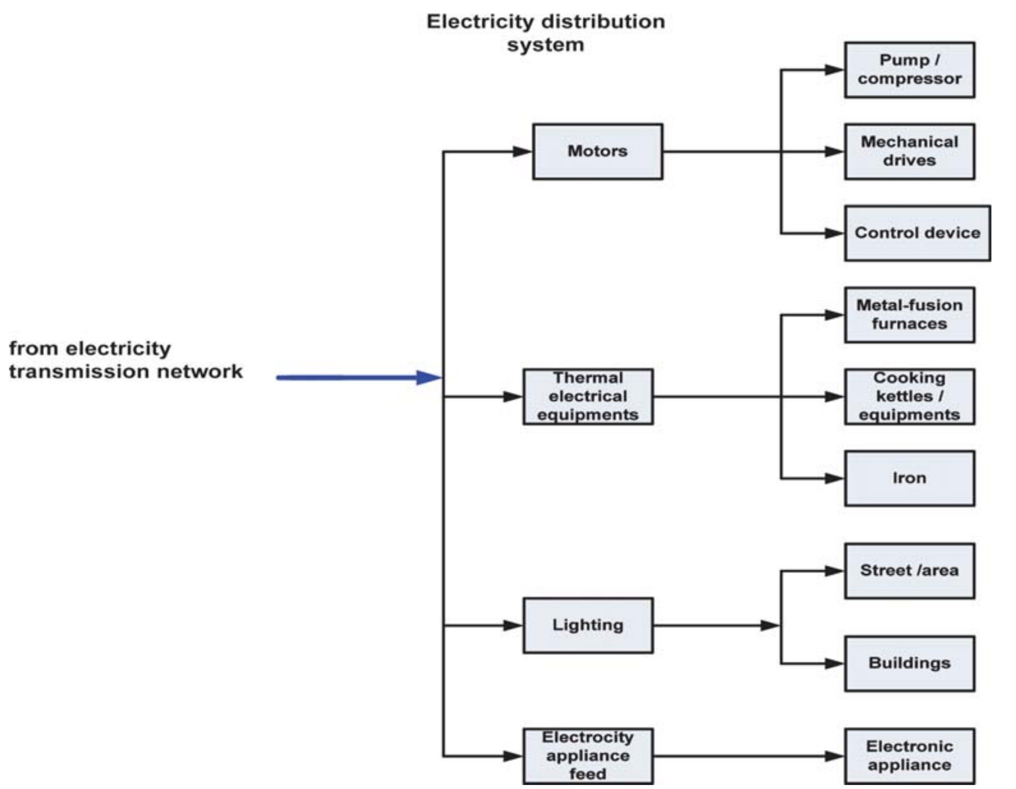


Figure 7.2. Structure of Electricity Distribution System

Heat Distribution System

Consumers of heat power energy are divided into the five main categories shown in below. An assessment of technological needs for the electricity distribution system was conducted for each category too.

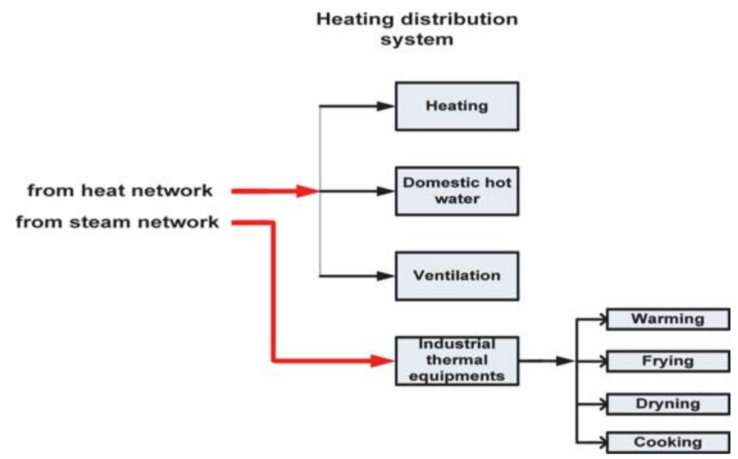


Figure 7.3. Structure of Heat Distribution System

Thermal energy is used for heating of buildings, production of goods and services and preparation of household hot water. 90 percent of overall energy is used the building heating purposes which is a peculiarity of Mongolia. Therefore, the introduction of technologies aimed at improving building insulation is critical to achieving increased energy efficiency.

Heat Consumption of Mongolia and Its Structure.

Daily social life without warm buildings is impossible to imagine in Mongolian climate condition, especially during cold seasons.

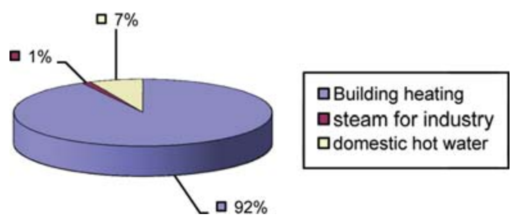


Figure.7.4. Heat Distribution Structure

Building Insulation Technology.

The purpose of heating is to keep the indoor temperature at a desired level during the cold season. The amount of heat a building loses depends on the outside temperature and air speed. This means the heat loss is the heat load of the building. Currently, buildings are poorly insulated and heat loss is high. An additional complication that adds to inefficiency is the fact that residential consumers have no means to regulate temperature inside of their homes. Houses in particular have relatively higher heat losses. If to compare these indexes with current standards, it is lower by 2-3 times; this fact shows that most of the houses have a higher than average rate of heat loss.

The introduction of technology that allows costumers connected to the central heat supply network to adjust their own heat consumption could help improve energy efficiency. This would be achieved by installing meters that would provide each household/ individual costumer with separate financial accounts reflecting the amount of heat used and charging accordingly.

Control and Measuring Equipment for Energy Consumption in Apartments.

Since 2000, production and service entities in Ulaanbaatar and Darkhan have been using heat meters. Although, the population’s interest in saving heat energy has grown, this is not strong enough in rural areas as it has become among urban inhabitants. In Mongolia, about 30 percent of the country’s population lives in public apartments connected to the central heat supply network. None of those apartments have heat meters and their heating fee and price is calculated based on fixed tariff that does not reflect the amount of heat used. Additionally, these apartments do have thermostats that allow residents to adjust their own heat consumption. Residents simply open their windows when indoor air temperatures are too high in order to let out the warm air.

Steam Systems.

The national production of steam has been in idle state since 1990 and the steam consumption has been greatly reduced. Even today in Ulaanbaatar, Darkhan, and Erdenet, the steam grid cannot operate at normal regime. Technological improvements to the steam systems could include:

- Improved return of condensate;
- The addition of insulation, repair of steam traps; and
- The installation of meters and other technologies to gage use and correlate charges accordingly.

7.2. Technology Needs in Transport Sector

Transportation is one of the most important economic sectors in Mongolia due to its sparsely populated vast territory. Currently, the following types of transportation are available in Mongolia:

a. Road transportation;

b. Railway;

c. Aviation; and

d. River and inland water transportation (but this sub-sector is relatively undeveloped).

There are not any oil companies or enterprises exploring liquid fuels. So far, all types of liquid fuels are imported from Russia and China.

7.2.1. *Railway Transport*

Currently the Mongolian railway is executing 96.0 percent of national freight, with 1,815 km of railways connecting Russia, China and big domestic industrial cities including Darkhan, Erdenet and Sukhbaatar. The Ulaanbaatar Railway has made a valuable contribution to the growth of the Mongolian economy and played a historical role in the development of a national transportation network, connecting new industrial areas, mineral resources and deposits, and the most populated villages. Diesel trains are manufactured in the Russian Federation.

7.2.2. *Road transport*

Also, the number of cars has been increasing from year to year and its percentage in overall vehicles is more than half as shown in statistics of 2006. In last 15

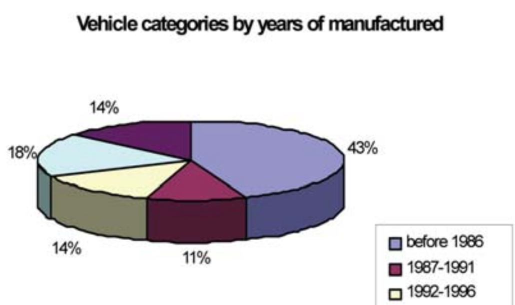


Figure.7.4. Heat Distribution Structure

years, Mongolia has imported many used cars from Japan, Korea and other countries.

The main characteristics of road transportation sector are:

- Approximately 75 percent of all cars are being used for more than 9 years;
- Mongolia is using petrol mainly imported from Russia and its emission factor is same as stated in the IPCC;

- Annual average distance traveled by a car is approximately 28,000 km; and
- The level of combustion efficiency for older vehicles is under average due to their engine condition.

7.2.3. *Air Transportation*

Since 1996, the air transportation sector has been in decline and passenger traffic has dropped off dramatically. Due to the high cost to travel by air, most domestic passengers are choosing to drive instead.

Technology Needs in Transportation Sector

The use of advanced technologies in the Mongolian transportation sector is low. For example: fuel compsumption in real way is high due to usage of old and inefficient diesel locomotives. One possible solution would be installation of electric railway system and use electric locomotives which would lead to increases in efficiency of railway transportation; and reduction of fuel consumption.

Automobile fuel consumption is increasing because of importation of second hand vehicles typically 9 years old. The following technologies could help improve fuel efficiency in the transportation sector:

- Hybrid vehicles;
- Eliminate traffic problems in Ulaanbaatar;
- Modal shifts from road transportation to rail and public transport systems (subway); and
- Increase vehicle service to improve fuel efficiency.

7.3. Technology Needs in Industry Sector

Since the 1970's, large industries were established by the State to supply the home market on a national basis and to process Mongolian agricultural production for export. Industrial production in Mongolian decreased significantly between 1990 and 2003. Since 2003 the industrial sector has been recovering gradually. The Mongolian industrial sector consists primarily of four categories:

- The Erdenet Mining Company. This is the largest industrial concern in Mongolia and consumes 65% of the electrical energy and 47% of the coal used by industry.
- Other main industries. There are some fairly large industries established by the State to supply home markets. These industries are mainly in food, textile, leather and building materials. They are in the course of a privatization.
- Small industries. According to the Ministry of Agriculture and Industry, there are about 6,000 small industrial enterprises registered in Mongolia. Many of them are established in the regions including soum centers, but little is known about their current activities. They include enterprises in the food and wood processing sectors.
- Modern industries.

7.3.1 *Cement Industry*

There are two cement factories in Mongolia. In transition period, the Darkhan cement plant was privatized and is owned by Erel Cement Company. The company improved the equipment and facilities with funds from Erel Company and has responded to the market economy. The Hutul cement plant's activity is being stabilized and technical innovations are being made. A new plant will be set up under Russian assistance in the near future.

In recent years, the construction industry has been recovering and demand for cement is increasing. Although the price of cement imported from China is comparatively low, the domestic cement industry has not improved. In 2008, annual cement consumption increased to 550 thousand tonnes and 25 percent of this increase was attributable to national demand.

According to the Feasibility Study on Energy Conservation and Modernization that the Darkhan Cement Company made, the installation and modification of equipment and the improvement of technology will result in energy conservation and reduction of CO_2 emissions if the following steps are taken:

1. Improvement of raw material proportioning process;
2. Improvement of raw material grinding process; and
3. Improvement of burning process.

Energy Savings Technology in Industry

Energy audits provided by ADB and demonstration projects financed by TACIS show that the energy saving potential is very high in Mongolian industry.

- Technologies to improve the effectiveness of industry electrical engine and transmission
- Technologies to improve the effectiveness of air system
- Technologies to improve the effectiveness of industry technological stoves
- Technologies to re-consume the consumed heat
- Usage of modern energy saving consumptions

7.4. Technology Needs in Agriculture Sector

Livestock husbandry is the main livelihood and source of wealth in Mongolia and the country's economy substantially depends on the production and development of this sector. The value added of agriculture sector is 20 percent of GDP of Mongolia in 2007. The livestock production comprises 80 percent of the total agriculture production. Due to the privatization of the domestic livestock industry, the number of livestock has increased in the last few years. Most of this growth has been in number of goats as the demand for cashmere wool has increased significantly.

Traditional Mongolian livestock are adaptable to a variety of different conditions, can adjust to changes in climate and feed themselves by grazing. These types of livestock belong to a system of ecological pure production.

Grasslands and arid grasslands are estimated to cover 125 million hectares of Mongolia, and forest and scrubland cover 15 million hectares of Mongolia. Grazing of livestock is the major form of land use in Mongolia and has been the traditional way of life for Mongolians for thousands of years. Grazing of large herds of horses, sheep, and goats has played a large role in determining the vegetation cover and species composition of the grasslands. There are a total of more than 40 million head of domestic livestock in Mongolia. The percentage of goats as compared to the total number of livestock in 2006 was 41.8% and in 2008 increased to 48 percent.

Grasslands account for 80% of Mongolia's territory. Although estimates vary, it is certain that a significant proportion of these lands are overgrazed, causing loss of biological diversity, soil erosion and economic losses that could become very serious if the present trends continue. Current livestock numbers, estimates of forage availability and an indicative feed balance have been made for all provinces of Mongolia. These show that many provinces are overstocked and those provinces with an apparent surplus of forage are usually those where water supply limits grazing. Furthermore, the annual yields of herbage are in most cases less than 500 kg of dry matter per hectare, and this is usually considered to be the optimum amount to be left after grazing to allow ragwort of palatable species and prevent desiccation of soils in dry environments.

The process of pasture degradation has two main causes:

1. Climate change; and
2. Increases in the number of livestock (including goats) which leads to overgrazing.

The best ways to combat pasture degradation and desertification are:

- To follow the traditional pastoral livestock breeding principle (as ecologically pure production);
- To support the intensive livestock production entities in crop production zones;
- To determine the optimal structure and carrying capacity of livestock in a given area, for example goats' number; and
- To improve the pasture utilization management

7.5. Technology Needs in Land Use and Forestry Sectors

Total agricultural areas of Mongolia equal 113,500 thousand hectares in 2005 and 99 percent of these areas consist of meadows and rangeland. Mongolia began to cultivate considerable land area only after 1958 by converting grasslands into cropland for cultivation. The area of arable land continued to increase until the end of 1980s. For example, from 1958 to 1990, 1.2 million hectares of grasslands were converted to arable lands.

For last 26 years, the number of sown areas has been decreasing rapidly. The crop production sector is bankrupt and Mongolia become importor for crop products, food and vegetation products. In recent years, the Government of Mongolia has determined that the replacement of the crop farming is a priority of its agricultural policy. Abandonment of cultivated lands has accelerated recently as marginal lands have been taken out of production in the recent transformation period from a socialist to a market economy. Specifically, about 140 thousand hectares of land have been abandoned on average during the last 16 years. These abandoned lands revert back to grasslands.

The nationwide average forest reserve indicators can be summarized as follows: average quality is 4.2; average density 0.53, 132 cubic meter reserve in 1 hectare of land, and average life expectancy for coniferous tree is 128 years and for deciduous tree 44 years. 58.3% of the state protected areas (or 35 out of 61 state protected areas) have forest. 1.80 million ha of state protected land is forest, out of which 3.32 million ha are deciduous forest and 1.54 million ha are sacsaul forest. In 2006-2007, forest harmful insects and diseases caused damages to 1,138,108 ha of Mongolian forest reserve. With the participation of local communities and financial support from the Ministry of Nature and Environment, Local Administration and UN Food and Agricultural Organization, activities toward restraining the spread of forest harmful insects in forest area and developing of new technology for combating harmful insects have been organized.

According to forest census, forest preserve areas have increased nationwide, however, in the past few years, because of human negative activities, large forests in certain areas have been affected by wildfire; however, a recovery has not been very successful. Out of the affected land, 391.8 thousand ha are forest area and 5,202.2 thousand ha are steppe.

In 2005, total of 609.9 thousand cubic meter timber was harvested. Out of this, 39.9 thousand cubic meters are for industrial use and 570.0 thousand cubic meters for firewood and 3,260 thousand trees were planted.

Parliament of Mongolia approved Law on Forest in May 17, 2007 in order to improve the coordination between policies and activities concerning forests. In the nearest future these technologies will be improved and following advanced technologies will be implemented:

- Forest conservation;
- Reforestations;
- Improved irrigation; and
- Reduction of sown areas by increase of crop yield per hectare.

7.6. Technology Needs in Waste Management Sector

7.6.1. *Municipal Solid Waste.*

Cities in Mongolia are not very large. However, one-half of Mongolia's population does live in these cities, with the main form of solid waste disposal being the open dump. There are 490 solid waste collecting posts, which cover the area of over 3,015 thousand square meters in Mongolia.

Assessments show that there are 1,500-1,800 m^3 daily and 650-700 thousand m^3 solid waste (SW) is produced annually in Ulaanbaatar. There are three final disposal sites in Ulaanbaatar. The manner of disposal is open dumping. At that time only 75% of annual SW was transported by municipal service companies and 15 percent was transported by private companies. Therefore, 10% of total annual SW is remains unmanaged. Also there are hundreds of illegal and unmanaged waste collecting points in Ulaanbaatar as well as other big cities. The World Heath Organizations calculated an individual in Ulaanbaatar produces 0.334 kg SW a day[2]. The solid waste management survey project has been implemented in Ulaanbaatar since 2004 and Solid Waste Master Plan for Ulaanbaatar until 2020 was developed.

7.6.2. *Wastewater.*

Water consumption for drinking and industrial needs is supplied by underground water. Water is distributed within 80 km from Ulaanbaatar by a centralized system to each customer. Water distribution has not created incentives for conservation, however, since 2000 water measurement equipment has been installed in some areas and water consumption was relatively decreased. More must be done to conserve water. One person who lives in a building consumes 240-250 liters water per a day and a ger household consumes only 5-9 liters water per a day. There are two basic types of wastewater handling systems:

- Domestic and commercial wastewater; and
- Industrial wastewater

Most domestic and commercial wastewater is handled by sewer systems with aerobic treatment. Mongolia consumed 71.0 mln. cubic meters of water in 2006. 30% of the total consumption came from the centralized system and 70% came from other sources that include the following: a) 24.8% of total consumption is supplied from water tanker transportation; b) 35.7% of total consumption comes from wells and water kiosks; and c) 9.5% of total consumption comes from rivers, streams, creeks and springs. Ulaanbaatar consumed 160 thousand tonnes of water per day in 1990, 237 thousand tonnes of water per day in 2001, and 340 thousand tonnes of water per day in 2006. (Dr.N.Jadambaa). There are four small and one large water treatment plants in Ulaanbaatar and they have a combined treatment capacity of 230 thousand. tonnes for industrial and domestic waste water.

In Mongolia, the activities such as sorting, sanitizing, disinfecting, recycling, reusing or disposing of waste are not completed in proper ways and as a result, unprocessed wastes are transported to and discarded at areas closer to cities and settlements. Because of this, the waste area enlarges and affects surrounding area including soil, water and air. The larger settlements such as Ulaanbaatar have not efficiently resolved the problem.

Collection of solid waste, and improvement of solid waste transportation, sorting, recycling and reusing management. Policy documents such as MDG based Nation Comprehensive Policy of Mongolia, Action Plan of the Government of Mongolia and Ulaanbaatar Regional Development Program (2006-2015) do address environmental pollution in Ulaanbaatar and larger settlements. Comprehensive measures need to be taken toward improving solid waste management including the improvement of legal, economic, managerial and institutional framework. The recent improvements include the following:

- Implementation of a registration system for the Ulaanchuluut central waste dump and the collection of information on the waste transporting companies such as the number of loads and weight; and
- A building control dispatcher in Morindavaa waste point has been erected. Within the assistance Japan, a waste treatment site has been established in Naran Mountain and 52 trucks and equipment worth approximately 10 billion tugrugs have been supplied in year of 2008.

The central wastewater treatment plant does not currently comply with standards. After treatment the water quality is unacceptable and is a source of contamination of the Tuul River. It is necessity to implement advanced treatment technology as *anaerobic treatment* of wastewater.

There are many factories in Ulaanbaatar processing raw materials, hides and wool, and food. All factories have their own wastewater treatment plants (Khagia) but their technologies do not meet with current standard. Many factories do not treat the waste water and drain the contaminated water into the river. This has resulted in Ulaanbaatar formally adopting a policy to move raw material processing factories.

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8 Key Conclusions of the Assessment on Climate Change

8. KEY CONCLUSIONS OF THE ASSESSMENT ON CLIMATE CHANGE

Based on the IPCC seven step methodology for conducting a climate change impact assessment, the following general observations and conclusions can be found from the Mongolia Assessment Report on Climate Change 2009:

1. Current climate changes
   - Temperature due to global warming in Mongolia has increased at least 2.14°C since 1940 and is projected to increase up to 5°C by end the 21st Century.
   - The occurrence of disturbances in climate and geophysical systems has already been observed and is projected to intensify in magnitude and frequency to need serious consideration, including the following:
     - Extreme hot and cold weather
     - Drought and decreasing water resources in the country, especially in Gobi desert areas
     - *Zud* (harsh winter)
     - Dust, sand storms and desertification
     - Flooding in some areas
     - Melting high mountain glaciers and snow caps
     - Degradation of land surfaces by permafrost
2. Vulnerabilities and Risks
   - Many studies and researches have brought about detailed assessments of impact and vulnerabilities
   - Sustainable development depends on close links between the environment and the economy. A significant portion of the economic activity has always targeted on natural resources such as pasture, animal husbandry, arable land and water resources.
   - Because of adverse impacts of climate change on the most vulnerable natural systems and economic sectors, risks in achieving the MDGs and national development targets would be increased.
3. Current Responses
   - Mongolia approved its National Action Programme on Climate Change (NAPCC) in 2000 that includes a set of measures, actions and strategies which enable vulnerable sectors to adapt to potential climate change and to mitigate GHGs emissions.
   - The Millennium Development Goals-based Comprehensive National Development Strategy (MDG-based NDS) of Mongolia approved by the Great Khural (Parliament) in 2008 that includes a Strategic Objective to promote capacity to adapt to climate change and desertification, to reduce their negative impacts.
   - The different recommended adaptation and mitigation measures are prepared and are useful in coping with current climate change. Many options are available and an inventory and assessment of existing adaptations that people have already made to deal with climate variability and extreme events need to be made to guide future actions.
4. Considering adaptation approaches
   - Today, Mongolia faces not only with the same problems in developing countries caused by the global climate change, but it also has specific concerns which relate to Mongolia's unique geographical and climatic conditions. For instance, melting of permafrost area, desertification, drought, etc. caused by global warming will have very adverse effects on agriculture

practices, water resources and infrastructure development like bridge and road constructions, buildings, etc. Permafrost covers more than 60 per cent of the territory of Mongolia, In addition, climate change would affect seriously on ecosystem, natural grassland, arable farming, pasture animal husbandry and soil quality. The adaptation problem would be a higher priority concern in the immediate term than the GHG mitigation problem for Mongolia, but the overall strategy would require a more balanced approach in the long term.

- Continuing researches and investigations have formulated adaptation measures in the critical sectors of animal husbandry, agriculture, water resources, forestry and human settlements in the country in line with concrete and practical adaptations that could minimize, if not possibly totally remove the sector's vulnerability to climate change impacts.

5. Provision for regional approach to vulnerabilities and adaptation

- Mongolia has very actively pursued climate change issues not only at the national and regional/sub-regional levels.
- It has pursued joint collaboration activities on various aspects of climate change not only through the UNFCC and Kyoto commitments but also other initiatives to reinforce these commitments
- Mongolia is active in establishing a Sub-regional cooperation among the North-east Asia Sub-region on matters of climate change and common development agenda.

6. Exploring sustainable approaches

- Time has already come to implement the adaptation measures obtained through research and assessments and mobilize resources and financing to implement of adaptation measures, to include the following approaches:
  - Strategic natural resources conservation
  - Maximizing ways of strengthening animal bio-capacity to cope with changing ecosystems
  - Strengthening capacities and opening opportunities for livelihood in currently and potentially affected communities
  - Improving the economic sustainability of livestock production and the ecological sustainability of natural resources used in livestock production is focused on improving feed availability to livestock
  - Intensifying production, supply and security of food and primary domestic commodities to be affordable and available to affected population
  - Expanding public information and forecasting to improve level of understanding and preparedness for climate and weather extremes and emergency situations

7. Evaluation of adaptation strategies

The Government of Mongolia is presently evaluating the adaptation and mitigation strategies. In line with the search for practical strategies, it also pursues public awareness as an important component that is crosscutting the overall climate change approach along the mainstreaming process that the Government of Mongolia is doing. This is to be articulated in the Second National Communication as a means of identifying and integrating the direction and courses of action towards sustainable development approaches.

9 Options for Planning on Climate Change

9. OPTIONS FOR PLANNING ON CLIMATE CHANGE

9.1. Achieving Goals

The Government of Mongolia, the general public and the private sector have made very significant progress in climate change research, awareness and planning since the UNFCCC and Kyoto Protocol joining in 1990s. In achieving goals, identification of possible barriers that would hamper success should be assessed at this point of preparation for the Second National Communication, as a course of mainstreaming, integrating and pushing forward climate change in the planning and implementation process. These would include:

- *Technical* – updating of instruments and methodologies for climate/weather forecasting and emergency preparedness as well as practical machinery and equipment that could ease drudgery in agricultural and livestock sectors, such as production tools, post-harvest technology, packaging, transportation, storage, etc.
- *Financial* - considering economic difficulties in most countries, including Mongolia, as it continue transitioning towards economic and financial stability. Therefore, for Mongolia, the mobilization of financial resources of domestic and international financial mechanisms and active participation in the existing bilateral and multilateral programs in climate change relevant areas are very essential to implement its climate change response strategies and measures.
- *Institutional* – the government is fully aware of the climate change adaptation and mitigation strategy requirements. Problems on climate change in Mongolia, as in most countries, would seem to be recognized at sectoral levels and they are being addressed to a certain extent. However, more effort and organizational structures and procedures will need to be strengthened at the local levels, where the impacts and vulnerabilities being discussed here are felt most intensely.
- *Legislative* – practical and adequate polices, strategies, guidelines and institutional mandates should be established both at the national, and particularly, at the local level in order to integrate climate change issues in the overall legislative and development agenda of the Government.

9.2. Planning options

- Reduce vulnerability of livestock and other sensitive sectors to impacts of climate change through the suggested adaptation measures which require actions in a coordinated way and incorporation in long-term planning.
- Continue research, training, strengthening, and building upon existing capacity might be most important measure in strengthening the adaptive capacity and vulnerability and adaptation strategic planning.
- Assess and, when needed, improve forecasting and warning systems for disaster preparedness such as for drought, zud, etc. to help meet potential dangers.
- Refine existing impact and vulnerability analyses discussed herein to the

greatest extent possible, reducing the uncertainties and fine-tuning the assumptions towards more meaningful policy recommendations. Translating these findings and recommendations in easily understandable and not-so-technical terms will be best.

- Continue to improve and refine the existing vulnerability and adaptation researches in other areas energy, biodiversity and forestry, crops and direct and indirect health effects of climate change
- Implement greenhouse gases reduction projects through the recommended mitigation measures in energy, industry, transport, forestry and waste management sectors.
- Pursue national and international collaboration such as research, resources sharing and climate/weather forecasting at the North-east Asia sub-regional level, for Mongolia to take active lead role due to current exigencies.

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ANNEXES

ANNEXES

Annex 2.1: Location of Climate Observation Sites in Mongolia

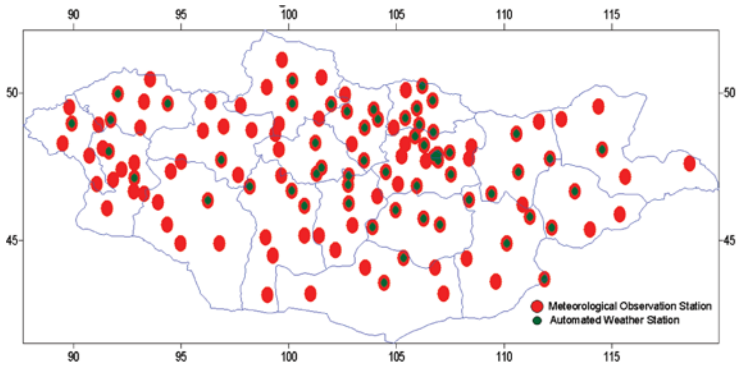

Figure A2.1.1. Location of the Meteorological Observation Stations

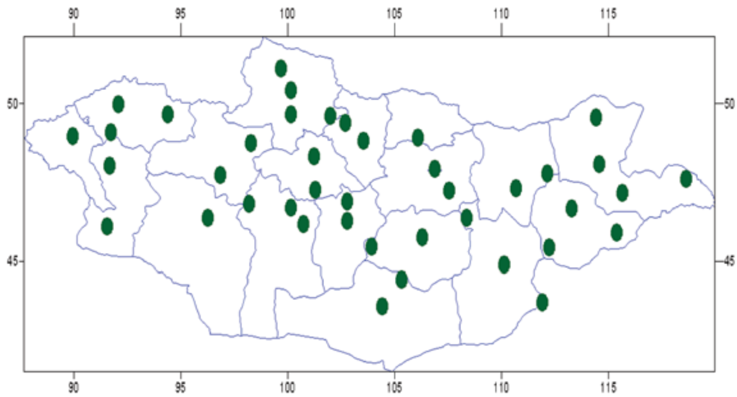

Figure A2.1.2. Location of the WMO's Basic Synoptic Stations in Mongolia

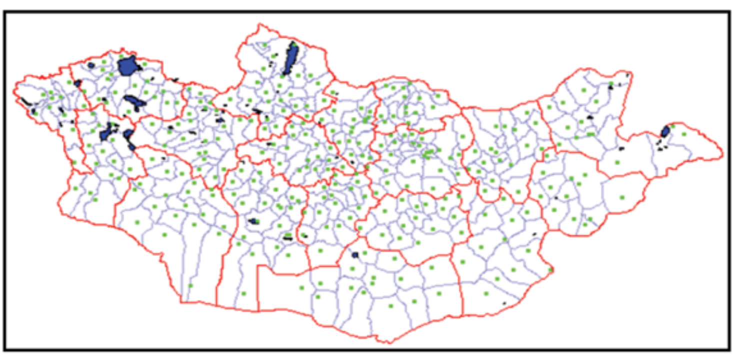

Figure A2.1.3. Location of the Weather Observation Posts at the *Soum* Level

Annex 2.2: Grassland Observation Network

Annex 2.2: Grassland Observation Network

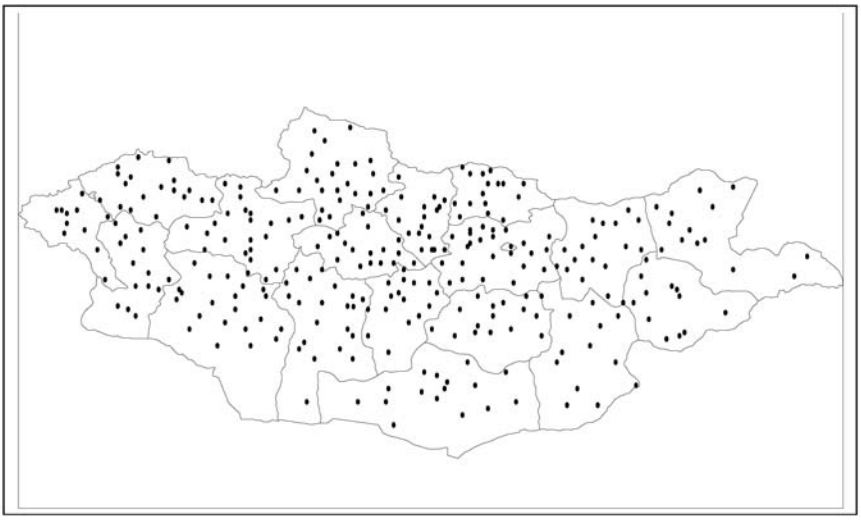

Figure A2.2.1. Location of the Pasture Vegetation Observation Sites

Annex 2.3. Hydrological Observation Network

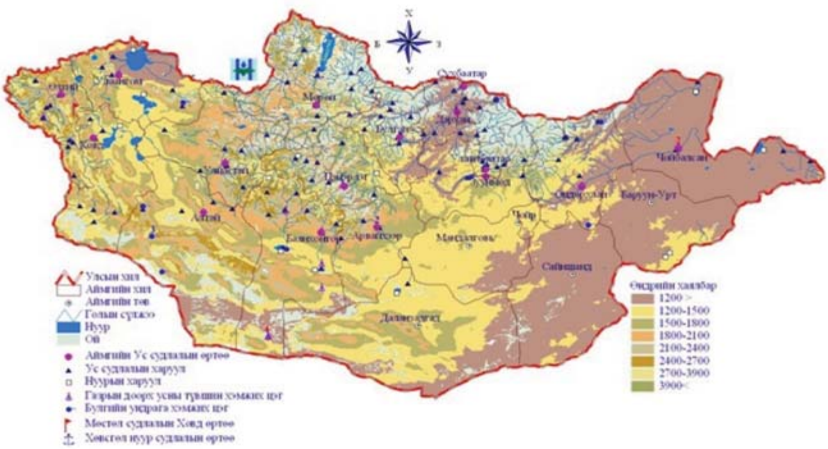

Figure A2.3.1. Location of Hydrological Observation Sites

Annex 2.4. Geographical Pattern of Temperature and Precipitation Projection

Temperatures

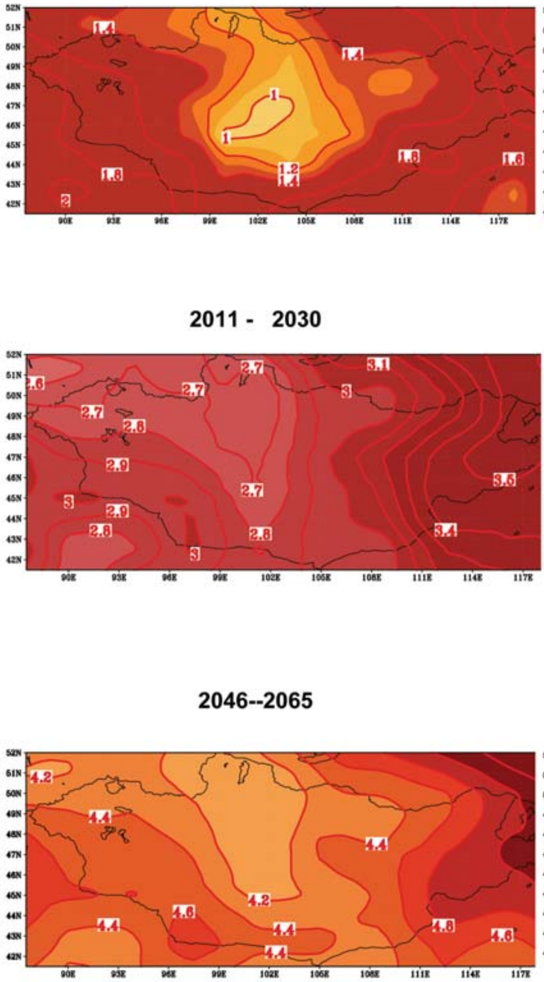

Figure A2.4.1(a). Winter Air Temperature Change, ^{0}C

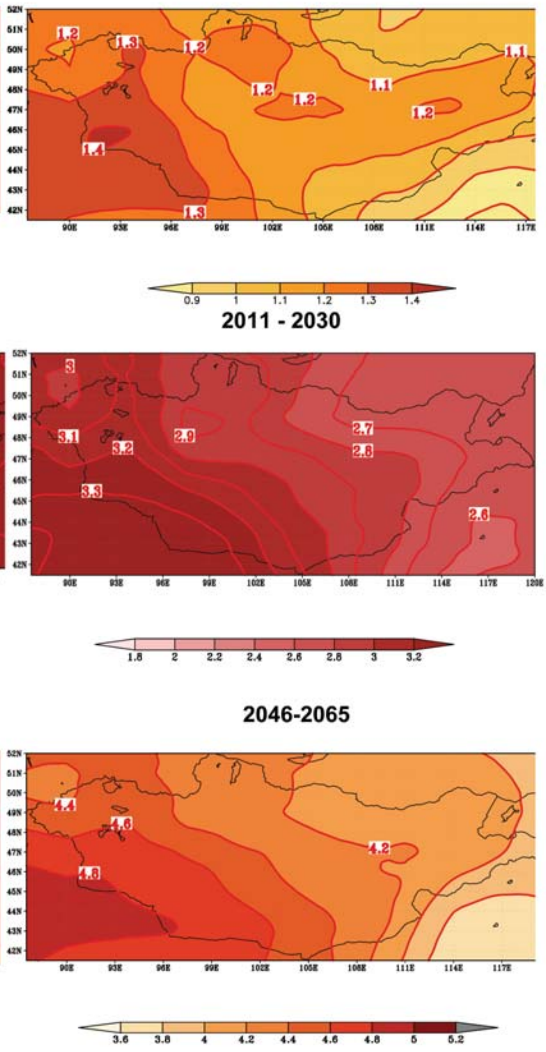

Figure A2.4.1(b). Summer Air Temperature Change, ^{0}C

Precipitation

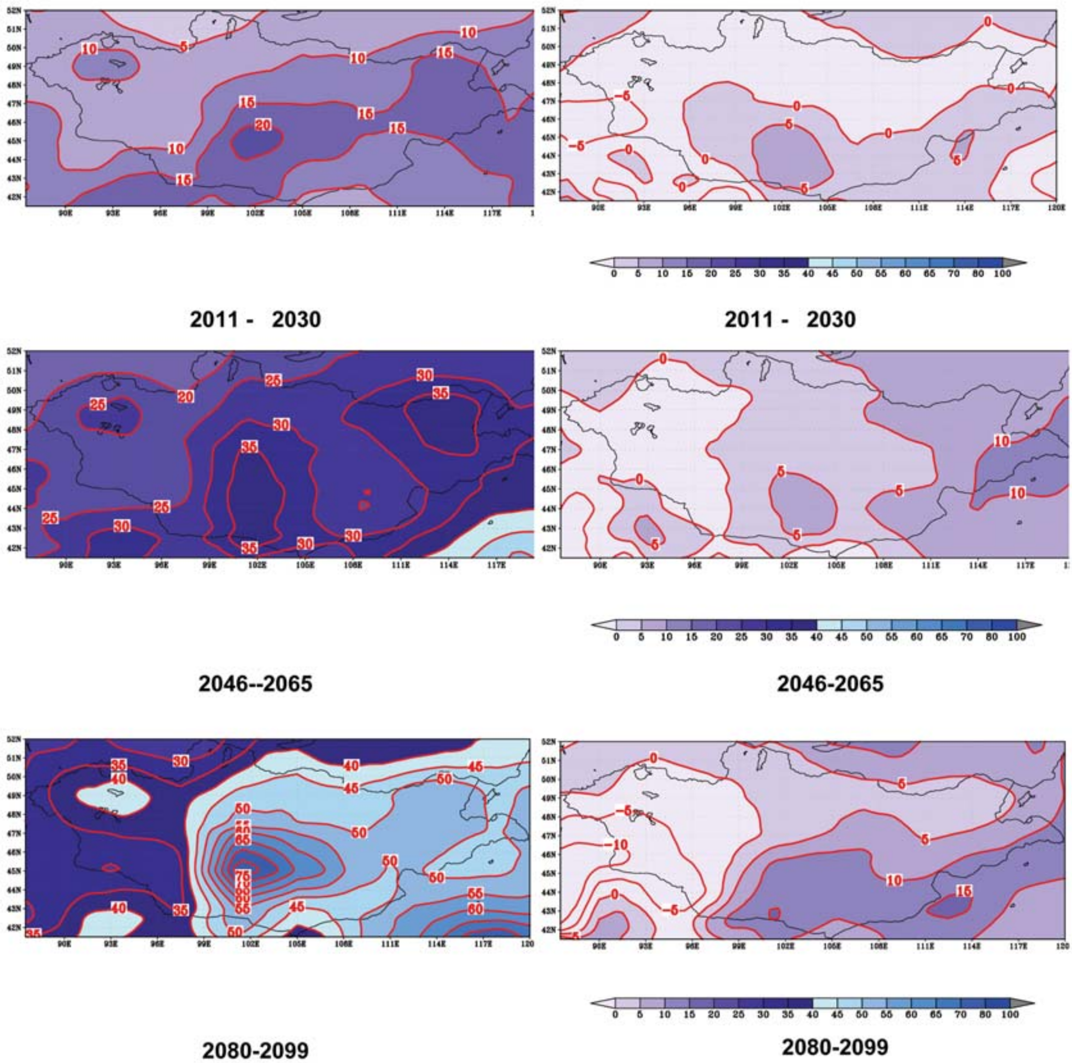

Figure A2.4.2 (a). Winter Precipitation Change, %

Figure 2.4.2 (b). Summer Precipitation Change, %

Annex 3.1 Evaluation of Land Surface Changes

1. Evaluating land surface changes using satellite data

In the last few decades, the Mongolian land surface has been altered due to climate change. It is difficult to evaluate land surface changes using numerical analyses because of the complex components in one ecosystem, such as plants, animals, and soil organisms. There is no method to do it. Further, because of its uniqueness, Mongolian land surface changes in a season not in a year. The use of environmental satellites a common practice to evaluate land surfaces and landscapes worldwide.

Mongolia has a large landscape and an extreme continental climate. Climatic conditions are reflected in soil and vegetation patterns. The world's three vegetation zones are represented in Mongolia: forest-steppe, steppe and desert. These vegetation zones slowly transition into one another and create overlapping zones. For example, mountainous forest-steppe has been created by forest-steppe and steppe zones, desert-steppe and semi-desert areas have been created by steppe and desert zones.

In 1995, for the first time in Mongolia, the Mongolian National Remote Sensing Center (NRSC) conducted an analysis using NDVI data for the years of 1992-1993 from the NOAA satellite to evaluate the land surface of Mongolia. In 1997 and 2002, the NRSC repeated the project to collect and validate satellite data for land surface changes. (**Figure** A**3.1.1 and A3.1.2)**

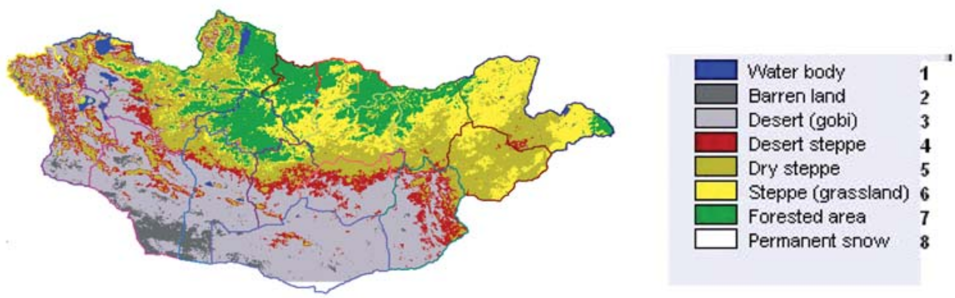

Figure A3.1.1. Land Surface Image in 1992

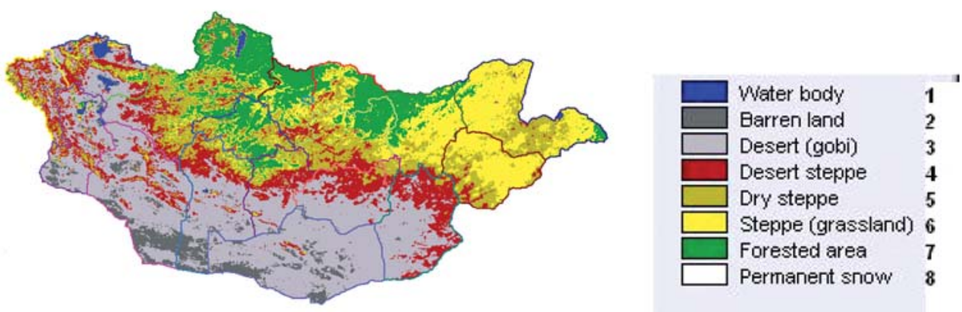

Figure A3.1.2 Land Surface Image in 2002

A comparison of the 1992 and 2002 images, which were taken 10 years apart, reveals that the land surface has changed significantly; desert area has increased and forest area has decreased. In 2006, the land surface was evaluated by utilizing MODIS satellite data which has 16 times higher resolution than the NOAA satellite data. (**Figure A3.1.3**, **Table A3.1.3**)

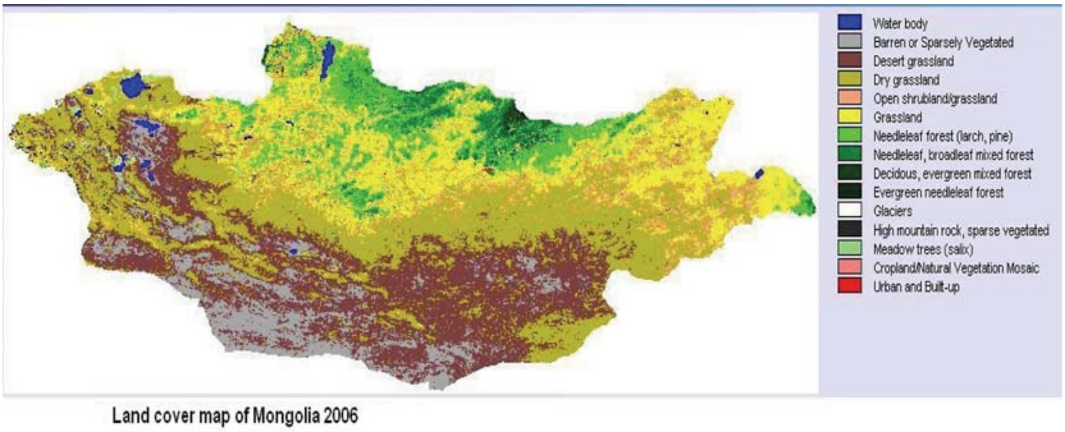

Figure A3.1.3. Land surface image in 2006

Table A3.1.1. Land surface change (sq. km)

	Classes	1992	2002	2006
1	Water	17,766	11,335	14,448
2	Barren	52,593	76,700	148,808
3	grassland I	1,012,424	1,019,592	948,904
4	grassland II	251,261	250,672	281,661
5	Forest	223904	205,534	164,293
6	grassland II + forest	475,165	456,206	445,954
	Total area	1,557,948	1,563,833	1,558,114

According to the table, water surface decreased by 38% from 1992 to 2002, but in 2006 the water area figures increased. Due to the higher quality satellite data resolution we could observe small lakes and ponds in the 2006 data which we could not observe before. Areas without grass (barren) increased by 46% from 1992 to 2002. By 2006 this area (barren) almost tripled, while during the same period forest area decreased by more than 26%.

2. *Evaluating vegetation zones using the entire biological product*

The CENTURY model was used to analyze the effects of climate change on ecosystems. This model is programmed to work with a grid. The 0,5x0,5 degree grid was built for each region and 899 grid cells were created for the entire Mongolian land surface. ArcView, a geographic information system software package, was used to create the grid and analyzie geographic data, vegetation zones and the land surface for each grid cell.

Biological product is the main criterion for representing the vegetation zones. **Figure A3.1.4** and **A3.1.5** illustrate a comparison of living vegetation zones and biomass created by samples.

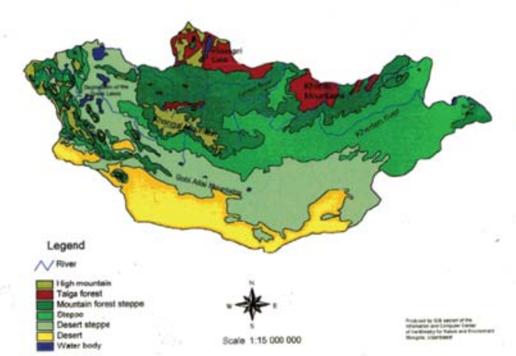

Figure A3.1.4. Mongolian Current Ecological Zones.

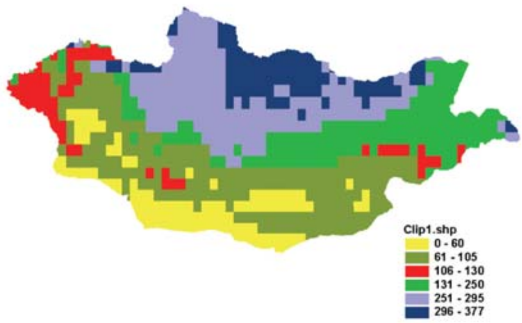

Figure A3.1.5. Biological Product Simulated.

Although it did not provide a clear image in the high mountain areas, employing the biological product sample and biological productivity, also known as net primary productivity (NPP), helped to provide clear images for ecological zones. Biological product can be represented by the amount of carbon dioxide released by biomass. The conversion used is carbon dioxide multiplied by 2.5.

In 1984, N.Ulziikhutag determined the percentages for the Mongolian vegetation zones. These percentages represent the proportion of the total area of Mongolia covered by each zone. **Table A3.1.2** illustrates a comparison of Ulziikhutag's research results and the model using NPP.

Table A3.1.2. Percentage of Vegetation Zones

	Name of Vegetation Zone	N.Ulziikhutag's Research%	Model NPP, C h/m^2	NPP amount, %
1	Mountain zone	4.48	>296	10.8
2	Taiga zone	3.89		
3	Forest-steppe zone	23.28	251-295	23
4	Dry steppe zone	25.86	131-250	25.5
5	Semidesert area	21.92	61-130	28.0
6	Desert zone	15.34	d”60	12.2

According to the NPP model, the forest-steppe zone and dry steppe zone are almost equivalent to the actual figures as represented by Ulziikhutag's research, and the semidesert area is greater by 7% and desert zone greater by 3%. Although, the percentages calculated by the NPP model for the vegetation zones seem close to the actual amount, the NPP model did not calculate accurately high mountain areas such as the Altai and Khangai high mountain zones and the taiga zone of Altai Mountain which is 5% of the landscape. However, the model provides sufficient data on the mountain zone, dry steppe zone, semidesert area and desert zone which are 90% of the landscape. Therefore, the CENTURY model can be used in the future to analyze the effects of climate change on plant ecosystems. The dynamics of climate change effects are different in high mountain ecosystems and so, employing research results for high mountain areas is more appropriate.

In order to calculate the effects of precipitation and temperature on biological product, or net primary productivity (NPP), and vegetation zone percentages, we varied the amount of temperature and precipitation.

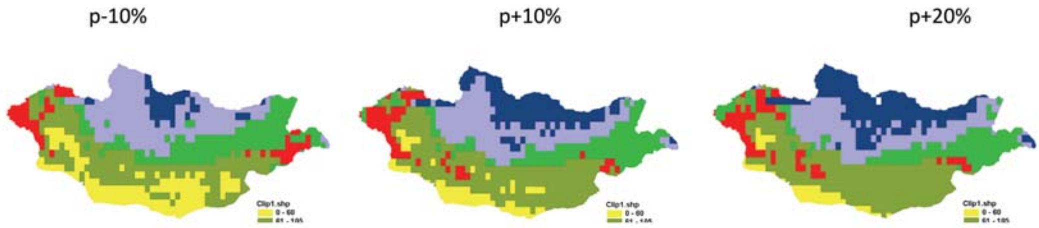

Figure A3.1.6. Change in the Percentage of Vegetation Zones when the Amount of Precipitation Changes.

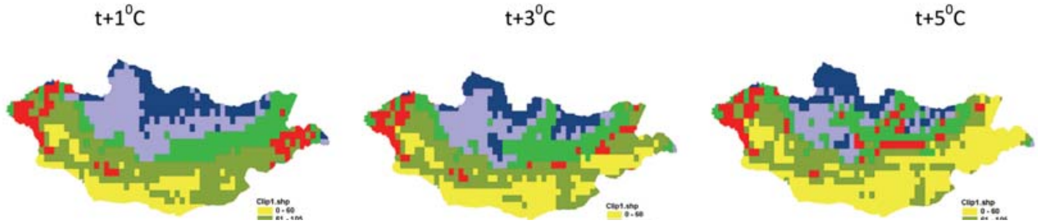

Figure A3.1.7. Change in the Percentage of Vegetation Zones when the Temperature Changes.

Table A3.1.3 shows the current percentage of the total area of Mongolia occupied by each vegetation zone (as represented by NPP) and the changes to these percentages for various changes in precipitation and temperature.

Table A3.1.3 Change in the Percentage of Natural Zones when Temperature and Precipitation Amount Change

NPP,C h/m²	Amount of Landscape Change, %					
	Precipitation Change %			Temperature Change, °C		
	-10	+10	+20	+1	+3	+5
>296	-51	+43	+82	+4	+7	-8
251-295	+9	-3	-9	-5	-33	-54
131-250	+6	-12	-20	-15	-8	-20
61-130	-22	+8	+22	+11	-10	+2
<60	+50	-34	-55	+19	+83	+179

According to the table, NPP>296 C h/m^2, which represents the taiga zone and a larger area, did not change when the temperature changed, but it was changed when precipitation changes. In other words, when the amount of precipitation declines, the percentage of taiga area declines and when the amount of precipitation increases the forest and taiga areas increase. Therefore, as temperature rises, the percentages of forest and taiga areas are likely to decline.

The forest-steppe zone (NPP=251-295 C h/m^2) is more sensitive to increases in temperature. When the amount of precipitation increases, the northern part of the forest-steppe zone increases and the overall percentage of the zone decreases. As temperature increases up to 5^{0}C the dryness increases, the forest-steppe zone moves slightly to the north and the total area of the zone decreases by up to 54%.

Although the percentage of the steppe zone (NPP=131-250 C h/m^2) seems small, it is sensitive to warmer temperatures. As the amount of precipitation increases, the percentage of the zone decreases and the forest-steppe zone characteristics will likely increase in the zone. When the temperature rises the steppe zone pushes the forest-steppe zone to the north and from the south it is transformed into semidesert; as a result the percentage of the zone decreases significantly.

As the amount of precipitation increases, productivity of the semidesert zone (NPP=61-130 C h/m^2) increases and it will likely turn into steppe zone. When the temperature rises, it pushes dry-steppe zone to the north while also pushing desert zone to the north. Even though it seems that the zone does not change too much, its geographical position changes drastically. When the amount of precipitation increases, the northern part of the desert zone (NPP=60 C h/m^2) turns into steppe zone and as a result, the percentage of the desert zone decreases. As the temperature rises, the desert zone moves to the north, thus the percentage of the desert zone increases.

The change in biological product when temperature and amount of precipitation both change are summarized in Table **A3.1.4**.

Table A3.1.4. Change in the percentage of natural zones when temperature and amount of precipitation both change

Precipitation Amount Change	Percentage of Natural Zones Change, %			
	t+0	**t+1**	**t+3**	**t+5**
NPP >296 C h/m^2 taiga zone				
p0	0	+4	+7	-8
p*-10%	-51	-52	-36	-54
p*10%	+43	+55	+46	+34
p*20%	+82	+96	+93	+65
NPP =251-295 C h/m^2 forest-steppe zone				
p0	0	-5	-33	-54
p*-10%	+9	+3	-28	-46
p*10%	-3	-13	-31	-55
p*20%	-9	-21	-36	-56
NPP =131-250 C h/m^2 steppe zone				
p0	0	-15	-8	-20
p*-10%	+6	0	-6	-23
p*10%	-12	-18	-20	-13
p*20%	-20	-18	-27	-17
NPP =61-130 C h/m^2 semidesert zone				
p0	0	+11	-10	+2
p*-10%	-22	-20	-28	-25
p*10%	+8	+15	+6	-23
p*20%	+22	+21	+26	-1
NPP <60 C h/m^2 desert zone				
p0	0	+19	+83	+179
p*-10%	+50	+67	+147	+226
p*10%	-34	-18	+29	+115
p*20%	-55	-50	-7	+76

According to **Table A3.1.4**, temperature change has no effect on the taiga zone, but the amount of precipitation affects the zone greatly. In other words, when precipitation decreases the percentage of the zone decreases and when precipitation increases the percentage of the zone is expected to increase. In contrast, temperature change has a huge effect on the forest-steppe and steppe zones. As the temperature rises, the percentages of the zones decrease. As precipitation increases, the percentage of semidesert zone increases, but as temperature increases up to 5^0C, the percentage of semidesert zone decreases slightly. However, the percentage of desert zone increases when temperature rises.

The formation and alteration of vegetation zones is a long process. Evaluating the effects of climate change on biological product and biomass in the years between 2010-2039, 2040-2069 and 2070-2099, we see the effects of climate change on biological product.

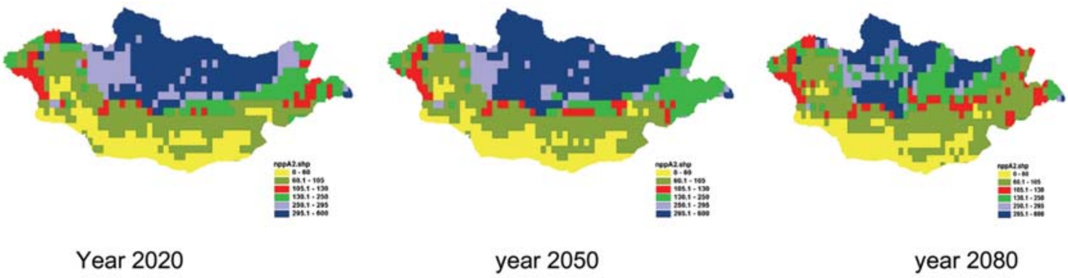

Figure A3.1.8. NPP, C h/m² in SRES A2 Scenario.

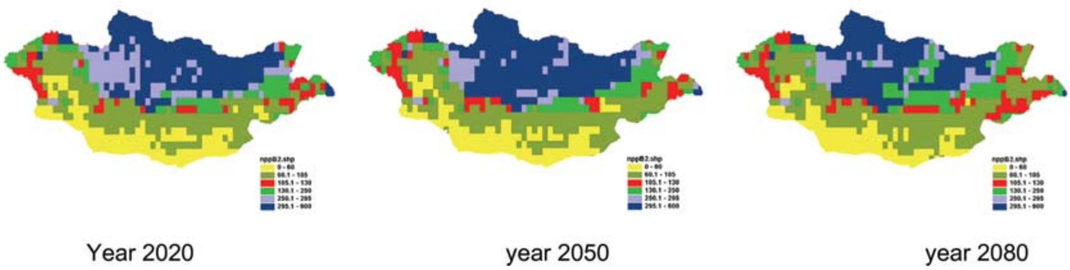

Figure A3.1.9. NPP, C h/m² in SRES B2 scenario.

According to the HadCM3 model, taiga forest (NPP>296 C h/m^2) is expected to increase. This is especially noticeable in the years of 2020 and 2050. However, it does not mean trees will grow naturally. There is the possible advantageous condition for trees to grow if biomass increases and there is no effect of human activity. In 2080, forest-steppe is likely to turn into steppe. But version SRES A2 shows that the warming rate would be slow and as a result the process of forest-steppe turning into steppe would be slow as well.

The steppe zone (NPP=131-250C h/ m^2) is likely to be pushed by the semidesert zone from the south and decreases significantly. Due to climate warming, the semidesert zone will push the steppe zone to the north, especially in 2080. In 2080, forest-steppe and steppe areas decrease; this is caused by a lack of rainfall and an increase in temperature in the growing season (June, July, September). Even if, the amount of precipitation increases up to 1.6-2.7 mm, temperature is likely to rise 4-7^0C which will cause evaporation and make the air dryer.

The percentage of desert zone (NPP=60C h/m^2) tends to expand to the north. Although the amount of precipitation is expected to increase, semidesert and desert zones are not decreasing; they are likely to expand. In other words, the increased amount of precipitation is still not enough for rapid evaporation.

3. Evaluating vegetation zones using degree of dryness

One of the criteria that defines an ecosystem is the degree of dryness. There are many indices that describe dryness. In this research, the degree of dryness is represented by the ratio of total annual precipitation to annual potential evaporation [Hare 1993]. In other words, it describes the system of precipitation and evaporation.

Figure A3.1.10 illustrates the Mongolian natural zones and the geographic spread of the degree of dryness.

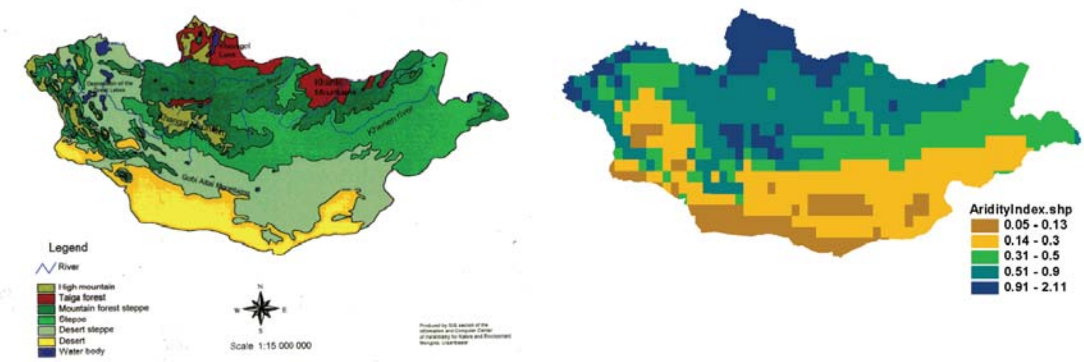

Figure A3.1.10. Map of natural zones and degree of dryness spread.

The dryness index map looks similar to the natural zone map and it is possible to see vegetation zone changes from the changes in the dryness index in the future. According to figure 10, for the following zones the dryness index is as follows: 0.05-0.13 in the desert, 0.14-0.3 in the semidesert, 0.31-0.5 in the steppe, 0.51-0.9 in the forest-steppe and greater than 0.91 in the taiga and high mountain.

Table A3.1.5 demonstrates the percentage of each vegetation zone using the dryness index. Obviously, the degree of dryness, or dryness index, can represent the vegetation zones.

Table A3.1.5. Percentage of Vegetation Zones

	Name of the Zone	N.Ulziikhutag's Research, %	Degree of Dryness	Landscape Percentage Sorted by Dryness
1	High mountain	4.48	>0.90	10.1
2	Taiga forest	3.89		
3	Mountain forest-steppe	23.28	0.51-0.9	30.2
4	Dry steppe	25.86	0.31-0.5	22.9
5	Semidesert	21.92	0.14-0.3	26.7
6	Desert	15.34	<0.14	10.1

Figures A3.1.11 and **A3.1.12** illustrate the dryness index changes in two potential climate change scenarios.

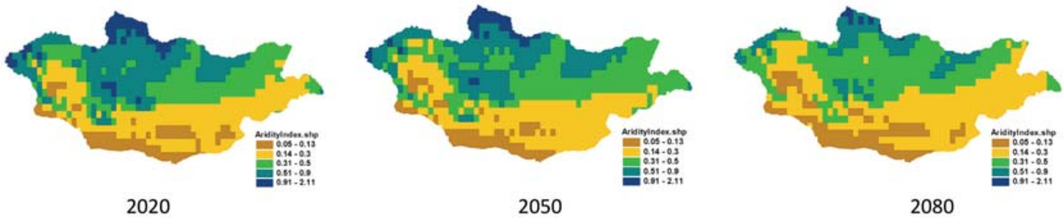

Figure A3.1.11. Degree of dryness in SRES A2 scenario.

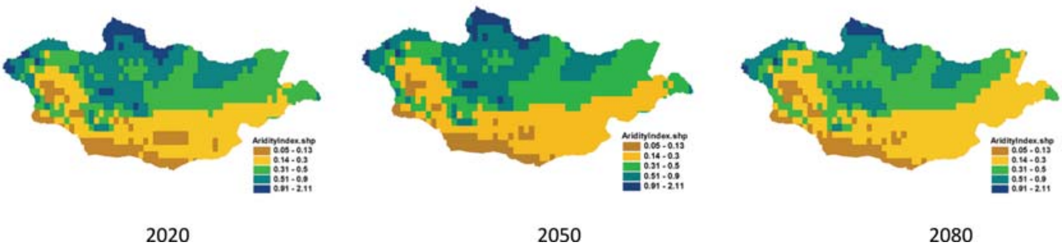

Figure A3.1.12. Degree of dryness in SRES B2 scenario.

As the climate warms, the total amount of annual precipitation also increases, but semidesert and steppe zones move to the north and the degree of dryness tends to increase more. These changes will be observed more in 2070-2099.

Based on calculations of the degree of dryness from future climate change scenarios, vegetation zones will move to the north and semidesert and steppe zones will likely expand. Therefore, the northern part of the country is considered to be a sensitive area. This does not mean that one zone will transform into another one immediately.

In conclusion, the northern part of the country tends to become dryer steppe, but if permafrost melts rapidly, then moisture in the soil will increase. Consequently, the drying process will occur over a long period of time. In other words, the drying process will affect plants when the moisture from the permafrost declines. However, the percentage of the desert zone will not increase extensively. The increase in the total amount of annual precipitation will reduce the aridity of the climate in this zone.

Annex 3.2. Permafrost Assessment

In the northern part of Mongolia, the total area with permafrost soil increases and continuous permafrost prevails.

1. The total area of long-lasting continuous permafrost is 141,000 square kilometers, 9.4% of the total territory of Mongolia. This permafrost area includes Khangai, Khentii, Khuvsgul and Mongol Altai Mountain ranges. In this region, the permafrost spreads around the lakes, the river valleys and the front and backsides of mountains. However, there is talik on the bottom of the larger rivers and lakes. Eighty percent of this area has long-lasting permafrost and the depth of the permafrost reaches 100-200 meters in the rivers basin and the mountain valleys, and 300-500 meters in the highly elevated area (3000-4000 meters above the sea level) where the soil temperature reaches -1.5^0 C to -3.5^0 C.
2. The total area of discontinuous permafrost is 27,000 square kilometers, 1.8% of total territory of Mongolia. Discontinuous permafrost is located mainly in the eastern branch of Khentii, the Khuvsgul Mountain ranges and the Mongol Altai Mountains. The long lasting permafrost is located predominantly in the northern parts of the mountains and on the bottoms of the lakes and rivers.
3. The total area of distribution of common patchy permafrost is 152,630 square kilometers, 10.2% of total territory of Mongolia. The bottom line of this permafrost starts from between 1460-1800 meters above sea level. Moreover, this type of permafrost can be observed in the wet, moist soil of hollows or valleys. Here, the depth of the permafrost is 50-100 meters and its temperature will reach -1.0^0 C to -1.5^0 C.
4. The total area of distribution of rare patchy permafrost is 190,930 square kilometers, 12.2% of total territory of Mongolia. This permafrost is distributed randomly in the mountain valleys and river basins. The depth of the permafrost is between 10-50 meters and the temperature is about -0.5^0 C to -1.0^0 C.
5. Occasional permafrost can be observed mostly in the central part of Mongolia, which is dry steppe, the Orkhon and Selenge river basins, the Great Lakes depression and the great Mongolian eastern steppe. The total area of distribution of occasional permafrost is 460,110 square kilometers, 29.4% of total territory of Mongolia. In these regions, the depth of the permafrost is about 5 meters, and its temperature is -0.1^0 C to -0.5^0 C. This type of permafrost mostly occurs near small springs and streams.
6. Non-permanent permafrost occurs in the eastern part of Dariganga high plateau and Khyangan Mountains. Due to the heavy snow in the winter, here it is almost impossible to develop permanent permafrost. However, in some years when there is small snow, permafrost may be formed here.
7. Seasonal permafrost occurs in the southern steppe and the Gobi region. Sometimes, in this region, the depth of the permafrost reaches 1.7-3.5 meters.

In the late 1990s, researchers R.Mijiddorj, D.Tumurbaatar and V.Ulziisaikhan used a permafrost index developed by O.A. Anisimov and R.Ye.Nelson in their own calculations while dividing the country's territory into two groups—with permafrost and without permafrost—to predict future changes[1]. This permafrost index is determined by using the sum of below and above zero air temperature.

$$F_{air} = \frac{\sqrt{T_{air}^{-}}}{\sqrt{T_{air}^{-}} + \sqrt{T_{air}^{+}}}$$

F_{air} = permafrost index

$\sqrt{T_{air}^{-}}$ = the sum of annual temperature below zero

$\sqrt{T_{air}^{+}}$ = the sum of annual temperature above zero.

If the index F_{air} is above 0.5, then there is permafrost soil, but if the index is below 0.5, then there is no permafrost soil.

The permafrost index, F_{air} , is calculated using the air temperature norms for 1961-1990, and the territory is divided by the air temperature into two groups, above and below 0.5. The division of the territory is compared with the actual permafrost map. As a result, the territory with 0.5 or above index overlaps with the continuous, discontinuous, common patchy, rare patchy permafrost. (**Figure A3.2.1**).

Based on these calculations, the F_{air} permafrost index shows that 34.4% of Mongolia has permafrost soil, which is similar to the percentage area of continuous, discontinuous, common patchy, rare patchy permafrost in total.

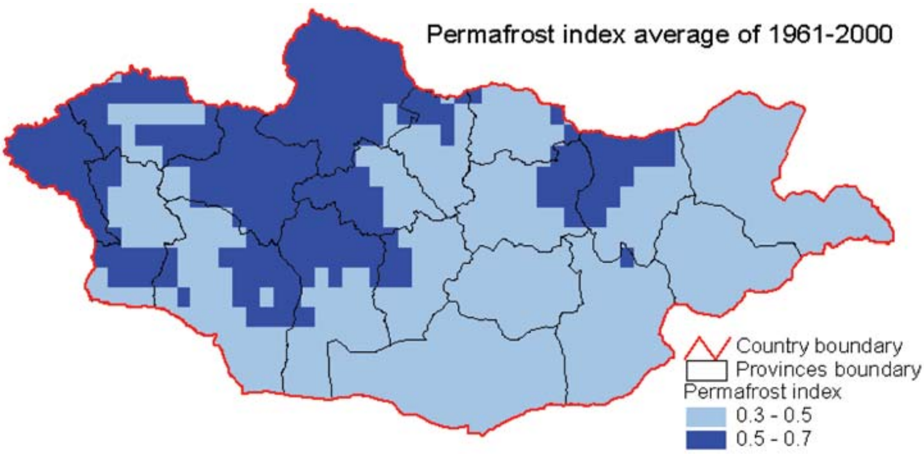

Figure A3.2.1. Permafrost Index, 1961-1990

[1] Climate Change and Its Impacts in Mongolia, edited by Batima P. and Davgadorj D., UB., 2000, 199p. R. Mijiddorj, D. Tumurbaatar, B. Ulziisaikhan. Global warming influence on permafrost and snow cover in Mongolia. - "Ecology and Sustainable development" series, № 5, pp. 120-131

For the ratio of temperature of coldest and warmest months: Russian scientists (P.F. Demchenko, A.A. Velichko, G.S. Golitsyn, A.V. Eliseev, V.P. Nechaev) have used the average temperature of the coldest and warmest months of the year to calculate the permafrost distribution[2].

$$F_{Jun/Jul} = \frac{T_{coldest}}{T_{warmest}}$$

$F_{Jun/Jul}$ = the ratio of the coldest and warmest months of the year

$T_{coldest}$ = the average temperature of January, the coldest month of the year

$T_{warmest}$ = the average temperature of July, the warmest month of the year.

When examining the ratio of multiyear temperature averages of the coldest and warmest months of the year in Mongolia, on average, below-zero temperature or -1.4^0 C prevails throughout the country. When this ratio of the coldest and warmest months is depicted on the map of Mongolia, continuous permafrost overlaps with temperatures of -2.3^0 C or less; discontinuous, common patchy, rare patchy permafrost overlaps with temperatures of -2.3^0 C to -1.4^0 C; occasional, non-permanent permafrost overlaps with temperatures of -1.4^0 C to 1.1^0 C; and seasonal permafrost overlaps with temperatures of -1.1^{O}C and above (**Figure A3.2.2**).

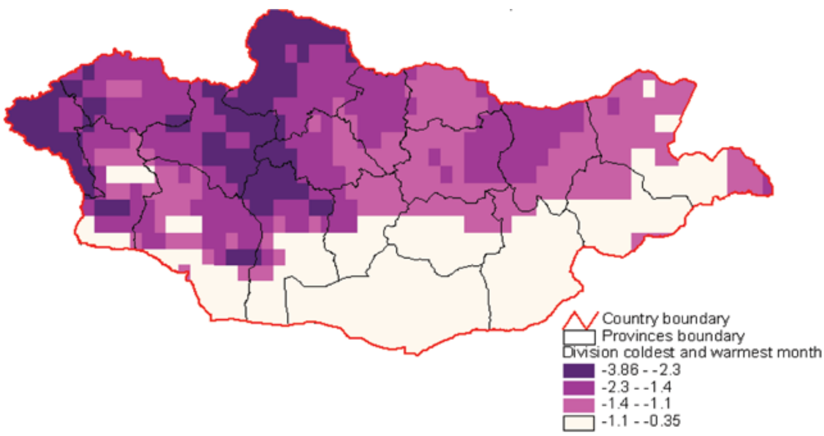

Figure A3.2.2. The Ratio of Multiyear Temperature Average of the Coldest and Warmest Months of the Year in Mongolia

Figure A3.2.2 demonstrates that the temperature distribution overlaps with the original permafrost distribution map. However, the temperature distribution does not reveal continuous permafrost within smaller areas in the Khentii Mountains. Despite this fact, this method calculates the permafrost area more accurately than the other method above. (**Table A3.2.1**).

[2] P.F. Demchenko, A.A. Velichko, G.S. Golitsyn, A.V. Eliseev, V.P. Nechaev, The fate of the permafrost: fron the past to the future Nature No 11, 2001, p.43-49

Table A3.2.1. Correlation between the Permafrost in Mongolia and Ratio of Multiyear Temperature Average of the Coldest and Warmest Months of the Year in Mongolia

Permafrost			Sum of negative temperature		
Type of permafrost	Percentage area compared to the total territory (%)	Total	scale (^{0} C)	Percentage area of the certain scale to the total territory (%)	Total area with permafrost
Continuous	9.4		Lower than -2.3^0 C	14.0	64.5
Discontinuous	1.8	24.2	Between -2.3^0 C and -1.4^0 C	26.2	
Frequent patchy	10.2				
Rare patchy	12.2				
Casual	29.4	29.4	Between -1.4^0 C and -1.1^0 C	24.3	
Total	63.0				
Seasonal	37.0		Above -1.1^{0}C	35.5	

This method identifies that 14% of the total territory of Mongolia has continuous permafrost, 25% of the country has discontinuous, common patchy, or rare patchy permafrost, 24% of the country has occasional permafrost, 37% of the country has seasonal permafrost, and consequently 63% of Mongolia has some type of permafrost. In order to identify the future distribution of the permafrost, according to the above methodology, calculations were made on 864 points on a 0.5x0.5 grid covering the territory of Mongolia using monthly average temperatures for 2010-2029, 2040-2069 and 2070-2099, calculated using the HadCM3, CSIRO, ECHAM models under the greenhouse gas emission scenarios SRES A2 and SRES B2.

Permafrost Distribution by HadCM3: According to the results calculated based on this model, the permafrost distribution rapidly decreases by 2020, and slowly diminishes further on. Moreover, discontinuous, frequent patchy, rare patchy permafrost slowly decreases in size, and as a result, the area of Mongolia with no permafrost will increase. For example, according to the calculation based on SRES A2 scenario, the area of continuous permafrost will rapidly decrease from 14% to 4.4% from 2010-2039, then to 0.5% from 2040-2069, and finally will decrease to zero from 2070-2099. Thus, the area of non-permafrost land in Mongolia will increase by 50% to 80%. (**Table A3.2.2**). The results based on SRES B2 scenario are generally similar to SRES A2 results.

Table A3.2.2. General Distribution of Permafrost Calculated Using the Ratio of the Temperature of the Coldest and Warmest Months of the Year, in %

Type of Permafrost	By the ratio of the temperature of the coldest and warmest months of the year.	1961-1990	HadCM3, A2			HadCM3, B2		
			2020	2050	2080	2020	2050	2080
Continuous	Lower than -2.3^0 C	14.0	4.4	0.5	0.0	3.1	0.6	0.0
Discontinuous, Frequent patchy, Rare patchy	Between -2.3^0 C and -1.4^0 C	26.18	23.94	17.92	6.49	22.29	19.58	15.33
Casual	Between -1.4^0 C and -1.1^0 C	24.3	21.8	14.6	12.6	17.7	15.4	14.0
Seasonal	Above -1.1^0 C	35.5	49.9	67.0	80.9	57.0	64.4	70.6

Permafrost distribution by CSIRO: The results of this model are shown in **Table A3.2.3**. According to this table, results based on the SRES B2 and A2 scenarios generally are similar. For example, the SRES A2 scenario predicts that the size of continuous permafrost for 2010-2039 will be 4% and will vanish by 2070-2099. The SRES A2 scenario also shows that the size of permafrost-free land (i.e., the land that will have seasonal permafrost or the soil freezes only in the winter) will tend to increase to 52% in 2010-2039, 67% in 2040-2069 and 82% in 2070-2099. Moreover, the SRES B2 scenario predicts the size of continuous permafrost will be only 2% of the total territory for 2010-2039 and will vanish by the 2070-2099. The SRES B2 scenario also shows that the permafrost-free land will tend to increase to 58% in 2010-2039, to 66% in 2040-2069 and then to 73% in 2070-2099.

Table A3.2.3. General Distribution of Permafrost Calculated using the Ratio of the Temperature of the Coldest and Warmest Months of the Year. in %

Type of Permafrost	By the ratio of the temperature of the coldest and warmest months of the year.	1961-1990	CSIRO, A2	CSIRO, B2				
			2020	2050	2080	2020	2050	2080
Continuous	Lower than -2.3^{0} C	14.0	4	1	0	2	1	0
Discontinuous, Frequent patchy, Rare patchy	Between -2.3^{0} C and -1.4^{0} C	26.18	23	19	6	23	19	16
Casual	Between -1.4^{0} C and -1.1^{0} C	24.3	20	14	12	17	14	12
Seasonal	Above -1.1^{0} C	35.5	52	67	82	58	66	73

Permafrost distribution by ECHAM: Compared with other models, this model shows that climate change will strongly affect the state of permafrost. For example, the area of continuous permafrost will take up only 1% of the total territory of Mongolia by 2010-2039. In addition, the total area of permafrost land will comprise only 33% of the total territory according to SRES A2 scenario and 19% according to the SRES B2 scenario. By the 2040-2069 period, the total area of permafrost land will comprise only 22% of the total territory according to SRES A2 scenario, and 19% according to the SRES B2 scenario. By the 2070-2099 period, the total area of permafrost land will decline to 3% of Mongolia according to the SRES A2 scenario and to 16% according to the SRES B2 scenario (**Table A3.2.4**).

Table A3.2.4. General Distribution of Permafrost Calculated using the Ratio of the Temperature of the coldest and Warmest Months of the Year usingECHAM model, in %

Type of Permafrost	By the ratio of the temperature of the coldest and warmest months of the year.	1961-1990	ECHAM, A2			ECHAM, B2		
			2020	2050	2080	2020	2050	2080
Continuous	Lower than -2.3^{0}C	14.0	1	0	0	1	0	0
Discontinuous, Frequent patchy, Rare patchy	Between -2.3^{0}C and -1.4^{0}C	26.18	20	10	0	17	8	3
Casual	Between -1.4^{0}C and -1.1^{0}C	24.3	12	11	3	12	11	13
Seasonal	Above -1.1^{0}C	35.5	66	80	97	70	81	85

The above three climate change models clearly demonstrate that the size of permafrost area is decreasing from year to year and that the type of permafrost is shifting from one type of permafrost to another type. For example, between 2010-2039, the mountains, that are currently continuous permafrost, will become the discontinuous common patchy, rare patchy permafrost. Between 2040-2069 and 2070-2099, the current continuous permafrost in Altai, Khuvsgul and Khangai Mountains will likely become discontinuous common patchy, rare patchy permafrost. The total size of the permafrost land will decrease by three folds and the size of the permafrost-free land will double. The thawing or disappearance of permafrost has both positive and negative sides.

Annex 3.3 Glacier and Snow Cover Assessment

The Mountain Snow Cover and Snow Cap

Most of the snow covered areas, the snowcaps and the glacial rivers (except Otgontenger and Munkhsaridag) are located in the Mongol Altai Mountains. Consequently, 60-90 percent of all water in the rivers and streams originating from the Altain Mountains comes from the snow melt and snow cap. A glacier is the product of the climate itself, and its continued existence strongly depends on the intensity of climate change.

In order to evaluate the snowcap, Mongolian scientist D. Davaa conducted research on Tsambagarav Mountain's snowcap, beginning in 2002. D. Davaa published the first results on the melting of snowcap and ground temperature in 2004, and on glacier melting along with its influencing climate information and the Ulaan am river flow in 2005. **Figure A3.3.1** shows the general image of Tsambagarav Mountain's snowcap and the locations of the monitoring points.

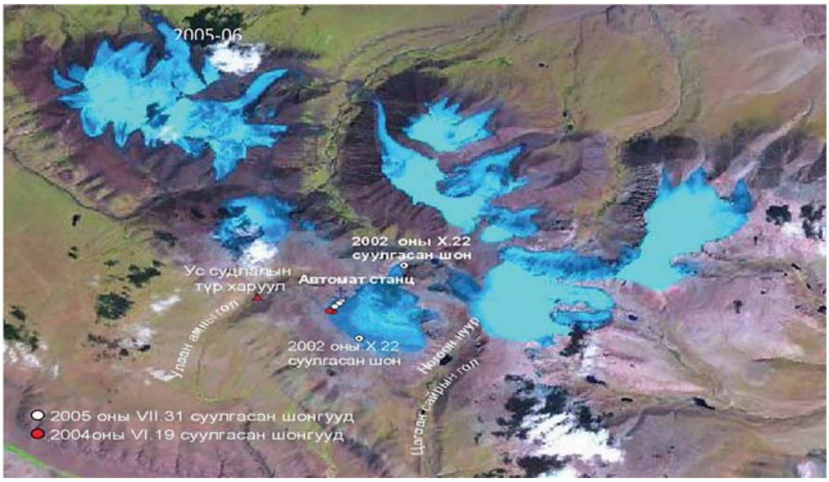

Figure A3.3.1. The General Image of Tsambagarav Mountain and the Locations of Meteorological Observation Points

The topographic map Ì1:100000 that was developed in the 1940s shows that the total size of snow cap in the Kharkhiraa, Turgen, Tsambagarav and Tavanbogd Mountains were 50.13, 43.02, 105.1 and 88.88 square kilometers, respectively. However, according to the studies conducted recently and the information received from LANDSAT 7 satellite, the size of the snow cap has diminished by 30%, and specifically, the Kharkhiraa and Turgen Mountains' snow cap has decreased by 37.5% and 21.4%, respectively.[3]

The size of the snowcap in the Tsambagarav Mountains was reduced by 13.4% in 1992, 28.8% in 2000 and 31.9% in 2002 as compared with the state in the 1940s mentioned above. From the bottom to the upper part of the Potanin region, the glacial volume in the Tavanbogd

[3] Davaa G., R.Mijiddorj, S. Khudulmur, D. Erdenetuya, T. Kadota and N. Baatarbileg, "Responses of the Uvs lake regime to the air temperature fluctuations and the environment changes", Proceedings of the first Symposium on "Terrestrial and Climate changes in Mongolia", Ulaanbaatar, 26-28 July, 2005, 130-133 p.

Mountains has melted away by 379-422 cm, the Turgen Mountain glacier by 230-177 cm and 210-100 cm seasonal snow, and the Tsambagarav Mountain snowcap by 249-158 cm. These mountains, comparatively in low altitude, have mostly glacier rivers.

Melting parameter is the degree-day [cm·°C^{-1}·day^{-1}] parameter that compares the level of snow melting to the daily average temperature. Identification of this parameter will help to determine the level of melting [M [cm]] using air temperature [°C·day] data. The volume of snow melting will not only be determined by the temperature regime, but also depend on wind speed, radiation balance, and the heat to be used for the density of water steam. Therefore, the melting parameter can be different depending on the climate and weather condition. This will require constant observation and research on glacier formation and melting and the flow of rivers beginning from the snowcap.

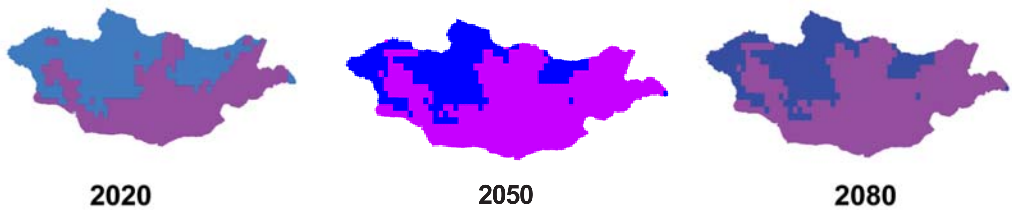

Figure A3.3.2a. Changes in Borderline of 0^0 C that has been Calculated by HadCM3 Model using SRES A2 Scenario

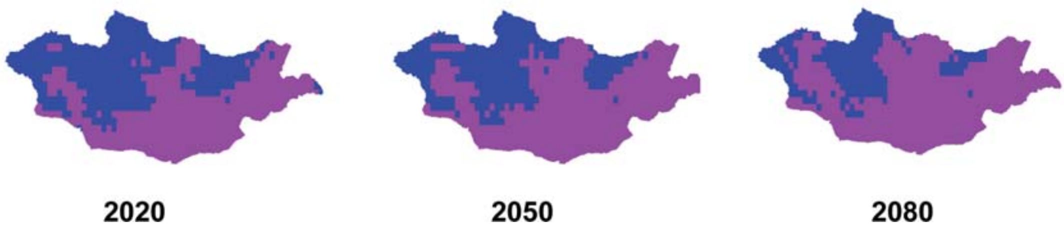

Figure A3.3.2b. Changes in Borderline of 0^0 C that has been Calculated by HadCM3 Model using SRES B2 Scenario.

Annex 3.4 Water Resources Assessment

The initial occurrence of ice occurs 10-15 days later in rivers originating from Mongolian Altai Mountains, 5-10 days later in the Khangai and Khentii Mountains, and 2-5 days later in the rivers originating from western branches of Khentii Mountains and Ikh Khyangan Mountains. Moreover, the date on which the ice deteriorates occurs 5-15 days earlier on average; specifically, ice deterioration occurs 10-15 days earlier in the rivers running from the Mongol Altai and Khangai Mountains, 8-12 days earlier in the rivers originating from the western branches of the Khentii Mountains, and, 3-5 days earlier in rivers originating from eastern branches of the Khentii and Ikh Khyangan Mountains. Because of this timing shift, the period that the rivers have ice cover is between 10 days to 1 month fewer on average.

The occurrence of ice on larger lakes also has changed. Even though no change has occurred with respect to the ice cover on the Khuvsgul Lake, the Uvs Nuur Lake has seen ice formation occurring 5 days later and ice deterioration occurring 10 days earlier. Lake Buir, located in the eastern part of Mongolia, now has ice formation 20 days later and deterioration 10 days earlier. In addition to the change in timing, the ice cover is no longer as thick as it once was. The thickness of the ice in the rivers running from the Mongolian Altai Mountains has decreased by 40-100 centimetres, by 20-40 centimeters in the rivers from the Khangai and Khentii Mountains, and by 20-40 centimetres in the rivers from western branches of the Khentii Mountains, within which the Khanui River has thinned by 100 centimetres.

Spring Snowmelt and Runoff Flooding

Before the soil is fully thawed in the spring, the river water levels are largely fed from snowmelt water, and in years with heavy snow, the snowmelt water can cause flooding. The river water flooding due to snow melting, known as called snowmelt runoff flooding, usually occurs in April or May. Depending on the geographic location of the rivers that originate in the mountains, the total volume of water from spring snowmelt runoff is approximately 10-35% of a river's annual flow. The intensity and volume of runoff water from the snowmelt depends completely on the climate conditions at that time. Because of this, the snowmelt runoff water is one important indicator that shows the effects of climate change.

Research results show that the timing of the snowmelt runoff flooding in the rivers from the southern branches of the Altai and Khangai Mountains has been delayed by 20 days. In the rivers from western branches of the Khangai and Khuvsgul Mountains, it has been delayed by 15 days. In the rivers from the northeastern branches of the Khangai and Khuvsgul Mountains, it has been delayed by five days. Also, in the case of the Tuul River, the beginning of the snowmelt runoff flooding begins 20 days earlier, and in contrast, the snowmelt runoff flooding has been delayed by 15 days for the Khalkh River and others running from the Khangai Mountains.

Summer Floods (Flashfloods) Caused by Rainfall

In Mongolia, 60-80% of the annual precipitation occurs in the summer, and the highest level of water flow can be observed in July and August when the heaviest rains occur.[4] The total volume of water caused by summer rains comprises 40-70% of the total river flow.

[4] Surface water in Mongolia,1999.

The summer floods in the rivers from western branches of the Khentii Mountains occurs 2-3 days later; in the rivers from southern branches of the Khentii Mountains, the summer floods are 10 days later; in the rivers from the Khangai, Khuvsgul and Khan Khukhii Mountains, the summer floods are 2-7 days later; and, the most extreme example is seen at the Khalkh River, where the summer floods are approximately one month later.

However, this change in the timing of the summer floods is less noticeable in the upper part of the rivers as comparative to the more noticeable change in the lower part of the rivers. Moreover, the continuity of the summer rainfall has declined by 5-10 days in the Khuvgul, Khangai and Khan Khukhii Mountains and declined by 5 days in the Khentii Mountains. Understandably, the intensity of the river floods increases when the duration of the flood is reduced; as a result, the river floods also can create increased risks. For example, the change in the timing of the Tuul River summer flooding is shown in **Figure A3.4.1**. This Figure demonstrates that there is almost no change in the volume of the river flow, but there has been a great change in the seasonal regime. Because of the intensity of the summer flood and the water passing at extremely high speeds, the river loses its ability to absorb water in the bottom soil. As a result, it cannot support the river during the summers with low precipitation, causing a disturbance to the river's flow. In other words, the harmony between the underground and surface water is lost due to climate change.

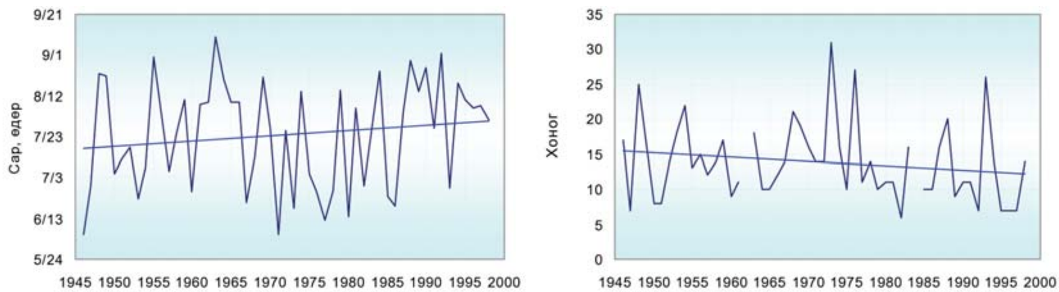

Figure A3.4.1. Change in the Beginning Date and the Continuity Period of the Tuul River's Summer Flood (P. Batima, 2005)

Besides the changes occurring with respect to the initial date of the summer floods and the continuity period, the floodwater flow is also changing. The intensity of the rivers originating in the southern branches of the Khangai Mountains, the Khuvsgul Mountains, and the Khan Khukhii Mountains has increased by 30-50 m^3/s. Also, the intensity of the rivers originating from the southern branches of the Khangai Mountains, the Khuvsgul Mountains and the Khan Khukhii Mountains has increased by 100 m^3/s or more. However, the intensity of the river flow has declined by 30-50 m^3/s in the rivers originating in the western and northern branches of the Khangai Mountains and the southern parts of Khentii Mountains.

Thus, the change in river flow regime is closely related to the changes in air temperature and precipitation, as well as the change in permafrost condition, soil erosion, and soil thawing, which are all caused by climate change. Therefore, to demonstrate the inter-relatedness of these causes, to determine the specific negative impacts of climate change and to determine preventative measures against possible dangers, detailed research should continue to be conducted on the rivers, lakes, soil, mountain snow cover, permafrost and rivers that begin from permafrost mountains.

Impact of Future Climate Change on River Water Flow

Researcher P. Batima has calculated the impact of climate change on the water reserve and predicted its future trend. Change in river flow was calculated using the climate change or the change in air temperature and precipitation.

Calculations show that when the air temperature is constant and the level of precipitation changes, the river flow directly depends on the precipitation amount. For example, if the amount precipitation decreases by 10%, while the air temperature is constant, the river flow in the Central Asian Internal River Basin, Arctic Ocean Basin and Pacific Ocean Basin will decrease by approximately 7.5%, 12.5% and 20.3%, respectively. When the level of precipitation decreases by 20%, the reduction in river flow is approximately the same in all basins; the river flow decreases by 20.2% in Central Asian Internal Basin, by 22.3% in the Arctic Ocean Basin and by 29.3% in the Pacific Ocean Basin.

The percentage increase of river flow due to the 20% increase in precipitation is comparatively less than the decrease in volume of river flow when there is the same percentage decrease in precipitation. When there is no change in the volume of precipitation, but the air temperature increases, then on average the river flow in the Arctic Ocean basin decreases by 4-20%, and decreases by 15-30% in the Pacific Ocean Basin. This fact is explained by an increase in evapotranspiration. Thus, the surface water cannot be supported by soil moisture or underground water.

However, in the Central Asian Internal Basin, the river flow will increase by 6.7% with a one degree increase in the air temperature, and as the air temperature increases by 2^0 C the river flow decreases by 3.4%, and with a 3^0 C increase in air temperature, the river flow decreases by 0.2%. This fact shows that the initial temperature increase causes snow cover and glaciers to melt, thereby increasing the river flow. However, as the temperature continues to rise, the snow cover and glacier reserve is exhausted; when the air temperature increases by 5^0 C, the river flow will decrease. Approximately 40% of the Mongolian river and water reserves belong to the Central Asian Internal Basin, and the Great Lakes Depression comprises another 20% of the water reserve of the country.

According to the calculation of the future scenario of climate change based on the large-scale climate models developed by UK Hadley Centre, river flow will increase greatly in the Pacific Ocean Basin and moderately in the Arctic Ocean Basin up to 2040-2070. Also, there is a tendency of increasing river flow in the Central Asian Internal Basin until 2040 and decreasing after that; the volume of river flow increase and decrease will be 11% and 19%, respectively, as compared to the level in 2040. When the results of the scenarios developed using the above mentioned models are combined with other models, one can predict with great certainty that the water reserve in Mongolia will increase until 2040 and then will decrease, eventually returning to today's levels.

The impact of climate change on the Great Lakes Depression has been calculated based on "WaterGap" model (Water – Global Assessment and Prognosis, Version 2.1; Alcamo et al., 2003, Doll et al., 2002) and (B. Lener and P. Batima, 2004). Parameters of the Khovd River flow have been identified based on this model and its tendency for 2011-2040 has been calculated based on the climate model developed by the Hadley Center. Moreover, the river flow in the Uvs Lake Basin tends to increase. By comparison, the water flow decreases in the Khyargas Lake Basin. Particularly, in the basins of the Khovd River and Buyant River, the river flow tends to decrease by approximately 25%. However, the "WaterGap" model does not account for the formation process of snow cover and glaciers and the snowmelt supplied to the rivers; instead, it mainly uses the future changes in temperature and precipitation.

Dr. G. Davaa has calculated the current water balance of river basin area and the future change in its elements while using greenhouse gas emission scenarios SRES A2 and SRES B2 and the UK Hadley Center's climate models. The results of the climate scenario, i.e., the precipitaion, air termperature, wind speed, humidity, and total radiation data for 2020 (2011-2040), 2050 (2041-2070) and 2080 (2071-2100), and the results of the climate change models based on the SRES A2 and B2 scenarios compared with the norm from 1961-1990 are shown on the map of Mongolia with 0.5^{o} x 0.5^{o} grid. In order to determine the current mean of the water balance elements and their future changes and to determine the model parameters, the volume of river flow, its evaporation and water surface evaporation must be determined, plotting the results on the 0.5^{o} x 0.5^{o} grid map throughout the territory of Mongolia.

Annex 3.5 Natural Disaster Assessment

There are many different, even contradicting definitions of the term disaster that can occur in the economy, society and environment, including natural disasters. In addition, many terms that are widely used in risk management can be understood having different meanings when referring to a disaster.

Definitions

United Nations General Assembly Resolution 42/169 regarding the designation of the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), states: “Natural disaster is the phenomenon that one or more natural phenomenon occur at the same time covering larger territory, causing human fatality, property damage or destruction where normal way of life cannot be continued on.” According to this definition, natural disasters occur because of natural causes. This definition also connotes that natural disasters occur without human will and power.

In the UN Resolution 42/169 that declared the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), “earthquake, storms (cyclone, typhoon, tornado), tsunami, flooding, land movement, volcano eruption, grasshopper migration and etc.” were considered natural disasters.

This definition of natural disaster includes human fatality and property damage, but damage to the environment and cross border social and economic damages are not counted. However, when the natural phenomena create natural disasters, it usually causes socio-economic damages and also environmental degradation. The environmental degradation also negatively impacts society and the economy. Therefore, those phenomena that negatively affect the environment should also be counted as natural disasters. In practice, Mongolia counts a sudden increase of rodents, forest fires and steppe fires as natural disasters. Therefore, environmental degradation, in addition to large sum property damage, should be included in the UN’s definition of natural disaster. Environmental degradation also includes irreversible damage to the ecosystem. For example, the drought and desertification that occurred in the Sudan-Sachel in the 1970s caused 1,793 human fatalities from 1970-1974 and millions of “environmental refugees.” Moreover, the drying up of Lake Aral in the Russian Federation and five lakes in the Gobi region in Mongolia, including Lake Ulaan that never came back to life, should be counted as ecological damage. The Center for Research on the Epidemiology of Disaster (CRED) has publicly announced that it will develop a list of natural disasters which includes the ecological disaster of the African “drought” in the list of natural disastrous phenomenon.

From here the next questions arise: what natural phenomenon should be counted as natural disasters, and how should an international standardized list of natural disasters be developed?

In the UN Resolution 42/169 that declared the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), “earthquake, storms (cyclone, typhoon, tornado), tsunami, flooding, land movement, volcano eruption, grasshopper migration and etc.” were considered natural

disasters. In other words, these phenomenons are the geological, meteorological, hydrological, ecological and biological phenomenon that may result to the natural disaster.

However, this issue is addressed differently in various documents worldwide. For example, the insurance company Munich Reinsurance, which insures against natural disasters, developed a list of natural disasters that occurred from 1960-1998, and its list did not include any biologically or ecologically caused phenomenon as natural disasters. The list did include extreme hot and cold temperatures or heat and cold waves, e.g., 1.2% of total listed items fell in the drought/ heat category. According to this information, droughts constitute nine percent of all natural disasters, are the number one cause of human fatality and caused 49% of all deaths worldwide from 1965-1999.

However, another UN[5] source states that droughts constitute 22% of all natural disasters (or impact 33% of affected population), but caused only 3% of human fatalities, the smallest percentage compared to other disasters. Today, there are a variety of different resources that address the types of natural disasters, their frequency and the damage caused. Therefore, it is essential to have a standardized methodology to evaluate these disasters.

The term "natural disaster" not only refers to the intensity of the phenomenon itself, but also to the vulnerability of the affected objects. Thus, the next question arises: how much damage must occur to constitute a natural disaster? It is difficult to place a value on damage with respect to human fatality. However, the damage that occurs to an economy, society and the environment can more easily be determined and value.

In the EM-DAT of CRED, a natural disaster occurs when (i) an incident that causes ten or more human deaths or adversely affects 100 or more people and (ii) when help from the international community is requested or the area is declared to be in a state of emergency. However, in Mongolia, where its population is scattered throughout the country, there has been relatively minor urban development and the nomadic husbandry lifestyle endures, the sudden death of animals is considered a natural disaster. Therefore, the term "zud" is being considered a natural disaster, especially when it greatly affects the nomadic lifestyle.

Frequency of Natural Disasters

According to data collected since the 1970s, Mongolia has experienced approximately 25-30 atmosphere related natural phenomenon, and of these almost one-third caused natural disasters and five to seven billion Tugrug in damage for the government and the society. Since the mid-1990s, excluding droughts and dzuds, temporary hard weather conditions caused 10-12 billion Tugrugs in damage every year, which is due in large part to lack of protective mechanism against natural disasters, or improved statistical data.

With regard to human fatality, continuous strong snowstorms (6 hours or more of snow) that cover a large territory are the most dangerous. During this type of storm, herders who are usually in the pastureland with their herds are especially vulnerable. For example, on from April 16 to April 20, 1980, a strong snowstorm, with up to 40 m/s of speed, continued for 60 hours and caused 43 human deaths (during the socialist era, the statistics on damage was not open to public) and 800,000 animal deaths. No information has been collected on whether wind speed or disaster frequency has been affected by climate change. However, information

[5] Kleshenko A.D. Modern monitoring issues - issue.33,2000,pp.3-13

is available on the frequency of droughts and zuds and on other types of atmospheric convection causing dangerous phenomenon (heavy rains, squalls, thunderstorms, and big hails) covering small territory.

The frequency of heavy rain is increasing when compared to the occurrence of rain; thus, the volume of rain per day is increasing.[6] For example, according to the data collected at the Arvaikheer station from 1979-1996, the frequency of heavy rain increased by 18% when compared to the total precipitation in warm season. Since the convection intensity is increasing, the frequency of socially and economically harmful phenomenon, including flashfloods, thunderstorms and hailstorms, has increased by twofold **(Figure A3.5.1)**

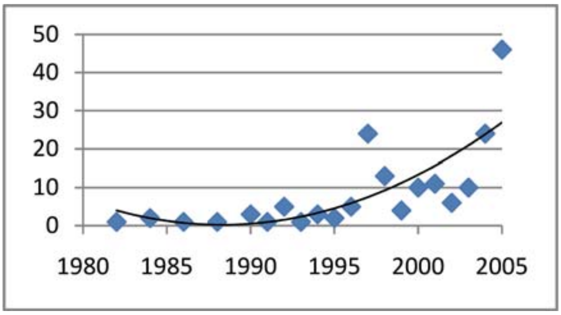

Figure A3.5.1. Multiyear Tendency of Atmoshperic-Convection-Related Natural Disasters

Moreover, if one looks at highest level of rainfall per day recorded at the 40 meteorological stations since the 1940s, 28 stations recorded the maximum level of rainfall before 1980 but 35 stations recorded maximum rainful between 1981 and 2006. But it is also noted that 19 out of 28 previous stations before 1980 had the second highest level of rainfall.

Drought

Drought is a natural disaster that causes a significant amount of damage to the economy and soceity. Drought usually occurs in dry, semi-dry and less moist areas. However, no uniform method exists to determine what exactly constitutes a drought and how to evaluate whether a drough occurred. Since there is no common understaing of droughts, the information received from areas with droughts usually differs. Moreover, it is important to differentiate between dry, semi-dry and less moist conditions from drought conditions. According to some definitions, drought is considered an anomalous climatic condition that occurs when an area lacks moisture. Stated differently, drought is an anomalous climatic condition when the temperature rises and there is no rain for months during the vegetation growing period.

Generally Mongolia has experienced a drought every three years. Depending on drought and precipitation levels, the condition of the vegetation cover in the pasturelands will differ from year to year. According to a study, during drought years, the vegetation cover will diminish by 12-48% in high mountain areas and by 28-60.3% in the Gobi and steppe regions. Global climate change affects the climate condition of Mongolia that now has an increased intensity of dryness.[7] **Figure A3.5.2** shows the multiyear history of drought indices.

[6] L. Natsagdorj. 2005: Special features of the precipitation during the vegetation growing period in Mongolia and its changes. – Geo-Ecological issues in Mongolia, No. 5, pp. 157-177

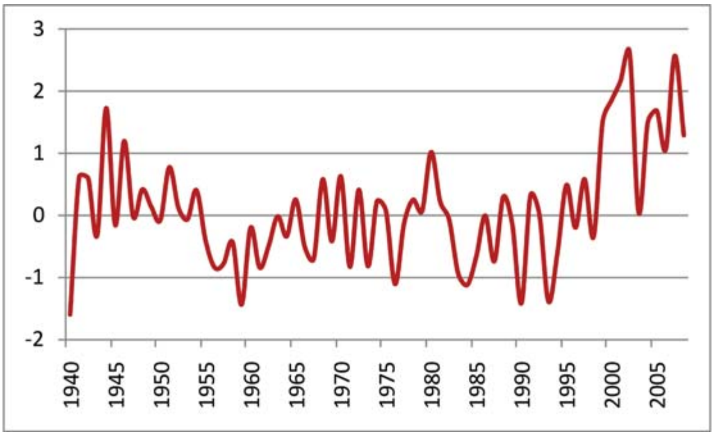

Figure A3.5.2. Multiyear History of Drought Indices.

It is clear from these climate models that the expected amount of precipitation cannot sustain the sudden increase in air temperature. Therefore, the intensity of the droughts is predicted to increase in the territory of Mongolia (**Table A3.5.1).**

Table A3.5.1. Future Trend of Drought Indices /used HADCM3 Model

	SRES A2			SRES B2		
	2020	2050	2080	2020	2050	2080
S_{SUM}	1.83	2.44	4.34	1.70	2.15	3.62

Zud (Harsh Winter)

The productivity of nomadic animal husbandry and the herders' livelihood are almost completely dependent on environmental and climate conditions. Due to harsh weather conditions, every year, millions of animals die, and as a result of these deaths, the herders' livelihood and the country's economy is hit hard. Mongolians have been engaged in nomadic animal husbandry for thousands of years, and the risk that this way of life will become extinct because of changing environmental, climate and weather conditions is of great concern.

Observation demonstrates that the colder the winter, the higher the number of animal deaths. This statement has been supported by previous research results.[8] Figure 6 shows the history of multiyear winter index. From here one can conclude that extreme winters occurred in 1956-1957 with S_{win}= -1.88; in 1944-1945 with S_{win}= -1.70; in 1954-1955 with S_{win}= -1.69; and, in 2005-2006 with S_{win}= -1.36.

[7] L. Natsagdorj, D. Dagvadorj, P. Gomboluudev. Climate change in Mongolia and its future trend. – A Scientific Organization of Meteorological Institute, No. 20, Ulaanbaatar, 1998, pp.114-133,
L. Natsagdorj, For the issues of aerial drought research on the territory of Mongolia –"Climate change and agriculture" theory and practice workshop (Darkhan city, November 22, 2002), - Ulaanbaatar. 2002. pp.26-47
L. Natsagdorj, B. Tsatsral, N. Natsagsuren. Aerial drought on the territory of Mongolia and issues of large scale correlation between ocean and atmosphere, - "Ecology and sustainable development" series No. 7, 2003, pp.151-180

[8] Natsagdorj.L, Dulamsuren.J 2001Some aspects of assessment of the dzud phenomena- Papers in meteorology and hydrology UB. 2001. pp. 3-18

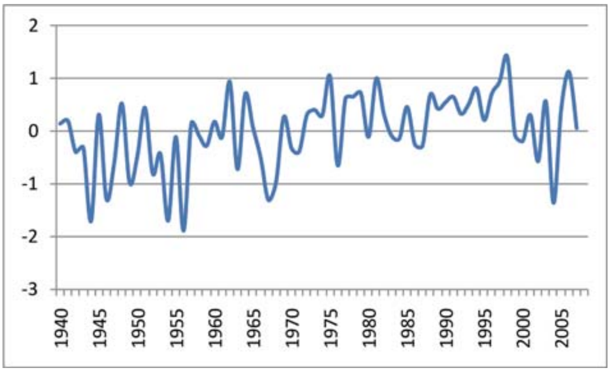

Figure A3.5.2. Multiyear Average Winter Iin Mongolia (S_{win})

The Figure shows the trend that the winters are somewhat less severe since the 1970s until 2000, and since then the winters again have been harsh. In the 21st century, it is expected that Mongolia will be affected by global warming; however, the winter precipitation levels tend to increase, so it is expected that there will be no increase in the winter index or that the winter will be harsher (**Table A3.5.2)**.

Table A3.5.2. Future trend of Winter Index as Calculated by HADCM3 Model

	SRES A2			SRES B2		
	2020	2050	2080	2020	2050	2080
S_{WIN}	-0.2	0.16	0.09	-0.05	-0.15	-0.325

Future zud condition. Harsh winters and summers will follow zuds. Figure 3.29 shows the multiyear history of the zud index. The zud condition has less impact since the 1940s until 2000; however, drought in the late 1990s and several zuds around 2000 caused a sudden increase in the zud index. The harshest zud occurred in 1944-1945 with S_{dzud}= 3.43, which caused the deaths of approximately 31% of the total herds. The zud index before 2000 can be explained mainly by the harsh winter conditions, but after 2000, it is mostly due to summer drought conditions.

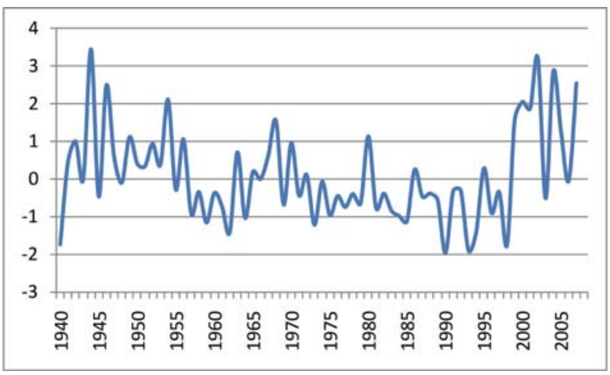

Figure A3.5.3. A Multiyear Trend of the Average Zud index of Mongolia (S_{zud})

The higher the zud index is, the larger the area that has been affected by the zud.[9] In other words, when the zud index value is high there is almost no chance of moving to nearby zud free area to avoid the damage. In order to determine the future trend of the zud condition in the territory of Mongolia, ∆S has been calculated using average monthly temperature and the total precipitation amount, which was determined by the net calculation for 2020 (2010-2039), 2050 (2040-2069) and 2080 (2070-2099) using greenhouse gas emissions scenarios SRES A2, SRES B2 by model HADCM3 (**Table A3.5.3**).

Table A3.5.3. Future Trend of Zud Index Calculated by HADCM3 Model

	SRES A2			SRES B2		
	2020	**2050**	**2080**	**2020**	**2050**	**2080**
S_{ZUD}	2.03	2.28	4.75	1.77	2.3	3.94

From the table, it can be observed that the future zud index might be higher than the maximum value in the past 60 years in Mongolia. This means that it is going to be more difficult to be engaged in animal husbandry and will cause habitual degradation for those animals that do not hibernate in winters.

9 Natsagdorj L Sarantuya G. ON THE ASSESMENT AND FORECASTING OF WINTER –DISASTER (ATMOSPHERIC CAUSED DZUD) OVER MONGOLIA – “the sixth internactional workshop proceeding on climate change in Arid and Semi-Arid Regions of Asia” Aug. 25-26 .2004 UB.pp 72-88

Annex 3.6 Desertification Assessment

Within the framework of the baseline study project for “Dynamic of desertification in Mongolia”, new assessment conducted in 2007 by using of land and satellite monitoring data result has shown that 78,2% of territory of Mongolia has been affected by middle and high rate decertification[10] (**Figure A3.6.1**).

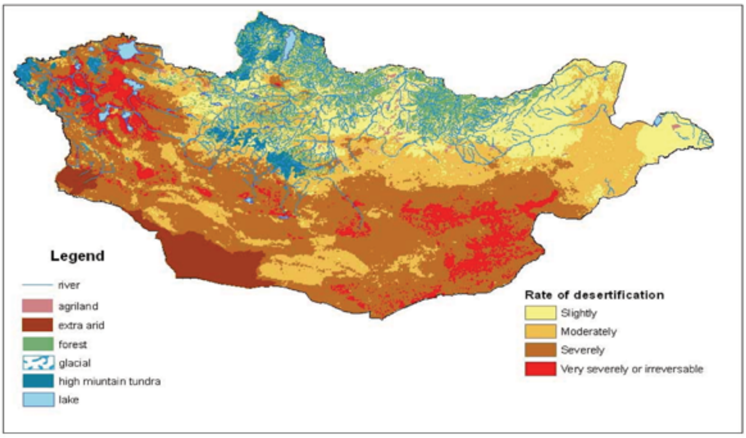

Figure A3.6.1. Dispersion of Desertification in Mongolia (A.Khaulenbek 2007)

Consequently, desertification impact assessment study results such as 20-30% decreasing[11] of a pasture grassland growth during the last 40 years and livestock vulnerability rise[12], due to the pasture degradation has shown that desertification issue shall be considered at the National Security Management level.

The following factors of current desertification process have been identified in Mongolia:

- Increase of air temperature during the vegetation growth period that causes to the intensive increases of surface evaporation process. In against to this, precipitation has been decreased rather than increase for the compensation of humid lost from evaporation.
- Number of extremely hot days has been increased and it makes a stress to the vegetable growth,
- Cloudburst occurrences have increased by 20% within annual rainfall in warmest seasons, consequently, duration period of rainfall has decreased

[10] Mandakh N. Dash D. Khaulenbek A. Present Status of Desertification in Mongolia- Geoecological Issues in Mongolia, Edited by J. Tsogtbaatar, UB., 2007, pp. 63-73

[11] Bolotsetseg B., Erdenetsetseg B., Bat-oyun Ts. Changes in grassland phenology and yields during the last 40 years. – Papers in Meteorology and Hydrology, Institute of Meteorology and Hydrology, Issue No.24, 2002, UB., p. 108

[12] L. Natsagdorj G. Sarantuya. On the assessment and forecasting of winter-disaster (atmospheric caused dzud) over Mongolia. – The sixth internactional workshop proceeding on climate change in Arid and Semi-Arid Regions of Asia. Aug. 25-26, 2004, UB, pp 72-88

- Due to snow cover melts in early time, number of soil surface bared days until the vegetation sprout period has increased, consequently, potential occurrences on dust storms have increased, by the result of surface free particles flowing with the wind

Figure A3.6.2 shows a historical process of surface evaporation and precipitation, during the vegetation growth period, observed at the Tsetserleg meteorological station, which locates in the central part of Mongolian territory. It is clear, precipitation (P) decreases and evaporation (E_0) increases and differences of these indicators rise for last 40 years. Such ficture has been observed almost in the whole territory of Mongolia. We have defined aridity, one base of estimated amount of differences between precipitation and evaporation and identified intensively aridy places (**Figure 3.32**).

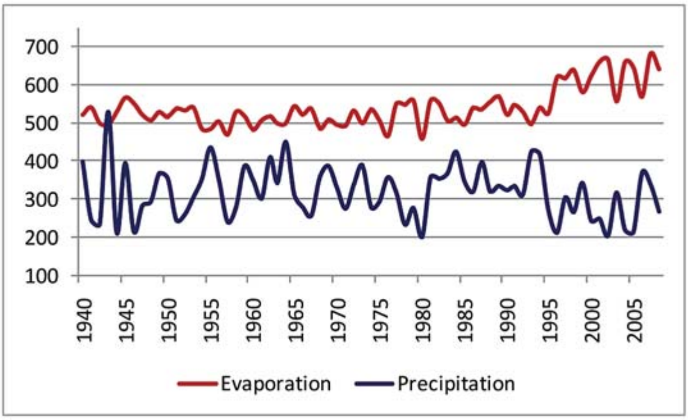

Figure A3.6.2. Historical Data Records on Precipitation and Evaporation at the Tsetserleg Meteorological Station

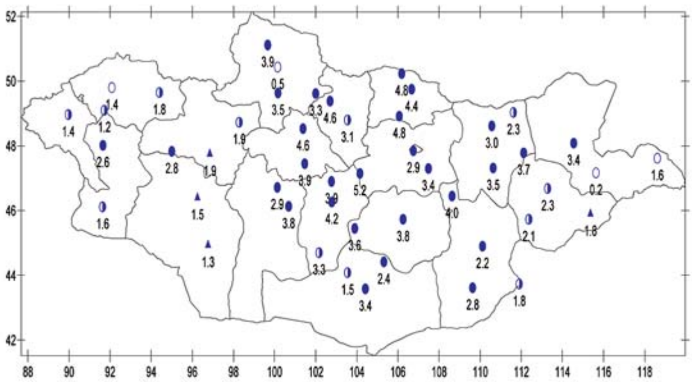

Figure A3.6.3. Equalization Coefficient for Right Angle of Historical Line Trend on Differences between Cumulative Surface Evaporation and Precipitation.

Note: pursuance of 99%, colored fully, 95%-semi colored. 90% of pursuance indicated by triangle, non statistical pursuance-uncolored

Figure A3.6.3 shows that rapid increases of differences between cumulative evaporation and precipitation occurred at the central and east region by 3-5 mm/year and at the Altai Mountains, Gobi desert farther Ailtai and at South east region by 1.3-2.0 mm/year. This indicator has been fixed at the Uvs lake basin and South east boundary area, with up to 90% non pursuance. Whereas, it has more that 95% pursuance in the central and western part of east region it reached to almost 99% of the entire territory of Mongolia.

Recognition of biogeophysical negative feedback mechanism of land ecosystem-atmosphere system into the regional climate system has greatest important to identify natural and human induced impacts of desertification. Feedback mechanism indicators regular monitoring and analysis has provided an opportunity to investigate climatic desertification process with regards to the changes affected by human activity. Climate related desertification means differentiated climate factors that make activation and enervation desertification spontaineity. A. Aubrevlle, French botanist and ecologist has firstly defined the concept on climate-related desertification in 1949, while he observed a contribution of climate-related aridity to the desertification process caused by human effects in African Savanna (Aubrevlle 1949).

The theory of climate related desertification developed as hypothesis on sun rise reflection by Otterman. L. P (1974) within the tiny area, D.G. Charni (1975) in regional area[13]. Russian scientist Zolotokrylin A.N. has analyzed relationship between surface albedo and temperature along desert and its boundary areas at the south region of Russian and African Sahara, using land and satellite data. Taking into account this analysis results, he has estimated that a desertification threshold mean is equal or less by 0.5 t/ha from green phytomass annual resources i.e. Normalized Difference Vegetation index (NDVI) mean is equal or less than 0.07 (Zolotokrilin 1997, 2000, 2003, 2003). According to his calculation, precipitation threshold value is 195±5mm for giving appropriate phytomass. In other words, in areas where precipitation occurs less than 195 mm, a surface energy has been balanced. Then during these 2 decades, period with threshold vegetation index extended by 0.5-1 month, in ecosystems of extreme arid steppe (semi-shrub, sward, grass) and desert-steppe. This period was shortened in desert area and in some places it has reduced by month. In other words, the period of summer time has increased[14]. Variation of vegetation index threshold mean has been increased over the Gobi region of Mongolia or from the Central Asian desert to Khangai region, through large scale of territories. It shows the occurrence of climate related desertification caused by albedo-precipitation negative feedback mechanism in these areas

Figure 3.33 shows that area takes for NDVId”0.07 was occupied 27 % of the territory of Mongolia in 1982 but it has increased by 21% (48% of total territory of Mongolia) in 2005.

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[13] Otterman J. Baring high–albedo soils by overqrazing hypothesized desertification måchanizm /Sciånce.1974. Vol.186. ¹4163. pp.531-533/ Charney J.G. Dynamics of deserts and drought in the Sahel-Quart J.royal M-t-orol.Soc 1975 Vol .101 .¹0428.

[14] Zolotokrylin A.N. Gunin P. D. Vinogradova V. V. Bazha S. N. The Climate Change and the Plant Cover Conditions of Mongolia at the and of XX Centure- Proceedings of International Conference, Ecosysrem of Mongolia and Fronter Areas of Adjacent Countries: Natural Resources, Biodiversity and Ecological Prospects, Sep. 5-9 2005, Ulaanbaatar, Mongolia, pp. 427-429

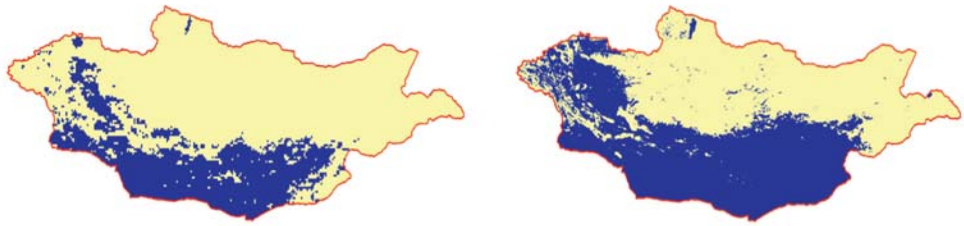

Figure A3.6.4. NDVId”0.0.07 /blue/ and NDVI >0.07 /yellow/ spatial pattern Note; a) 10 days interval in Aug, 1982, b) 10 days interval in Aug, 2005

Figure 3.34 illustrates remote sensing drought index-RSDI formulated by Scientist M.Bayasgalan, using average mean of 1982-2003.

RSDI formula characterized as following:

$$RSDI_{ijk} = \frac{NDVI_{\max_{ij}} - NDVI_{ijk}}{NDVI_{\max_{ij}} - NDVI_{\min ij}}$$

Where RSDI- remote sensing drought index, i – point or pixel, j – ten day‘s number (j=1-36), k – year, $NDVI_{max}$, $NDVI_{min}$ – maximum and minimum factors of NDVI observed during j ten day period on i pixel.

RSDI indicates generally the area of the vegetation green phytomass variability. It indicates only variability of vegetation index rather than drought, without identification of drought and pasture exceeding impacts.

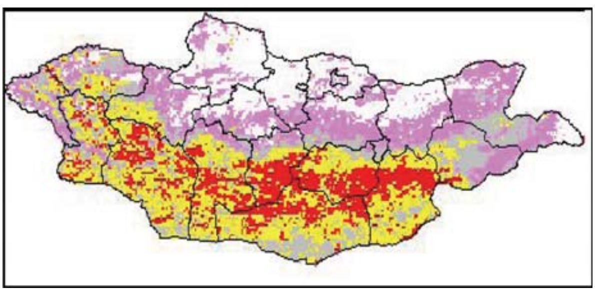

Figure A3.6.5. Historical Average Mean of RSDI estimated by Satellite Data (M. Bayarsgalan 2005)

It shall be considered that a maximum mean of RSDI has observed in the area along border site of Gobi and arid steppe, not in Desert, which is bare in terms of vegetation index valuation.

The climate will be moderately changed in these areas, where landcover degradation by the negative feedback mechanism impacts. By this point of view, amount of precipitation decrease in the central region of Mongolia and middle area of the Gobi region, during vegetation season would not be extreme cause to the desertification. However, precipitation amount slightly increased in the western region and south-east boundary areas of Mongolia it is also not guarantee of the pasture eco-system improvement.

According to study results, it is clear that climate related desertification occurs in central region of Mongolia, north-east part of west region and northern part of east region, in larger scale from the desert to other regions or ecoton zone between the Central Asian desert and Khangai region[15], through the indication as light rain percentage decrease and cloudburst percentage increase.

It is shown by the result of numeral experiment on the land cover parameters variability. Using the regional climate model, this numeral experimentation was aimed to prove the indication of the regional climate system's biogeophysical negative feedback on the sustainable historic average and seasonable mean of climate parameters[16].

Experiment was performed with the modified version of the National Centre for Atmospheric Research's (NCAR) Regional Climate Model (RegCM v.3). /Giorgi et. al. 1993, Giorgi and Mearns 1999/. To identify the Land Surface-Atmosphere relationship RegCM v.3 model was interchanged with BATS model /Biosphere-Atmosphere Transfer Scheme/ . /Dickinson et.al. 1993/

Regular summer of 1998, decent summer of 1994, and drought summer in 2000 were selected to this research. On the reanalysed global data of Western British University experiment was used monthly average mean of air temperature and monthly total precipitation data of 62 meteorological stations, located over the territory of Mongolia.Using the land surface classification recommended by World Food and Agricultural Organization, experiment was performed through such direction as current reality disturbed by desertification, semi desert replaced by Desert (DSR), short grass replaced by semi-desert (**Figure 3.35a** and **3.35b)**.

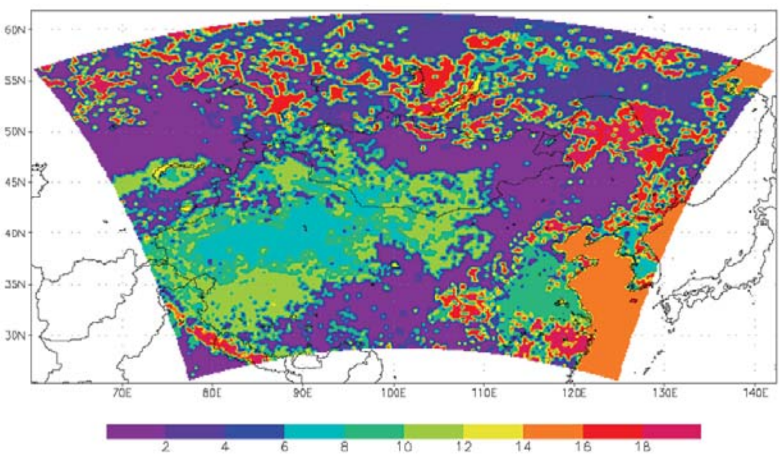

Figure A3.6.6a. Land surface model / classification of vegetation cover,
(reality: 1-cultured pasture, 2-arid steppe, 3- coniferous forest, 4-deciduous coniferous forest, 5-broadleaf forest, 6-broadleaf deciduous forest,7-steppe, 8-desert, 9-tundra, 10-irregated pasture, 11- gobi, 12-ice, 13-marshland,14- basin, 15-ocean, 16-evergreen bush, 17-deciduous bush, 18-mixed bush)

15 Natsagdorj L Various characteristics of vegetation time precipitation over territories of Mongolia Geo-ecologicla issues in Mongolia, num. 5, 2005 pp-157-177

16 Natsagdorj L.Gomboluudev. Evaluation of natural forcing leading to desertification in Mongolia-Mongolian geoscientist, 2005, pp. 7-18

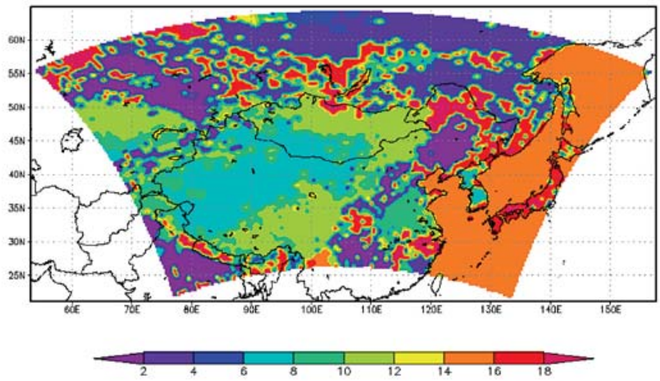

Figure A3.6.6b. Land Cover Model /Classification of Vegetation Cover, updated.
(See explanation on **Figure A3.6.6a**.)

The calculation was made over region at 41.5^{0}N-53.0^{0}N, from 87.5^{0}E, 120.0^{0}E. Based upon numerical simulation, the land mantle parameter variability causes climate characteristic dispersion change in certain level. Occurred changes were observed mostly over the border area between impacted and normal territories (**Figure A.3.5.1** and **A.3.5.2, Annex 3.5**). Particularly, while the daily precipitation decreases in 1.5-2.0 mm within the border area of forest-steppe and steppe regions, in high mountain regions remains unchanged significant climate temperature changes zone observed mostly in the border area of desert and steppe. **Table 3.18** shows monthly variability of climate characteristics associated by land cover (mantle) change.

Table A3.6.1. Land Surface Current (CTL) and Desertified (DSR) sensitivity study Version Numeral Simulations Results. Variation of parameters/

	June			July			Aug		
	CTL	DSR	Δ	CTL	DSR	Δ	CTL	DSR	Δ
Hydrological cycle									
Precipitation mm/day	2.86	2.31	-0.55	2.97	2.53	-0.43	2.67	2.36	-0.31
Evaporation mm/day	2.09	1.44	-0.65	2.26	1.66	-0.60	1.93	1.55	-0.38
Run off mm/day	0.38	0.25	-0.13	0.44	0.32	-0.12	0.40	0.29	-0.10
Top soil reserve moisture /0-10cm/ mm	22.7	25.2	2.5	23.6	25.3	1.7	24.2	24.6	0.4
Underground soil retained moisture /1-3m/ mm	228.0	143.4	-84.6	233.0	161.5	-71.6	238.4	179.4	-59.0
Surface climate									
Air temperature	16.8	18.5	1.7	20.2	22.0	1.8	17.7	19.0	1.3
Anemometer relative humidity %	60.4	48.8	-11.6	59.4	49.6	-9.8	62.6	55.1	-7.5

Table A3.6.1 shows that land surface change impacts is clearly observed at regional average weather characteristics. Therefore, when the surface characterizing (actually vegetation) interaction, the average summer precipitation decreases by 40mm in average, particularly, over the border area of forest-steppe, and steppe regions by 92-140mm. In this case, average summer temperature expected to increase up to 2-3^{o}C in desert, steppe regions. Biogeophysical negative feedback mechanism of land ecosystem-atmosphere makes a regional climate balance at certain level.

Annex 3.7 Dust and Sand Storms Assessment

A dust storm is a meteorological phenomenon common in arid and semi-arid regions of the world. Dust storms that continue through several days in Mongolia are known as an "*Ugalz"* and the same storms are identified locally in different countries or regions by various specific term. For instance, it is called "*Afganets"* in Middle Asia. *Sand storm* is the term prevalent in Russia, Europe, Canada and USA. In Egypt and east regions of Sahara is named "*hasmin",* in northern Sahara is "*meheli*", in southern Sahara is "*harmaton"*, in Italy and northern regions of Africa – "*sirroka",* in Sudan – "*haboob*", in Iraq it's known as "*samoom*", in China identified as "*huan fin",* which means "yellow dust" and "*hin fin"* which means "black dust".

According to P.S.Zaharov's record[17] about Russo-Japanese war fought from 1905 through 1906, the dust storm occurred in the Mongolian Gobi desert was carried to northeastward over the territories of China where it caused an interruption of the battle of Mukden.

In recent years, dust aerosols, originated from Mongolian Gobi and Northern China become familiar in East Asia as "Yellow dust storm" or "Yellow dust"[18]. The dry soil particles contained in the dust passes over the Northeast Asia regions of China, Korea, and Japan, can stimulate significant environmental damages and affect human health. Recent written records show that the yellow dust of East Asia was found in the ice samples that were deposited nearly 44000 years ago in Greenland[19].

Sand-and Duststorms in Mongolia

Less frequency of dust storm has been identified in the Khangai region, due to weaker wind velocities, rich vegetation cover and long sustained snow cover. However, even with stronger wind power in Steppe areas, considering the consequence of good vegetation cover and long sustained snow cover, the dust storms occur with less frequency in these areas. Sandstorm occurrences are more significant in urban areas where the soil erosion are caused by human-related activities. Figure has shown this in the certain places as in cities of Moron, Bulgan, Kharaa, Ulaanbaatar and Binder.

The geographical distribution of the number of days with drifting duststorms is shown on the **Figure A3.7.1**.

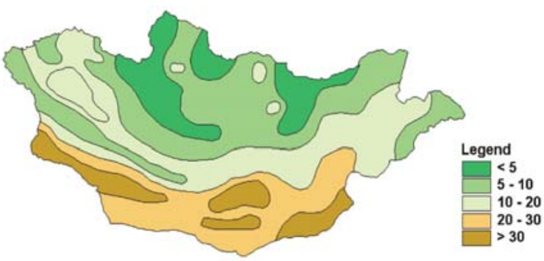

Figure A3.7.1. Geographical Distribution of Number of Days with Dust Storm

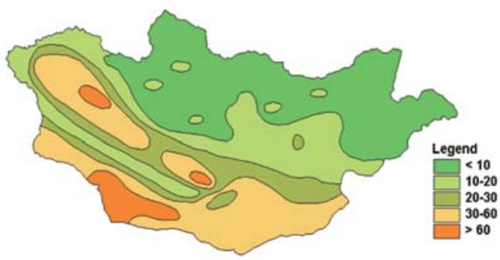

Figure A3.7.2. Geographical Distribution of Number of Days with Drifting Dust Storm

[17] Zakharov P. S. Dust storms –L., hydrometeor-publishing., 1965, 164 p

[18] Regional master Plan for the Prevention And Control of Dust And Sanstorms in Northeast Asia- ADB, GEF, 2005

[19] P.E.Biscaye, F.E.Grousset, A.M.Svensson; Science. 2000. V.290. ¹5500. P.2258. USA

It is clear from **Figure A3.7.2**, that the number of days with drifting duststorms is significantly higher than frequency of dust storms, especially in the Great Lake Depression and Gobi desert areas, and it is 30-110 days. The maximum numbers of dust blowing days are 110 in Mongol Sand region, Altai farther Gobi 50-70 days and Zamiin uud and Arts bogd area has maximum frequencies.

It is noteworthy that the urban area experience more in the number of days with blowing dust. For instance, blowing dust occurred in 16.3 days in Ulaanbaatar while in Buyant Uhaa, it is 4.2 days. Remarkably, the amount of total number days both with sandstorm and blowing dust have identified less than 5 days in Khangai, Khentii, Khuvsgul mountainous areas, 71-125 days around Great Lake Hollow, 70-98 days within Altain farther Gobi area and nearly 80 days in the region of Arts Bogd. In other words, the significant occurrence of dust flowing arises over Mongol Sand desert area (**Figure A3.7.3**).

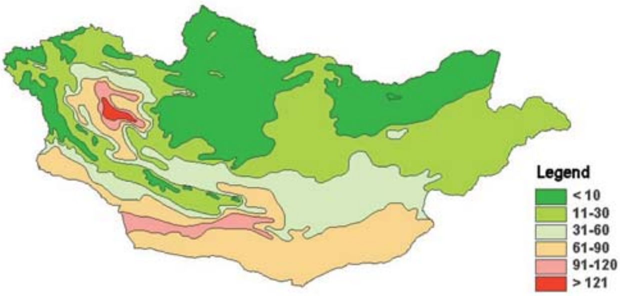

Figure A3.7.3. Geographical Distribution of Number of Dusty Days

In order to indicate dust storm dispersion through desert zone of the Central Asia, a Map was developed by using data base on climate information of China Meteorological Administration and Meteorological Services of Mongolia. **(Figure A3.7.4)**.

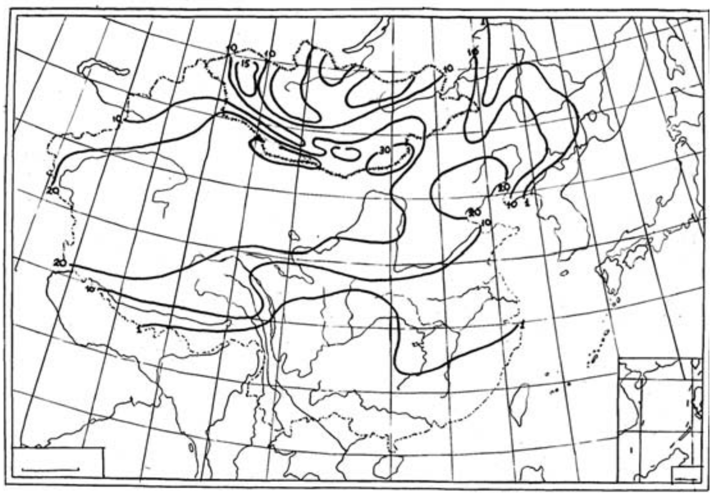

Figure A3.7.4. Geographical Disptribution of Number of Days with Dust Storm in Central Asia

Mongolian desert sandstorm has clear historical occurences. Due to the cyclone impacts transferred southward and northward from mid-latitude, the peak frequency of sandstorm occurs during springtime (59%) and the second effective frequency - during autumn in September and October (10%). The least frequency occurence in a year are during summer season, with lowest atmosphere pressure (7%). Secondly, it is at winter time, with sustained atmospheric high pressure (10%), when the impact of cyclone is weak. In other word, four extreme means of the annual occurences of sandstorm have been presented during four seasons.

Based on geographical dispersion of the annual average summary mean, the annual periodic duration of sandstorm has exceeded 100 hours in South Gobi and Altai. Farther Gobi, particularly, it is 364 hours in Saikhan. But, the maximum duration of blowing dust occurs within Altai farther Gobi (in Toroi) is 373 hours a year. On average, the duration of an individual dust storm in desert areas is approximately 4.6 hours.

Soil Erosion

The Mongolian dry climate, maximum frequencies of strong wind and lack of vegetation cover on soil surface have been common in spring time. Therefore, this season has the most serious potential harm from soil erosion by wind. According to Chappell Woodruff formula in "Climate and Land Degradation " published in 2005 by World Meteorological Organization the wind factor of soil erosion has been calculated as follows:[20]

$$C=U^3/2,\ 9(P-Eo)$$

where, E_o = the ability of surface evaporation or transpiration.

Figure 3.42 shows that estimated wind index of soil erosion by the meteorological stations data is stronger (more than 1.0) in the Gobi and Desert areas of Mongolia, particularly, in Bulgan sum of Umnogobi aimag, it has highest mean wind index. Although, Great Lake Depression has the longest dry climate duration, however, due to the central location of anticyclone in winter season in this area, wind has not been an important factor for soil erosion. Therefore, C index mean is significantly low here. Due to less occurrences of blowing wind, observed by Durvuljin station of Mongol sand region, C index mean has slightly exceeded by 0.20.

Because of effective vegetation cover, number of days with blowing dust is fewer in the western regions of Mongolia where the wind is critically strong. Consequently, C index mean is higher than Great Lake Depression region.

It shows, as a result of the less amount of pasture degradation and desertification in the Dornod steppe (at the moment 31 heads of livestock occupy 100 hectares in this region. In comparison to the average national ratio, it is less than 10 heads). In the future, there is a potential risk of intensive soil erosion by wind as a consequence of vegetation cover degradation and bare soil.. It is proper to evaluate wind speed influence that causes soil erosion, by duration of wind deflation velocity.

Scientists, Jie Xuan, and I.N Sokolik[21] estimated the percentage of annual duration of wind, which exceeded value of threshold velocity at 4.5 m/s, in total annual wind duration (8,760

[20] Climate and Land degradation, 2005:-WMO –No 989, Geneva, Switzerland

[21] Jie Xuan, Irina N. Sokolik 2002: Characterization of sources and emission rates of mineral dust in Northern China- "Atmospheric Environment", ¹ 36, pp. 4863-4876

hours) within the northern China region. According to this estimation, it is 10 times lesser in severe arid Taklaman desert. But in the national bordering areas as Southgobi, Eastern Gobi, Gobi Altai and Bayankhongor aimag of Mongolia, where it is most windy, the percentage is 30 times more. This has matched with geographical distribution of wind speed on the territories of Mongolia.

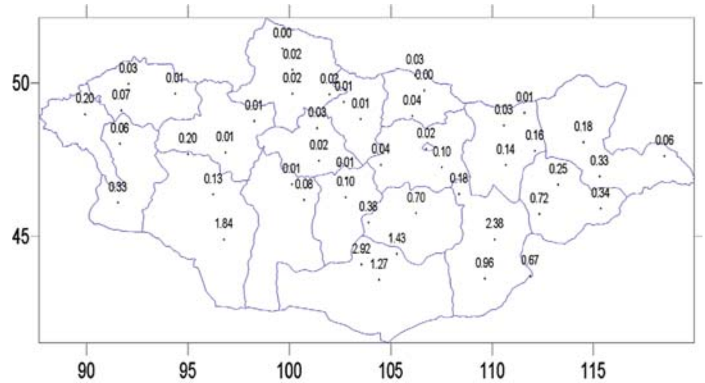

Figure A3.7.5. Wind Index of Soil Erosion

The wind threshold speed with 4.5 m/s or higher causing blowing dust and continuously occurred over 4,000 hours a year in the regions of Dornod and Mongolian desert. Particularly, it continues for approximately 4,000-5,000 hours in the eastern spreads of the desert and southern areas of Dornod; while it does not exceed 1,000 – 2,000 hours in Khangai region and Great Lake Depression. This means that the possible deflation of the total annual duration would occur in the southern spreads of Dornod and the eastern spreads of the desert. The wind speed significantly increases, especially, during spring and autumn season which makes likely conditions for soil erosion by wind influence.

Therefore, effective deflation starts at 8 m/s or higher wind speed. The wind duration continues over 1,000 hours within eastern steppe and Gobi desert regions, particularly, within southeastern regions and eastern spreads of the desert it continues for 1500-2000 hours. (**Figure A3.7.6**)

This shows that the soil erosion effectively appears with wind, by 17-23 percent of the annual duration in a particular territory. But the wind with large speed continues through less than 500 hours in Khangai regions and Great Lake Depression. Obviously, the altitude and hollowness of the land significantly affect on the duration of the wind with particular velocity.

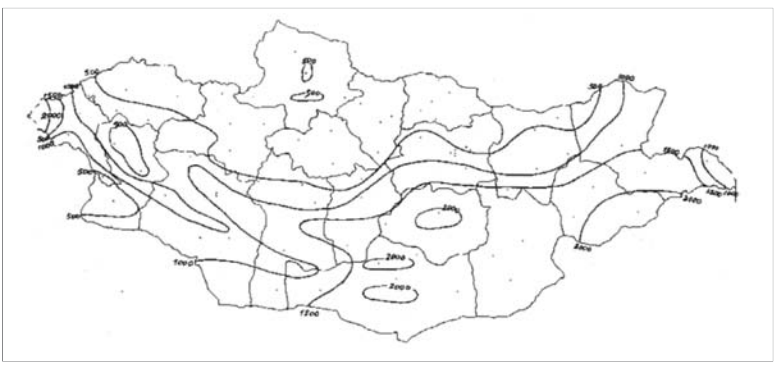

Figure A3.7.6. Average Duration of Wind Velocity with 8 m/s or higher (hours/year)

Dust Contents in the Atmosphere[22]

Regular monitoring measurement for dust partular contents in the atmosphere has started in Mongolia by the assistance of JICA, Japan since September 2007. Four automatic dust monitoring stations were established on the base of meteorological stations at the most dust storm originating places as Zamiin Uud and Sainshand of Dornogobi aimag, Dalanzagad of Umnugobi aimag and Ulaanbaatar. Lidar monitoring has been measuring the total dust contents in the atmosphere, or totat suspended particles (TSP), particulates less than 10 and 2.5 micrograms (PM10, PM2.5), vertical distribution of dust from the soil surface up to 18 km above, wind velocity, visibility, etc.

This new measurement database has provided an opportunity to confirm that Mongolian Gobi area has become a dust source area in Northeast Asia. Dust monitoring results are used to estimate fine particle dust mean in the atmosphere, highest point of vertical spread etc., andconsequently, forecast dust storm origination and movement by modeling methodology. In addition, seasonal and annual mean air pollution idicators as PM10 in the atmosphere over Ulaanbaatar city and another many new research measurements, can be estimated.

Recent observation results indicated that PM10 dust particle contents in 1 m^3 of the atmosphere in Zamiin Uud of Dornogobi aimag reached up to 1,128 micrograms, which is higher than the monthly average mean by at least 20 times more. This was particularly observed at the severe dust and snowstorm that ocurred on May 26-27, 2008 in territories of the eastern aimags of Mongolia (**Figure A3.7.7**). During this occurence, the Lidar Observation site located in Zamiin Uud has indicated that the laser beam was blocked at the distance of 1 km above the land surface, due to extremely increased dust contents in the atmosphere. Then, on 27-28 May, the dust has spread out up to about 3 km high. (**Figure A3.7.8**)

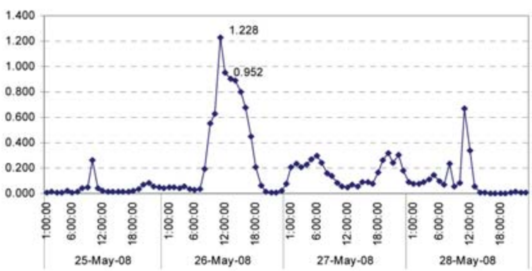

Figure A3.7.7. PM10 concentration in Zamiin uud on 25-28, May 2008, mg/ì^3

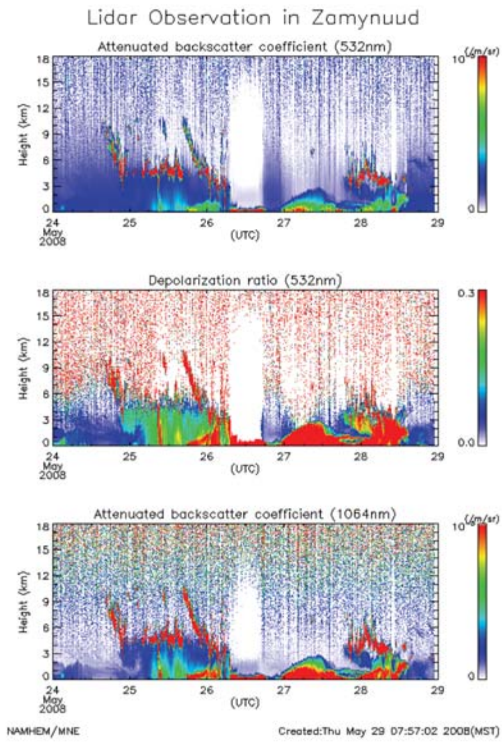

Figure A3.7.8. Results of Lidar Observation in Zamiin uud, 24-29, May 2008

22 Source by D. Jugder

Historical Records of Dust Storm

Sandstorm is a phenomenon that occurs at places with poor vegetation cover and presence of strong wind blowing the particles. Therefore, according to historical data on blowing dust and dust storm days, it is possible to identify activation of desertification process..

L.Natsagdorj et al. have analyzed 30-year historical data of meteorological stations at Sainshand, Tooroi and Dalanzadgad, located in the Mongolian Gobi desert region. The study reported that earlier in 1960 -1969, the annual avarage was 16 days with dust storm. . For the next period in 1970-1979, the figure increased to 23 days and further increased in 1980-1989 to 41 days. This is a record of increasing by more than 2 times increased for 20 years[23].

The data analysis was extended using existing records until 2007 observed at 34 meteorological stations located in different geographical regions of Mongolia.

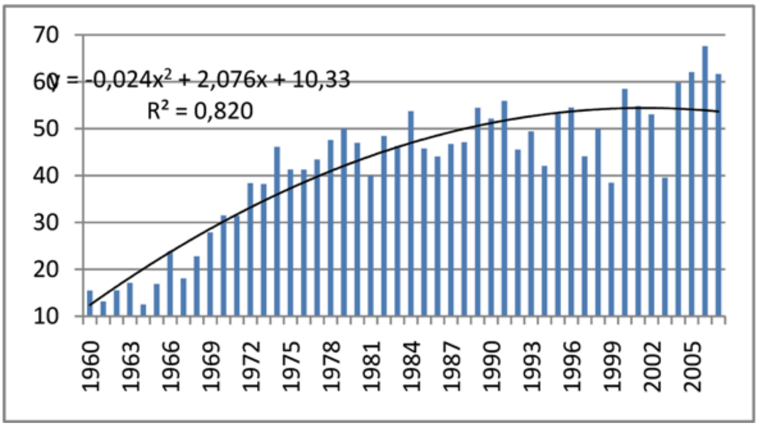

Figure A3.7.9. Historical Records of Annual Dust Blowing Days

According to results summarized in Figure 3.46 , dust blowing days were 18,3 days annually between 1960-1969 , but in 1970-1979 it has rised to 40.9, in 1980-1989 to 47.4, in 1990-1999 to 48.5, and in 2000-2007 it was reached to 57.1. There are no available information regarding the intensity of the cyclone and wind speed rise during this period in Mongolia.

[23] L. Natsagdorj, D. Jugder. Dust storms in Mongolian Gobi - "Global change- Gobi desert" symposium / 1991-12 -19/, UB, State environmental Supervision Committee publish, pp 25-40

Annex 3.8 –Assessing Climate Change Impacts in Animal Husbandry

Study on sheep, goat and cattle live-weight and other productivity, in accordance with weather condition was conducted at the animal husbandry meteorological stations in Orkhon soum of Bulgan aimag, as a representative of forest-steppe, Bayanunjuul soum of Tuv aimag, as a representative of the steppe and Bulgan soum of Umnugobi aimag, as a representative of Gobi area, which are functioning within the observation network of National Meteorological and Environmental Monitoring Agency.

Due to the only representative places which were involved in this investigation, result would be inadequate to the whole livestock consideration. However, negative and positive impacts on animal live-weight and productivity would be different in specific places, the overall tendency of climate change impacts on animal husbandry has indicated by the investigation results.

Livestock Grazing and its Changes

The adequate climate formulates normal living condition to livestock with effective productivity and genetic ability. The warm and cold air temperature, wind, precipitation amont, particularly, thick and density snow cover has become the pasturage condition unfavorable for Mongolian livestock during the entire year[24].

When air temperature, wind speed, snow thickness and density, and other weather parameters reach to a critical levels, livestock grazing on pasture restricts. For instance, the Mongolian sheep mob would be prevented grazing on pasture, if air temperature reached to range 16^{o}C at the high mountain area, 22^{o}C in forest steppe and steppe and 26^{o}C in the desert areas in sunny, cloudless day with low wind in summer season. If air temperature exceeds -30^{o}C without wind, sheep grazing on pasturage would interrupt within the any landscape of Mongolia. It was estimated that when wind speed increases by 1 m/s, the air temperature would be decreased by 1-3 degrees. For example, livestock grazing would prevent when air temperature is above 15^{o}C and wind velocity 8 m/s. In other words, the surface wind has been impacted positively in summer season and negatively in winter season.

As a result of snowfall quantity, the pasture and nutrition adequacy makes a change, whereas the snow became a main factor of the animal grazing on the open pasture. Therefore, its investigation has significant importance. However, pleasant summer took place in the forest steppe in winter season if snowfall occurs below 5 cm thickness with density less than 0.28 g/cm^3, and it would be causing difficulty on pasturing, if snow cover thickness reaches 23 cm and it makes hardest situation for pasture grazing. In the steppe, snow occurrence with 5 cm in thickness and 0,24 g/cm^3 in consistent became a negative factor on pasturing and when it has been reached to 18 cm, even snow is mild, the graze pasturing would be inadequate for lamb mob (**Figure A3.8.1**)

[24] Evaluation method of climate change impact on Mongolian sheep by Tuvaansuren G UB, 1993, page 148, Climate condition impact on livestock sector by Tuvaansuren G, Sangidsranjav S, Danzannyam B - “Orchlon” pibl.,Ulaanbaatar,1996, page 121. Climate Change and Its Impacts in Mongolia /edited by Batima P. and Davgadorj D./- UB., 2000, 199p

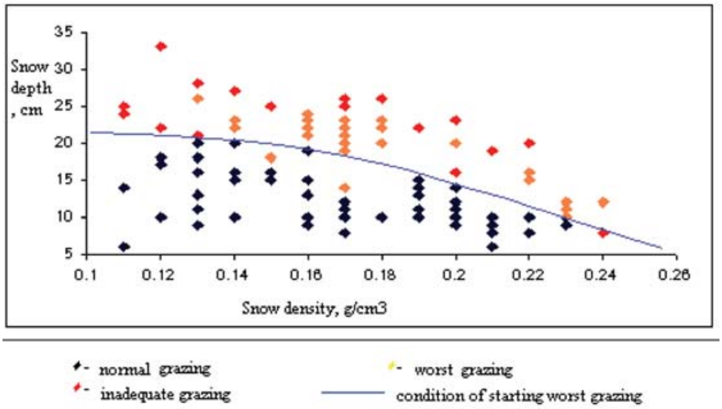

Figure A3.8.1. Snowfall influence to graze pasturing of baby sheeps in forest-steppe zone / inadequate condition has indicated above the curve /Source: B.Bayarbaatar, 2002

Climate change impact on animal husbandry

Studies conducted based on the 21 years monthly data for 1980-2001 for the meteorological stations at Tsetserleg soum of Khuvsgul aimag and Orkhon soum of Bulgan aimag show that average weight decreased for ewe by 4 kg, for goat by 2kg, especially sharply decrease has indicated since end of 1990s **(Figure A3.8.2)** In other word weight lose tendency in winter-spring season has been fixed. Particularly, ewe spring weight was reduced by 8.5 kg or 0.405 kg per year.

On the other hand, some herders and researchers have opinion on that last time animal weight increases generated by fat rather than meat, therefore animal weight lose has been identified in winter time due to fat lose (melted down).Average cattle live-weight was indicated as 263.4 kg in the observation records for 1980-2001. However, weight change vary has fixed by year to year, in total it has reduced by 13.8 kg. Even though, cattle weight was not reduced in summer, autumn time, but it was increased in winter and spring seasons. Livestock weight loses, a reduction of meat productivity consequently has been generated negative biological and economical outcomes. Lack of energy, nutrition and weight accumulation in summer and autumn time has been affected on the ability to survive harsh winter and spring time, with less forage and unpleasant condition.

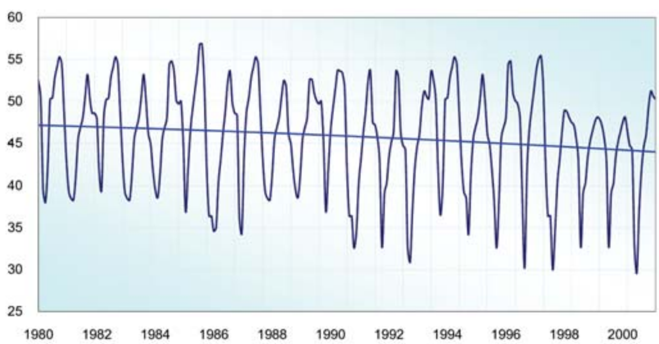

Figure A3.8.2. Observed Changes in Sheep Weight

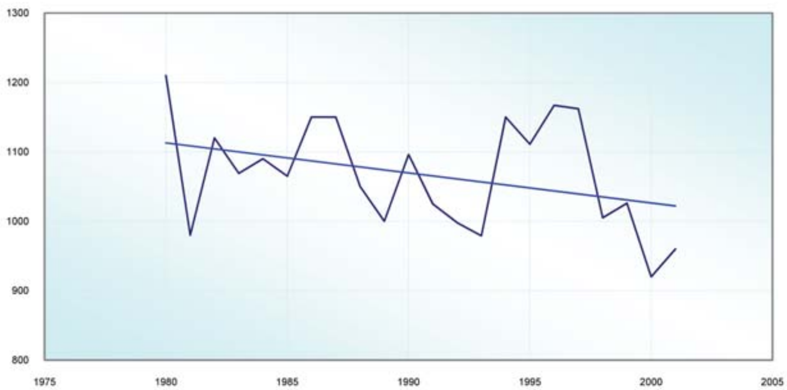

Figure A3.8.3. Sheep wool output changes. Source: G.Tuvaasuren, 2002

Animal that loosed significantly its weight has become a dwarf, due to less ability on taken its normal fat. Reduction of animal meat productivity has causes a weight lost, consequently in the meat production it would influence as food loss outputs. Therefore, commercial meat supply and overall national meat resources has been decreased by thousands of tons a year. Therefore, it impacts on herders and government economical revenue lost.

Livestock weight loses and dwarf has been affected on animal productivity. Animal husbandry meteorological station's historical observation records in the forestry steppe show that ewe wool outputs decreased by 90 gr or 4.3 gr annually. Individual sheep annual wool loses of 4.3 gram would be about 60 tons decrease of total livestock wool output in national level. It was estimated that if 0.6 m carpet or 1 m wool blanket produces by 1 kg wool, consequently there might be lost the opportunity on production of 36000 m carpets and 60000 m wool blanket a year. If this situation would continue, then economical effectiveness of light industry of the country will be reduced significantly and that can cause high damage to not only the Livestock sector but also to the national economy. Also, a trend observed on reducing of goat cashmere and cattle wool outputs. For instance, cashmere output of last 20 year decreased by 4,1 g or 0.2 g annually. This means nationwide loss about 2.0 tons of cashmere outputs from 11 million goats.

In the **Table A3.8.1** the increase of weight growth indicated by positive sign and the decrease indicated by negative sign. There has shown below some calculated data from several meteorological stations as an example.

Table A3.8.1 Mongolian Sheep Live-weight Changes on Variable Air Temperature and Pasture Biomass Condition.

Hutagt station of Bulgan aimag

Projected temperature changes ^{0}C	**Change of pasture biomass, %**						
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**
1^0 C	-4,721	-4,590	-4,460	-1,763	-1,510	-1,258	-1,006
2^0 C	-7,113	-6,987	-6,861	-4,219	-3,968	-3,718	-3,469
3^0 C	-9,230	-9,009	-8,448	-6,435	-6,202	-5,960	-5,718
4^0 C	-9,350	-9,070	-8,682	-6,960	-6,684	-6,502	-6,119
5^0 C	-9,583	-9,371	-8,841	-7,602	-7,003	-6,828	-6,611

Uliastai station of Zavhan aimag

Projected temperature changes ^{0}C	Change of pasture biomass, %						
	-30	-20	-10	0	10	20	30
1^0 C	-4,956	-4,828	-4,700	-2,019	-1,765	-1,510	-1,256
2^0 C	-7,176	-7,053	-6,930	-4,347	-4,101	-3,855	-3,610
3^0 C	-9,073	-8,154	-7,350	-6,335	-6,097	-5,859	-5,621
4^0 C	-9,612	-8,697	-7,968	-6,796	-6,486	-6,582	-5,211
5^0 C	-9,844	-9,197	-8,584	-7,162	-6,943	-6,782	-6,319

Dalanzadgad station of Umnugobi aimag

Projected temperature changes ^{0}C	Change of pasture biomass, %						
	-30	-20	-10	0	10	20	30
1^0 C	-2,626	-2,510	-2,395	0	0,267	0,498	0,730
2^0 C	-2,718	-2,603	-2,488	-0,062	0,169	0,400	0,631
3^0 C	-2,959	-2,844	-2,729	-0,314	-0,084	0,146	0,376
4^0 C	-3,141	-3,079	-1,982	-0,429	-0,195	-0,082	0,215
5^0 C	-4,025	-3,658	-3,121	-0,762	-0,486	-0,125	-0,012

Table A3.8.2 and **A3.8.3** shows sheep spring and autumn weight variability through the regional average mean by air temperature changes of 4-5^{o}C. Sheep weight changes are simillar and depended on ecological zones. Analisys results predicted that degradation possibility to gain sufficient weight in any ecological zone in case of the climate warming.

Table A3.8.2 Sheep Weight Changes in Summer with Changed Temperature by 4^{o}C and Pasture Biomass (%)

Natural zone	Pasture biomass change, %						
	-30	-20	-10	0	10	20	30
Forest-steppe	-51.21	-47.76	-45.05	-39.24	-37.65	-36.26	-34.30
Steppe	-33.34	-30.01	-23.10	-20.05	-17.57	-15.99	-12.48
High mountain	-33.35	-29.43	-26.05	-24.83	-23.04	-20.62	-19.82
Desert	-23.73	-21.11	-14.66	-11.52	-9.45	-8.87	-4.00

Table A3.8.3 Sheep Weight Changes in Summer with Changed Temperature by 5^{o}C and Pasture Biomass (%)

Natural zone	Pasture biomass change, %						
	-30	-20	-10	0	10	20	30
Forest-steppe	-57.37	-55.03	-50.98	-43.32	-40.91	-39.16	-36.92
Steppe	-39.14	-35.42	-28.93	-26.19	-22.98	-19.55	-15.66
High mountain	-42.33	-39.64	-36.38	-33.88	-31.72	-29.71	-27.64
Desert	-29.18	-24.94	-17.87	-7.17	-3.54	-0.95	-0.13

The Summer-autumn weight growth decreasing trends, depending on ecological zone and air temperature increase, were observed. It is clear that degradation of pasture plant has become a main factor on weight loss. In addition, the air temperature influences were observed. However, in gobi region there is identified slight impact of air temperature increase.

By the results of ECHAM model that has calculated the dispersion value of summer-autumn sheep grazing condition, it is clear that warming impact would be higher in future, in comparison to other modeling outcomes.

There is clearly identified negative impact on Mongolian sheep pasture graze in summer season related with warming process.

Table A3.8.4. Forecast condtions of sheep graze pasturing by ECHAM model (%)

	Current	ECHAM by SRES A2			ECHAM by SRES B2		
		2020	2050	2080	2020	2050	2080
Normal	25.14	14.35	3.89	0.00	13.13	3.56	0.67
Difficult	36.60	28.59	25.25	9.68	28.59	24.03	20.13
Prevent	38.26	57.06	70.86	90.32	58.29	72.41	79.20

By the results of climate change evaluation SCIRO model we have estimated the variation of sheep graze pasture condition in summer time as shown in **Table A3.8.5**.

Table A3.8.5. Future Projected Changes of Sheep Pasture Condition by CSIRO Model Results /%/

	Current	CSIRO A2			CSIRO B2		
		2020	2050	2080	2020	2050	2080
Normal	25.14	19.91	6.45	0.00	13.79	3.89	1.89
Difficult	36.60	38.15	28.48	14.91	30.14	28.25	23.80
Prevent	38.26	41.94	65.07	85.09	56.06	67.85	74.30

As a result of the estimated above mentioned 3 models, it shows the comparative percentage regions where the sheep graze on pasturage interrupted during summer season would be as are approximately 40-60% of the total territory in 2020, 65-70 % in 2050, and 70-90 % in 2080,. The Figure 3.52 shows the future tendency on slight reduction of regional areas with unfavorable sheep pasturage condition, affected by cold temperature

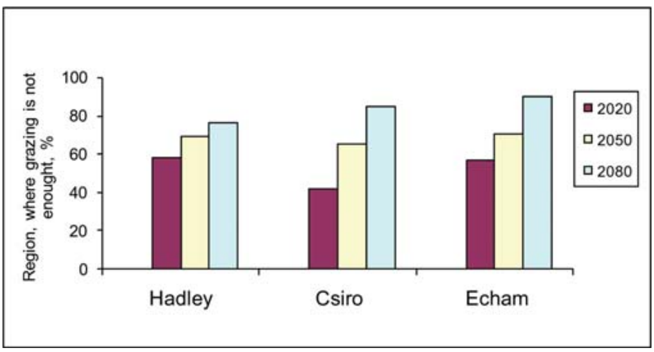

Figure A3.8.4. Climate Change Impacts on Sheep Graze on Pasture Condition

The influence of winter cold temperature on the sheep pasture

One of the negative impacts on animal pleasant grazing during spring-winter seasons is the cold weather condition. Cold weather influences on the significant loss of the animal's body heat and causes inability to graze on pasture and able to being frozen. When the average regional temperature reduces to -22- -25°C, the grazing condition became complicated and the period of sheep's grazing shortens. It was identified regional wide variability of impacts on sheep's winter grazing that could be caused to its interruption, in case of climate change occurrences in 2020, 2050, and 2080

In addition to, regional dispertion of negative and positive condition for sheep grazing was defined, by the research results on cold weather condition, through temperature data analysis, which can be associated livestock pasture interruption. Analysis aimed to determine regional zones that could be negatively influenced on sheep pasture in 2020, 2050, and 2080 based on HADCM3, ECHAM, CSIRO model results by projected climate change.

HADCM3 model results. The percentage of the entire region which is pleasant and unpleasant for the sheep pasturage under the influence of the cold winter temperature was calculated and shown in Table 3.26.

Table A3.8.6. Forecast on Sheep Pasture Winter Condition Estimated by HADCM3 Model Results /%/

	Current	HADCM3 SRES A2			HADCM SRES B2		
		2020	2050	2080	2020	2050	2080
Prevent	36.26	30.03	21.69	19.91	28.92	26.36	19.91
Difficult	47.27	50.28	53.73	55.51	51.17	50.50	55.51
Normal	6.46	19.69	24.58	24.58	19.91	23.14	24.58

The other climate models show the similar results on the decrease of temperature stress to the sheep grazing in the winter season. Figure 3.1.2.9 shows the compared size percentage of regions with the condition of pasturage prevents identified by HADCM3, CSIRO, and ECHAM models.

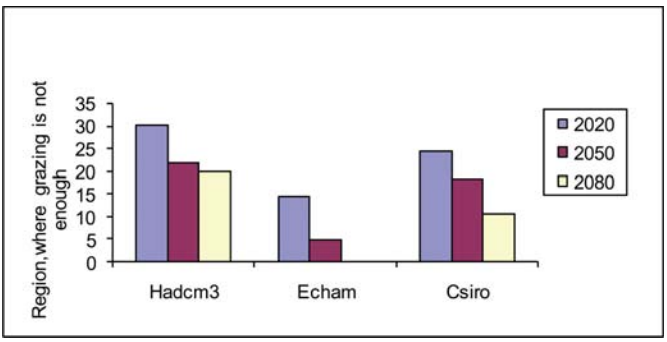

Figure A3.8.5 Climate Change Impacts on Sheep Graze Pasture

The above graph shows future tendency of decreased area size of regions with the sheep pasturage prevents affected by cold winter temperature, identified similarly by all models that. According to temperature change analysis results, estimated by ECHAM model, territorial area with sheep pasture prevents would decrease up to 15% in 2020, 5% in 2050, and only 1% in 2080, which has shown the maximum warming output. Slight reducing trend observed by the CSIRO and HADCM3 models. It would be possible tendences that cold condition, with sheep pasture prevents would decrease in the Gobi and steppe regions.

According to climate warming process the regional zones and number of days with pasturage intterupt, due to cold temperature has been decreased in winter time. Only temperature influence has considered there rather than snow inlfuence consideration. Cold season annual precipitation change clearly described in other section of the report.

Climate change impacts on the Sheep weight changes

The weight change means the indicator that integrated various live circle changes of the Mongolian sheep and environmental impacts on it. The growth, fredelity, ability to live and another defferent additional facts are all depend on weight change. During this analysis, trends on ewe weight changes in winter-spring period was assessed by 2 models such as EKZNJTZ and EKUKJTZ, using data outputs of climate change condition impacts on ewe weight, estimated by HADMC3 model. The changes of pasture biomass at 37 meteorological stations representing different geographical regions of Mongolia, estimated by CENTURY model, was used to evaluate the influence of climate change on the pasture growth in the future, within certain time and space.

Based on the estimates by dynamic-statistical model for sheep weight change, the formula for estimating daily energy balance has been written as following:

$$Wei=Wpi-(Woi+Wmi+Wni+Wci+Wti+Wfi+Wli)$$

Where, We – energy balance; *Wp* - energy intake; *Wo* - energy requirement for basic metabolism; *Wm* - energy requirement for grazing; *Wn* - energy requirement for warming ingested material; *Wc* - energy requirement for digestion; *Wt* - energy requirement for maintaining body temperature; *Wf* - energy requirement for fetus growth; *Wl* - energy requirement for milk production. Unit: kcal day-1; i –model time step, day

The climate change impacts on sheep weight during winter-spring season. Mongolian sheeps even during the cold temperature, snow cover on pasture, dust and snow storm, strong wind and lack of grassrange can survive with optimal spending of their accumulated body energy from the gained weight and successfully multiply by producing young in spring grazing on open pasture during winter-spring time.

Assessment of climate change impacts on sheep weight during winter-spring period was conducted using local simulation models based on the weather and pasture grassland actual data.

Annex 3.9 Assessing Climate Change Impacts in Agriculture / Arable Farming

There are many historical evidences, proving that Mongolians dealt with agriculture from the ancient time. But during the recent few centuries agriculture was almost abandoned and only from the 1950s Mongolia started to cultivate new lands. The new policies of development of this sphere and those of supplying the nation with flour, produced by domestic industries were implemented.

In result of implementation of the above mentioned policies Mongolia has highly skilled professionals, specialized in agriculture, and the total square of cultivated lands reached 1.3 million hectares. Mongolia applies new technologies, which are suitable for the local soils and climate conditions. There are guaranteed reserves of cultural plant and crop seeds of high sorts. The entire field of agriculture is well-equipped with advanced and fully mechanized techniques.

By their geographical situation, soils and climate features the agricultural lands occupy three main regions **Figure A3.9.1**

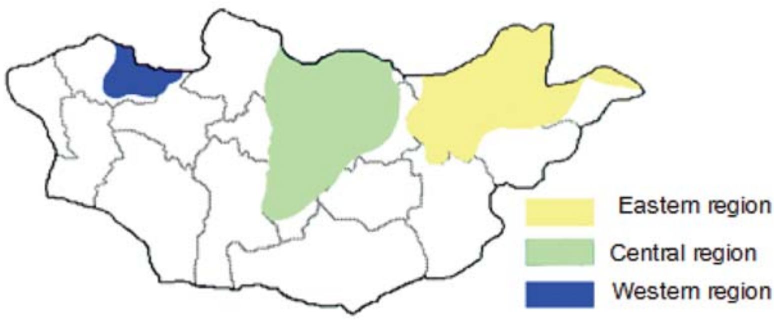

Figure A3.9.1. Main Locations of Agricultural Land Regions

First region: It lays on dry steppes and steppes area i.e. the Eastern region of the country. The soils here are basically powdery and rich with carbonates, dark brown and brown. There are many other types of soils as well. This region lays on the territory of the Khentei and Dornod aimags and on the Northern part of the Sukhbaatar aimag.

Second region: It lays on forest-steppes and steppes area i.e. the Central agricultural region. The soils here are basically black earth. This region lays on the territory of the Tuv, Selenge and Bulgan aimags, the most of the lands of the Uvurkhangai aimag, on the Eastern part of the Arkhangai aimag and on the South-eastern part of the Huvsgul aimag.

Third region: It lays on the mountainous area i.e. the Western agricultural region. The soils here are basically brown and black earth. This region lays on the territory of the North-western part of the Zavkhan aimag and on the Eastern part of the Uvs aimag.

In 1986-1990 years, Mongolia sown crops on the area of average 645.0 thousand hectares, wheat seeds were sown on nearly 500 thousand ha. Potatoes – on 11.2 thousand ha, vegetables – on 3.5 thousand ha. For satisfying domestic needs for provision the 770.0 thousand tons of crops were harvested, wheat - 633.0 thousand tons, potatoes -127.0 thousand tons, and vegetables - 46.0 thousand tons. The excessive part of the harvests was exported to the international market.

Total area of planted potatoes, sown wheat of Mongolia and harvests are shown in Table A3.9.1 below. 'Before 1990 Mongolia was capable to satisfy own domestic market needs for wheat, but soon later the wheat harvests dramatically got down (Table 3.1.2.11 and 3.1.2.12). The average of the recent years shows that Mongolia is capable to harvest wheat that satisfies only 40 % of total domestic needs.

Table A3.9.1. Agricultural Areas and Crop Yields.

Years	Area sown with wheat seeds, thousand ha	Wheat harvested/ thousandtons/	Wheat harvested from 1 ha/ centners/	Area planted with potatoes, ha	Potatoes harvested/ thousand tons/	Potatoes harvested from 1 ha/ centners/
1960	214.5	215.5	10.0	2215.2	18.5	83.4
1965	362.2	319.6	8.8	2733.2	24.3	88.8
1970	348.0	288.1	8.3	2873.7	22.0	76.6
1975	315.6	413.0	13.1	4309.0	42.3	98.1
1980	408.2	229.8	5.6	7450.9	39.3	52.8
1985	482.1	688.5	14.3	10338.1	113.9	110.1
1990	532.9	596.2	11.2	12167.0	131.1	107.7
1995	348.5	256.7	7.4	6225.7	52.0	83.5
2000	194.9	186.2	9.6	7882.6	58.9	74.7
2005	159.1	74.0	4.8	9757.8	82.8	84.8
2006	126.2	139.0	10.8	10723.4	109.1	101.7
2007	121.8	109.6	9.4	11461.5	114.5	99.9

Note: 1 centner = 0.1 tons

Table A3.9.2. Ratio between demand and supply of the wheat in 2001-2006 (October/September) (thousand tons)

Total supplies	2001	2002	2003	2004	2005	2006	2007
	402	**374**	**389**	**406**	**375**		
Domestic harvests	139	123	160	136	74	139	110
Import	243	191	209	236	251	260	261
Aid from abroad	44	43	41	39	35	??	??
Total demands	**402**	**374**	**389**	**406**	**375**	**??**	**??**
Food consumption	292	297	303	312	318	??	??
Other needs[1]	50	58	51	45	37	??	??

Source: FAO/GIEWS food balances and Mission's estimates for 2006/07.

[1] Other needs mean demand for wheat seeds for sowing.

The food demands of average Mongolians are basically needs for potatoes and vegetables. Domestic harvests of Mongolia are sufficient to satisfy 60-70% of domestic needs for these types of food. Although the domestic harvests of potatoes and vegetables are increasing, their market prices are still high for the low hygienic quality of the vegetables, imported from China. The domestic demand for Mongolian origin vegetables remains very high. /Joint Food Security Assessment Mission to Mongolia, April 2007/.

Table A3.9.3. Domestic Harvesting of Potatoes, Vegetables and Fruits and their Import (thousand tons)

	1989	1990	1995	1999	2000	2001	2002	2003	2004	2005	2006	2007
Potatoes												
Harvested	155.5	131.1	52	63.8	58.9	58	51.9	78.7	80.2	82.8	109.1	114
Imported			2.9	9	13	22	36	474	1 035	1 383	35.6	30.2
Vegetables												
Harvested	59.5	41.7	27.3	39	44	44.5	39.7	59.6	49.2	64.1	70.4	76.4
Imported	2.7	2.1	1.8	0.1	1.1	0.3	0.1	0.1	0.6	0.2	4.3	1.9
Fruits and berries												
Imported	3.4	3.5	2.6	8.4	11.4	12.1	18.7	23.3	22.9	22.6	15.3	17

Source: NSO.

Food safety and quality guarantees

Food safety and quality guarantee means the particular food meets quality standards and is free from contamination with microorganisms, which may provoke infectious diseases that affect human health and free from the contents of harmful chemicals.

In Mongolia permanent controlling and monitoring of the quality and safety of importing food during entire trace from the moment of importing until supplying the consumers are weak and inappropriate. The conditions of food transportation, storage and sales are inadequate, which undermines the safety guarantees. The 5% of meat and meat products of the highest demand, 2.3% of milk and dairy products are produced using industrial methods. As for the rest of percentage, it is supplied by private traders or through so called “black markets”. Storage and transportation of food requires abiding with certain regimes, so it is quite doubtful that the current infrastructure and private trading conditions can guarantee food safety and quality.

More than 30% of infectious diseases in Mongolia are caused by consuming food products, which do not meet hygienic and safety requirements and by the environment that violates sanitary requirements. The major part of infectious diseases is caused by bacillus and bacteria that provoke gastroenterological disorders and intoxication.[25] From the studies it is seen that spread of infection, provoked by food origin bacteria in 2005 year, if to compare with 2003 year, is increased by 11,2%. In 1995-2000 years the rate of oncologic disorders among the population got increased, among them dominates cancer of liver, it proves that the population consumed food with no safety guarantee.

Nutrition facts of food

Food of everyday consumption of the Mongols are flour, meat and dairy products (See Table 3.1.2.14), and consumers takes from such food nearly 86 % of the daily calories needed. Although Mongolia leads in meat consumption in the World, 55 % of the daily calories consumers take from vegetables.

25 Public Health Report -2006, issued by the MPH of Mongolia

Table A3.9.4. Average yearly food consumption per one consumer (in Kg)

	2001	2002	2003	2004	2005	Average
Meat and meat products	97.2	97.2	98.4	94.8	99.6	97.4
Milk and dairy products	100.8	100.8	130.8	138.0	140.4	122.2
Flour and bakery products	110.4	110.4	114.0	105.6	118.8	111.8
Rice	15.6	15.6	18.0	18.0	26.4	18.7
Potatoes	26.4	26.4	31.2	33.6	43.2	32.2
Other vegetables	16.8	16.8	18.0	16.8	25.2	18.7
Fruits	3.6	3.6	4.8	6.0	12.0	6.0
Vegetble oil	6.0	6.0	8.4	8.4	12.0	8.2
Fish and sea food	2.4	2.4	0.0	1.2	2.4	1.7
Sugar and confectionery	12.0	12.0	12.0	12.0	16.8	13.0

Source: NSO.

Table A3.9.5. Daily Calories per Consumer (%)

	National average	Urban areas	Rural areas	Ulaanbaatar
Meat and meat products	20	17	23	15
milk and dairy products	11	7	16	7
Flour and bakery products	55	59	52	58
Vegetables	3	4	2	5
Fruits	1	1	0	1
Sugar and confectionery	6	6	5	6
Tea, Coffee, drinks	1	1	0	1
spices	4	6	2	7
Total	**101**	**101**	**100**	**100**

Source: 2002/03 HIES/LSMS.

Although consumption of potatoes, vegetables and fruits by the consumers, especially by those, living in urban areas, is increased for the recent years, the rate remains low. Consumption rate is lower than that of the Asian standard.

The fact that the Mongolian consumers cannot consume food rich with valued nutrients affects the public health, immunity of people gets weakened and they become vulnerable and less resilient to health disorders. Various public health and food studies prove that healthy growth and physical development of the children slows down.

The researchers state that increase of infectious diseases and oncologic disorders, allergies, and body joints disorders (arthritis, arthrosis, rheumatism, ostheohandrosis) is closely related to the fact that food is poor with nutritional value.

The research studies performed by the Public Health Institute of Mongolia /PHIM/ shows that daily food of average Mongolian consumer grown short in calories in 12 times the permitted standard of 2200 k\cal. Protein became 2 88.6- 105.4 gr, fat 77.6-90.1 gr, carbohydrates 213.8-290.7 gr a day. This leads to misbalance of nutritional substances in organism. A member of the family with the income lower than the lowest guaranteed income and poor livelihood gets only 58.1-68.5 % of the daily calories needed. It is a far low indicator.

One of the main indicators, determined on the objectives of the Millennium Development of Mongolia, is the fact that Mongolia started to put much of attention to minimize nutritional deficiency among the children under 5 years old. But the research studies of the PHIM state one of every four children under 5 years old is behind in height than others, one of eight is affected by anorexia, 32% are affected by rachitic and dystrophy. 43.6% - suffer iron deficiency and anemia.

Climate change impacts on harvesting and agricultural products

Changes of the past time

The network of measuring and assessment of agro-meteorology and agro-climate in Mongolia was first established in 1959 year, the **Table A3.9.6** shows monitoring results, taken from various measuring stations:

Table A3.9.6. Location of Stations and Measurements Taken

№	Names of the stations	Agricultural regions	Longitude	Latitude	Height above the Sea level m
1	Darkhan	Central Agricultural region	105.98	49.47	706
2	Yuruu	Central Agricultural region	49.75	106.67	676
3	Tarialan	Central Agricultural region	49.6	102	1236
4	Ugtaal	Central Agricultural region	48.27	105.42	1160
5	Khankhgol	Eastern Agriculturalregion	47.62	118.52	688
6	Baruunkharaa	Central Agricultural region	48.92	106.07	811
7	Baruunturuun	Western Agriculturalregion	49.4	94.6	1232
8	Erdenesant	Central Agricultural region	47.2	104.25	1356
9	Orkhon(Selenge)	Central Agricultural region	49.15	105.4	748
10	Khutag	Central Agricultural region	49.37	102.7	933
11	Jargalant	Central Agricultural region	48.52	105.9	1200
12	Ingettolgoit	Central Agricultural region	49.45	103.95	800
13	Tsagannuur	Central Agricultural region	50.1	105.43	800
14	Kharkhorin	Central Agricultural region	47.2	102.77	1430

Changes harvesting

The rate of harvesting within the agricultural regions in Mongolia fluctuates year after year, depending on the weather precipitations. The diagram below shows fluctuation of wheat harvesting rate for many years.

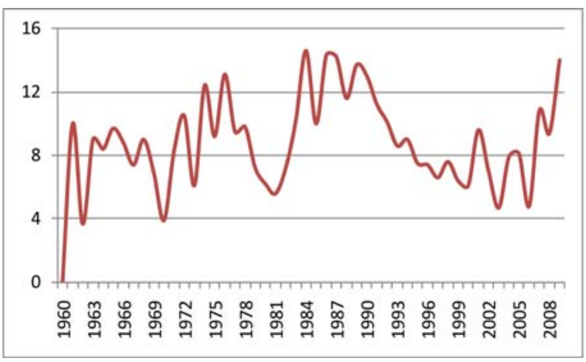

Figure A3.9.2. Spring Wheat Harvesting Rate Fluctuation for Many Years

Table A3.9.7. Coefficient of Changes in Timing of Wheat Growth

Name of station	Year	Length of mature wheat	Germination –emergence	Emergence-Double ridge appearance	Spikelet initiation – Heading	Heading-Maturing	Maturing-Grainfilling
Tarialan	65-07	42	-0.28	-0.38	0.06	-0.19	0.13
Yuruu	66-06	38	-0.18	-0.12	0.16	0.12	-0.16
Orkhon	70-07	35	-0.19	-0.1	0.05	-0.17	-0.34
Ugtaal	80-07	27	-0.003	-0.29	0.12	0.05	-0.16
Darkhan	85-07	21	-0.31	0.13	-0.24	-0.03	0.06
Baruunkharaa	98-07	16	-0.63	-0.38	0.16	-0.07	-0.17
Baruunturuun	85-07	15	-0.19	0.32	-0.15	-0.18	-0.27
Khutag	86-06	15	0.62	0.15	-1.1	-0.45	-0.61
Khalkhgol	86-07	13	0.38	-0.31	0.23	0.56	-0.40
Average			**-0.09**	**-0.11**	**-0.08**	**-0.04**	**-0.21**

The average cumulative air temperature, favourable to wheat growing, starting from 1st day of May when the stages start to be observable, was assessed. The sinusoid shall show the fluctuation between the maximal and minimal temperatures, all the assessments and measurements were done using INSTAT.

Table A3.9.8. Cumulative Temperature at the Time of Each Stage

Name of Station	Germination - emergence	Emergence-Double ridge appearance	Spikelet initia-tion – Heading	Heading - Maturing	Maturing-Grainfilling
Tarialan	189	398	689	812	1127
Yuruu	201	457	749	904	1225
Orkhon	265	510	822	982	1272
Ugtaal	179	414	733	856	1149
Darkhan	163	311	737	800	1202
Baruunkharaa	341	627	908	1022	1373
Baruunturuun	218	416	691	803	1171
Khutag	242	457	813	961	1256
Khalkhgol	262	474	870	951	1342
Average	229	452	779	899	1235

Since there was some warming observed during the last time, so almost all stations indicate warming trend of the air temperature per each stage of growth.

The table below shows coefficient of correlation between the time span of each stage of wheat growth and cumulative favourable air temperature.

Table A3.9.9. Coefficient of Correlation between the Time Span of each Stage of Wheat Growth and Cumulative Favourable Air Temperature.

Name of Station	Germination - emergence	Emergence-Double ridge appearance	Spikelet initia-tion – Heading	Heading - Maturing	Maturing-Grainfilling
Tarialan	0.44	0.40	0.20	0.35	0.24
Yuruu	0.26	0.67	-0.05	0.67	0.49
Orkhon	0.82	0.37	-0.07	0.30	-0.11
Ugtaal	0.50	0.20	-0.14	0.35	-0.15

Darkhan	0.57	0.00	-0.12	0.18	0.34
Baruunkharaa	0.52	0.41	0.00	0.06	0.25
Baruunturuun	0.09	0.68	-0.09	0.46	-0.11
Khutag	0.15	0.40	-0.20	0.24	0.56
Khalkhgol	0.18	0.15	0.54	0.23	0.62
Average	0.39	0.36	0.01	0.32	0.24

From the above table is visible that at the stage between spikelet initiation and heading wheat growth is less dependable on cumulative favourable air temperature.

Annex 3.10 – Assessment of Impacts on Forestry

Forest resources. The coniferious forests of Mongolia serve important purposes; they provide soil and water conservation, runoff regulation and mountain ecosystem balance. In accordance with the implications of these important purposes all forest areas are classified into one of three zones: (1) special (prohibited or strictly protected); (2) protected; and (3) industrial or utilization.

The forest stock of Mongolia consists of all types of trees and shrubs including saxauls and culitivated trees. This forest stock is composed of 140 species of trees and shrubs, such as larch, cedar, fir, conifer, spruce and siberian fir, along with broad-leafed trees such as birch, aspen, poplar, elm and willow. Saxaul forest occupies 25.3% of the total forest area. This vegetation covers spacious geographical areas such as flat steppe areas of mountains and mound downhill, ravines with laved soil, dunes, gravel soil and sand cover at the flat surface of the desert-steppe zones over the areas of Great Lake Hollow, Olon Nuur Valley, Dornogobi, Gobi Altai mountain, Dzungarian Gobi, Southern Altai Gobi and Alashan Gobi.

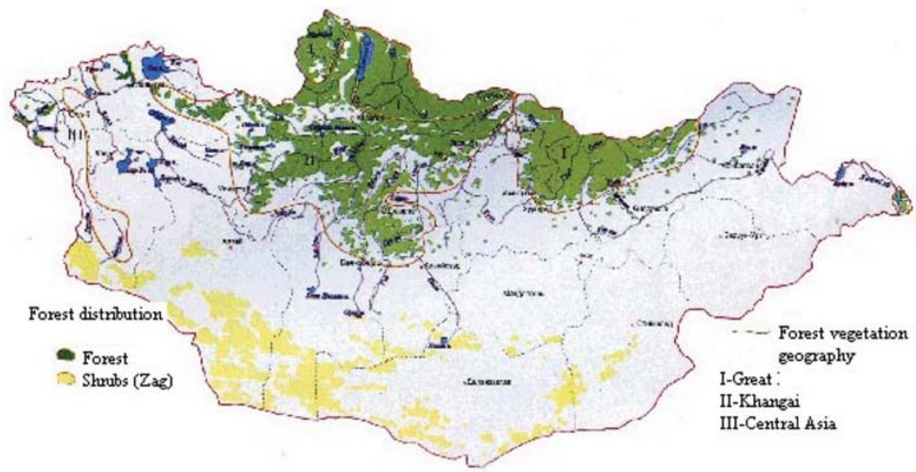

Figure A3.10.1. Forest Cover of Mongolia

Forest exploitation. Fire and harmful insects cause particular damage to the forest resources of Mongolia, and in addition, human-related activity has had a significant effect during the last 100 years. A study of the impacts of human-related activity on the forest ecosystems of Mongolia during the last 100 years has identified the following:

- approximately 40% of total forest stand stock has suffered by unwise human-related affects;
- nearly 680,000 hectares of forest area has not regenerated naturally after forest fire damage;
- 250,000 hectares of forest area has not recovered after clear-cutting;
- 1,730,000 hectares of coniferous forest has been replaced by broad-leafed trees such as birch and poplar;

- 159,000 hectares of forest land has been deforested and transformed into steppe and desert areas; and
- the production quality of 1,230,000 hectares of forest area has declined.

Therefore, boreal area, adapting to continental, dry ecological conditions, has degraded, and 16% of the total forest ecosystem has been replaced by other types of ecosystems.

According to various statements, there is data demonstrating that from 1974 to 2000 approximately 1.6 million hectares of forest area has vanished. Forest resource deficiency and declining quality occurred as a consequence of the unsystematic grazing of livestock, mining operations, illegal timbering for firewood and industrial and construction use, haymaking in areas close to forest zones, noncompliance with the Forest Law of Mongolia and damage from harmful insects and pests.

Reforestation activity has been underway in Mongolia since 1971 with the purpose of replenishing forests depleted due to above mentioned numerous negative impacts. A report has confirmed that 84,000 hectares of forest cover has been re-established in total. Outcomes of reforestation and tree planting have been inefficient and with low quality because of inadequate technology and unpleasant climate conditions. Logging activities in Mongolia started in the 1950s; 12 centralized state timber production enterprises were established in the northern, central and other aimags with available forest resources.

In terms of age, Mongolia's forest is mostly old growth forest that is distributed on inaccessible mountain slopes. Therefore, timber has been harvested more in areas suitable for equipment and transportation operations. From 1970 to 1980, when the forest industry was being intensively developed, electric sawmills and mechanical chain techniques were introduced for timber harvesting purposes and used to cut up to 2 million cubic meters of timber annually. During the transition period towards a market economy, due to the decline of the state owned enterprises, the timber harvest decreased by up to 400,000-500,000 cubic meters a year. According to a statistical data source, from 1940 to 2000, a total of 320,000 hectares of Mongolian territory was used to cut up to 43.8 million cubic meters of timber.

The regulation on forest use contracts, Resolution No. 125, was adopted by the Mongolian Government on June 22, 1998. The long-term forest use contract establishes the obligations and responsibilities for logging and wood processing, as well as, forest restoration and recovery. Pursuant to this regulation, a contractor has the opportunity to acquire and use certain amounts of forestland area for a specific term. The term of the contract can be for 15-60 years with the possibility of an extension of up to 40 years. Timber harvesting has been carried out according to this regulation from 1995 to the present day.

The wood industry cut an average of 2.2 million cubic meters in the mid-1980s, 860,000 cubic meters in 1992, and only 500,000 cubic meters in 2000 for timber production. Reduction in the annual output of timber production is associated with policy changes and the structural and management reorganization of the wood industry. These changes were pursuant to, and in accordance with, the privatization process of state owned enterprises and decentralization of authority.

Moreover, the forest utilization zone has significantly changed. Over the years, a great area of forest that had been classified for utilization has been reclassified as protected. Forest designated for utilization has decreased as follows: from 5.8 million hectares in 1985 to 2.4 million hectares in 1990, and further, to 1.19 million hectares in 1996. The Forest Law of Mongolia, adopted in 1995, has prohibited clear-cut harvesting and permitted exclusively selection-cut upon basic utilization. In addition, the logging process has generated massive waste and ineffective outcomes. Logging waste was 25-30% during the technical methods period of clear-cut harvesting; it has likely increased up to 55-60% during the period of selection-cut harvesting.

Currently forest exploitation has become an income source for the poorest households in Mongolia. It occurs in protected green zones because of the close proximity (green zones are established around towns and villages), the low cost and the assortment of resources of adequate quality. Currently, one of most critical problems is that cedar and spruce, which have occupied a small percentage of the overall forest area in Mongolia, have been cut in larger amounts during recent years. This is due to the objective of maximizing commercial profit by minimizing costs and labor effort.

Forest insects and diseases. Research results have identified 400 species of insects including 40 that are severely harmful such as the Siberian silk moth (Dendrolimus superans sibiricus), Pine-tree lappet (Dendrolimus pine), Sirex woodwasp (Sirex noctilio), Spicebush swallowtail (Papilio troilus Linnaeus), Pine moth (Dendrolimus pini L.), Geometrid (Caripeta) of Yakobson, Larch wooly adelgid (Adelges laricis Vallot), long-horned beetle, flat bug and bark bug. Harmful insects and diseases are becoming the primary factors that negatively impact forest ecosystems which are fragile; these insects have significant ecological implications for Mongolia.

Over recent years, negative influences on forests, such as climate change, aridity, forest fire, harmful effects of human activities on biological systems, and harmful effects of insect and disease propagation have caused hotbeds of damaging activity that have led to critical injury. This injury is on the scale of environmental disaster. Six hundred species of insects are recorded in Mongolia. In recent years, the Siberian silk moth, Pine-tree lappet, Sirex woodwasp, Spicebush swallowtail and Geometrid (Caripeta) of Yakobson have propagated remarkably and generated injury hotbeds.

Lepidoptera, an order of harmful forest moths, have propagated once in the period of 8 to 12 years generating forest damage. The significant propagation of moth populations, such as the Siberian silk moth, Pine-tree lappet, Spicebush swallowtail, Sirex woodwasp and Geometrid of Yakobson, has harmed forests, spreading over certain areas every year since 1998. For example, there was a massive propagation of harmful insect populations, such as Geometrid of Yakobson and Spicebush swallowtail in 2007-2008, and of the Siberian and pine-tree lappet moths in 2008-2009. Further, injury hotbeds have intensified since 2006, due to environmental, weather and other factors.

In the following forest areas of Mongolia the specified insects have destroyed large areas of forestland and generated injury hotbeds:

- Sirex woodwasps in the forest soums of Uvs aimag;
- Siberian silk moths in the Tsenkhermandal and Binder soums of Khentii aimag;
- Pine-tree lappets and Geometrids of Yakobson in the green zone forests of protected Bogd Khaan Mountain of Ulaanbaatar city;
- Siberian silk moths and Pine-tree lappets in the forest soums of Bulgan aimag;
- Pine-tree lappets and Sirex woodwasps in the forest soums of Zavkhan aimag; and
- Geometrids of Yakobson, Pine-tree lappets, and Sirex woodwasps in the forest soum territories of the Uvurkhangai and Arkhangai aimags.

Forest Fire. According to scientists who study forest fires and the impact caused by the warming of the earth's climate, the configuration and evolution of gymnosperms (200 million years ago) and angiosperms (100 million years ago) are indicators of forest fire occurrences. Since the period when it began spreading via lightning, forest fire may be considered as a factor with a certain repetitive frequency generated by a natural path. Air ionizes through large quantities of photons, and volatile components generated by flowering plants reduce electrical ressistance. Consequently the probability of a thunderbolt occurrence increases 100 times in vegetation cover over that for the ocean surface.

According to some scientists, there was a positive turn for plant evolution, and the volume of wood species in forests increased, because of the frequency of forest fires before humans appeared on Earth. Forest fires have occurred regularly in Mongolia over the centuries, and it often positively affected the recovery process as well as the growth of ancient forests and plants. For instance, during the dendro-perological forest study over the eastern regions of Khubsgul and the northern part of Mongolia, it has been confirmed that naturally created forests with tree species such as mountain cedar, larch and birch originated from fire.

In the meantime, fire occurrences have increased from year to year because of improper human activities; human acitivity accounts for up to 95% of the total occurences of fire each year. Moreover, climate change and global warming, desertification, and aridic phenomena frequency have facilitated adequate conditions for fire to occur and spread.

From 1996 to 1997, precisely 23.1 million ha of forestland and pastureland were burned by fire. This period of fire attracted significant attention worldwide because of the amount of damage that resulted; the fires destroyed territories that comprised over 30% of the entire forestland. This has been recorded as an enviromental disaster by the Food and Agriculture Organization of the United Nations. Due to frequent and massive fires, there have been negative effects on forest conditions such as destroyed forest cover, river runoff fluctuation, mountain forest soil erosion and degradation, along with a further reduction of fire resistance in the forests.

Forest fires occur in the northern part of Mongolia every year with irregular spread. In recent years, the density of forest fires increased over certain areas (**Figure A3.10.1**). For instance, forest fires have been observed over Khentii and the southern areas of Dornod as well as the Orhon-Selenge river basin of the Bulgan and Selenge regions.

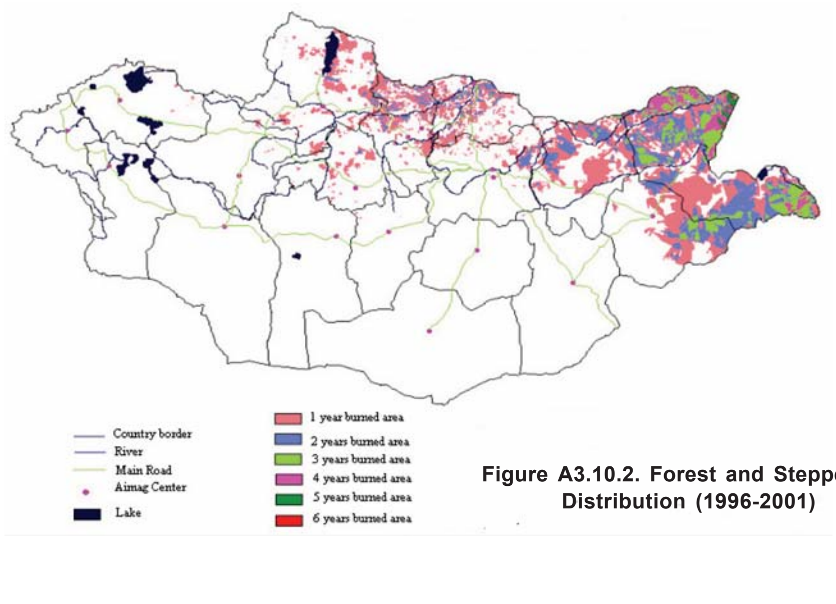

Figure A3.10.2. Forest and Steppe Fire Distribution (1996-2001)

There were various critical forest fires that occurred over entire specific regions of Mongolia. For instance forest fires occured in 1965-1966, 1968-1969, 1972, 1976-1978, 1982-1984, 1986-1987, 1992-1994, 1996-1998, 2001-2002 (see figure 3). The vertical axis represents the number of occurences in one year; the y-axis is the year. (**Figure A3.10.3**)

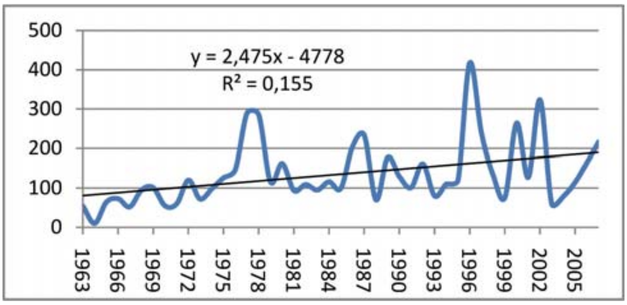

Figure A3.10.3. Forest and Steppe Fire Frequency

Fire occurrences in Mongolia have specific characteristics. In the forest area the fire season starts later in the year and ends earlier as compared to the steppe area where the fire season starts earlier and ends later in the year. In addition, there is transfer movement from the steppe to the forest and fast fire flaming and a high likelihood of spread in the steppe area.

Lightning in the mountain taiga is the main reason for forest fires occurring in the forest-steppe and boreal zones. A data source states that burned forest land comprises 3.36% of the total forest stock in Mongolia.

During the mid-1990s scientist V. Ulziisaihan investigated the variability of forest types and forest productivity at selected points using the forest dynamic model (FORET). ("Country Study" project by the U.S. Enviromental Protection Agency (EPA) in Mongolia, Project Report-1996; R. Michiddorj and V. Ulziisaihan, "Future Tendency and Change of Biomass of Forests in Mongolia," *Ecology and Sustainable Development*, Issue 3, UB, 1998, pp 89-97.) This model estimates growth and the fruit maturation process of specific tree species. (Herman H. Shugart, A Theory of Forest Dynamics, 1984.) In addition, another researcher has calculated the biomass dynamics of larch, cedar, and birch along the Yeruu River Basin using the UKMO model, developed by the Hadley Centre for Climate Prediction and Research, part of the United Kingdom's national weather service.

The biomass accumulation dynamics of selected trees was estimated in comparative periods using the normal amount of ambient air carbon dioxide, as well as, an increased amount of carbon dioxide (the mean amount of carbon dioxide was doubled or multiplied by 2). This comparison is shown in **Table A3.10.1** and **Figure A3.10.3**.

Table A3.10.1. Current Forest Biomass and Increased CO_2 Biomass (mean amount doubled)

	Larch(Larix)	**Spruce (*Picea obovata*)**	**Pine/Cedar (Pinus/Cedrus)**	**Birch (*Betula platyphylla*)**
Current biomass (t/ha)	101.7	76.3	76.9	50.9
CO_2 biomass increase by twice (t/ha)	74	48.4	73.6	48.3
Difference	27.7	28.5	3.4	2.6

The biomass of the following selected tree types (represented in the figures below) are expected to decline:

- Larch (Larix) by 27.2 %
- Birch(*Betula platyphylla*) by 5.1%
- Siberian pine/cedar (*Pinus/cedrus sibirica*)
- Siberian larch (*Larix sibirica*) by 35.3%
- Scotch cedar/pine (Cedrus/*Pinus silvestris*)
- Scotch larch (Larix silvestris) by 4.2%.

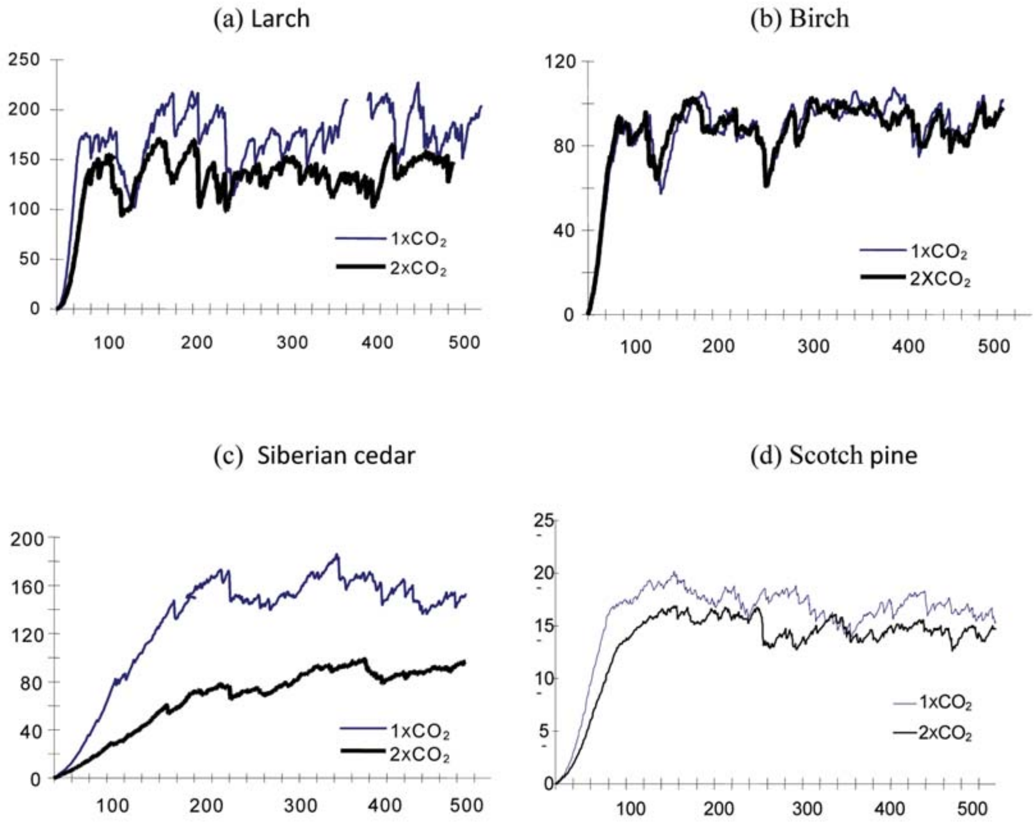

Figure A3.10.4. Biomass of the Selected Tree Types

Annex 3.11 – Vulnerability

Many important aspects of environmental and socioeconomic development are sensitive and, in some cases, highly vulnerable to climate change.

Impact of climate change: *the consequences being witnessed by environmental and socioeconomic systems and, depending on adaptation objectives, consequences can be divided into two types—potential and irreversible*

Sensitivity*: the level of response of any type of system to climate change. For example, the composition of the system may vary and change in response to the change of ambient temperature or precipitation level*

The impact of climate change is being witnessed in different places and in numerous, various ways. In some areas, the negative impact of climate change is irreversible, whereas in other places climate change may bring some benefits or advantages. In either case, climate change definitely is having a serious impact on different aspects of socioeconomic life as well as on the environment.

Vulnerability (a state of being affected): *the level of damage or loss to any system due to climate change. Also, it may be expressed as a level of resilience to overcome damage or to resist changes. Vulnerability depends on the capacity of a system to undergo this change and also depends on a system's adaptation capacity. Climate change speed, coverage and scope are important factors that influence any system's capacity to undergo changes and define its vulnerability.*

Little industrial development occurred in Mongolia where mining and animal husbandry are the dominant economic sectors. For example, the contribution of animal husbandry to Mongolia's Gross Domestic Product was 43.8 percent in 1996. Yet, when the country transitioned to the market economy in the early 1990s, the agricultural sector fell to 20 percent of the GDP (and animal husbandry constituted 80 percent of agricultural sector) due to the shift to the mining sector as a result of the increasing prices of minerals prices in the world markets.

Table A3.11.1. Development of Animal Husbandry Sector

	1990	1995	1996	2000	2001	2004	2005	2006	2007
GDP	**15.2**	**38**	**43,8**	**29,1**	**24,9**	**22.2**	**21.9**	**19.5**	**20.6**
Increase in Animal husbandry			2,4	**-14,9**	**-18,5**	15.8	10.7	7.5	15.8
Number of labor force engaged in animal husbandry		44,6	45,2	48,6	48,3	40.2	39.9	38.7	37.6

The productivity of animal husbandry is very dependent on the environment and climate in any given year, especially on the drought and zud conditions. During the three years of consecutive zuds during 1999-2000 and 2001-2002 about 10,000,000 livestock were lost due to the zud, i.e., the harsh winter weather conditions. More than 12,000 herder families were left without a means of living due to the loss of their herds, which in turn lead to migration to the cities. Considering the fact that 200 heads of livestock constitutes a means of living for a family of five, during the above mentioned period around 200,000 people or 50,000 herder families lost their sources of income. In other words, assuming that there are two persons of working age in a single family, more than 100,000 people became unemployed. Therefore, the loss of livestock has had a devastating effect not only on the livelihood of the herders but has directly contributed to economic instability. Indeed, the phenomenon of dzud creates the real disaster for nomadic pastoralism.

The mortality of adult livestock can be affected by short, temporary and unfavorable weather conditions such as snowfall, thunderstorms, flood, sandstorms, dust storms and strong winds, as well as by drought and zud, which are seasonal events. The zud has more devastating consequences for animal husbandry than other weather phenomena. The zud phenomenon rarely causes human life loss. However, malnutrition, fatigue associated with caring for their livestock and the lack of access to the medical services are common issues faced by the herders, and they contribute to the decline in the quality of public health in countryside. Animal corpses pollute the winter and spring herders' stands as well as the rivers and lakes where the corpses are washed with spring water.[26]

During the zud, not only are the livestock affected, but also wild hoofed animals suffer from a lack of browse, leading to the decline of their populations and the change of habitat. For example, marmot, mice and other rodents often perish in their dens during the winter due to the unavailability of food after a summer drought. The annual national statistics from 1940 demonstrate that on average 3.8 percent of the total number of livestock die per year; however, in the years with either drought or zud, the number of deaths increased to anywhere from 6 percent to 31 percent of the total livestock.

From April 15 to April 20, 1980, heavy snowstorms (named "Sunjidmaa" by meteorologists)—which occur in the three western provinces of Mongolia—claimed the lives of 800,000 livestock, 81 percent of total of adult livestock mortality that year. In recent years, the National Statistical Office collected (and continues to collect) data about the livestock mortality from those provinces, which have been declared by the National Emergency Agency as zud affected areas. Nationwide data, coming from other provinces has not been incorporated, and comprehensive national data on livestock mortality is not available. Therefore, the severity of the dzud is assessed based on the ratio of the unnatural deaths of adult livestock to the last year's inventory of total livestock, being expressed in percentage ($\Delta N\%$). The calculation of this value takes into account livestock deaths clearly not attributable to the zud, like in case of spring snow storm of 1980.

Data on monthly average temperature and average precipitation level from 47 meteorological stations throughout the country were analyzed to generally assess the climatic conditions during phenomenon of the zud and used to develop a hypothesis that whenever the summers are dry (or drought occurs) and the winters are harsh, the livestock mortality rate would be higher. Summer is characterized as dry or a drought if there is less rainfall and considerably warmer than average summer temperature; winter is characterized as harsh if it is a colder than average winter, with heavy snowfall and snow cover. These extreme and unusual seasons have been assigned different indeces.

[26] Lessons learnt from zud phenomenon, JEMR printing house, Ulaanbaatar, 2000

There might be many factors that lead to the increase of mortality of adult livestock. These include snow cover on pastures, the density of the snow cover, the number of days unfavorable for grazing, and the number of days with snowstorms. Although there are many factors that affect livestock mortality, one indicator must be selected to represent the main characteristics of climate conditions in order to predict the trend of summer drought and winter zud.

Seasonal climatic conditions have been calculated from data from 1940 to 2002 from the nearly evenly distributed 47 meteorological stations throughout Mongolia. The data used included: the mean monthly temperature; the total monthly precipitation amounts; the temperature for winter months (December – February); the precipitation for November - January; the summer temperature (June – August); the precipitation deviation; the standard deviation (ΔT_{summer}, ΔP_{summer}, ΔT_{winter}, ΔP_{winter}); their difference ($\Delta T'$, $\Delta P'$); the drought index, the difference between the mean average temperature and mean average precipitation (S_{summer}); the winter index, the difference between the standard deviation of winter temperature and the standard deviation of precipitation for the same period (S_{winter}); and, the difference between the zud index and the drought/grazing index (ΔS). (Natsagdorj, Sarantya 2003). Values for standard deviation of average ambient temperature and precipitation have been calculated, allowing the comparison of data from different meteorological stations.

As it was mentioned above, if summer is warmer than average ($\Delta T_{summer} > 0$), and precipitation is lower than average ($\Delta P_{summer} < 0$), the summer would be considered as droughty ($S_{summer} > 0$); conversely, if summer is cooler ($\Delta T_{summer} < 0$) and precipitation is higher ($\Delta P_{summer} > 0$), the summer is favorable ($S_{summer} < 0$). Also, if winter is less cold ($\Delta T_{winter} > 0$) and less snow ($\Delta P_{winter} < 0$), the winter is milder ($S_{winter} > 0$); conversely, if winter is colder ($\Delta T_{winter} < 0$) with lots of snow ($\Delta P_{winter} > 0$), the winter is harsh and severe ($S_{winter} < 0$). If summer is droughty ($S_{summer} > 0$) and winter is harsh ($S_{winter} < 0$), then a dzud is likely to occur during winter ($\Delta S >> 0$).

It has been tested to verify the correlation of adult livestock mortality and meteorological conditions by using nine factors. The most significant factor affecting ΔN is the zud index ΔS, followed by the difference between winter and summer temperature $\Delta T'$, the drought index S_{summer}, and abnormal winter temperature ΔT_{winter}, accordingly.

Table A3.11.2. Correlation Matrix of Adult Livestock Fall and Meteorological Conditions

	ΔS	S_{WIN}	S_{SUM}	ΔT_{SUM}	ΔT_{WIN}	ΔT'	ΔP_{SUM}	ΔP_{WIN}	ΔP'	ΔN
ROW 1	1	-0.74	0.6	0.54	-0.69	0.93	-0.41	0.46	-0.68	0.63
ROW 2	-0.74	1	0.1	0.1	0.94	-0.72	-0.07	-0.62	0.4	-0.42
ROW 3	0.6	0.1	1	0.91	0.1	0.52	-0.68	-0.06	-0.51	0.45
ROW 4	0.54	0.1	0.91	1	0.12	0.56	-0.32	0.01	-0.27	0.37
ROW 5	-0.69	0.94	0.1	0.12	1	-0.76	0	-0.32	0.24	-0.43
ROW 6	0.93	-0.72	0.52	0.56	-0.76	1	-0.21	0.28	-0.38	0.6
ROW 7	-0.41	-0.07	-0.68	-0.32	0	-0.21	1	0.18	0.68	-0.38
ROW 8	0.46	-0.62	-0.06	0.01	-0.32	0.28	0.18	1	-0.6	0.14
ROW 9	-0.68	0.4	-0.51	-0.27	0.24	-0.38	0.68	-0.6	1	-0.41
ROW 10	0.63	-0.42	0.45	0.37	-0.43	0.6	-0.38	0.14	-0.41	1

If there is a drought in summer, winter is harsh (ΔS >>0), and if also summer is hotter than normal ($\Delta T_{зун}$>>0) and winter is colder than normal or there is a drought in summer (S_{summer} >>0), then adult livestock mortality would be higher. But in some cases, independent variables are highly interrelated with each other. For example, ΔS is related with $\Delta T'$, S_{winter}, $\Delta P'$, ΔT_{winter}, ΔT_{summer} is related with more than $r \geq 0.60$, in other words, the zud index is the main compound factor affecting the mortality of livestock.

Another objective was to identify factors that have influence on ΔN dispersion D_y, using stepwise liner regression analysis. Taking ΔS as the main determiner of ΔN, and composing a single number regression equation, an independent variable for ΔN dispersion would provide an explanation for 40.2 percent of sum of dispersion and the coefficient of linear regression shall be $r = R = 0.634$. Then, taking ΔS along with ΔP_{winter}, and making a two member regression, this regression analysis could be used to explain the 43.2 percent of dispersion sum and $R = 0.658$ would be accordingly. Independent variables applied to regression modeling, as well as the chosen seasonal meteorological indicators, can explain 49 percent of dispersion sum, coefficient of set correlation equals to R= 0.70, but this one is a linear evaluation.

However, the adult livestock mortality and seasonal climatic conditions might not be linear. The correlation coefficient between adult livestock mortality and climatic conditions is about 0.634, but in reality, they can be represented by a quadratic curve. (**Figure A3.11.1**). It is clear from Figure 1 below that, if the value of livestock mortality is smaller than ±1 , then $\Delta N \leq$5.0%, but if ΔS >>1.0, then ΔN increases sharply, and the non-linear correlation coefficient becomes $R = 0.8835$, which is a considerably higher value. The difference between $\Delta T'$ and ΔN is $R = 0.81$, considering that ΔT_{winter}, S_{summer} and ΔN –non linear correlation coefficient, –increase by 0.66, +0.60 of linear correlation coefficient.

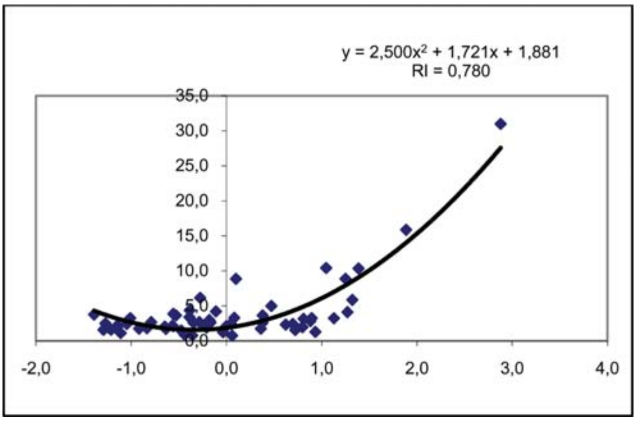

Figure A3.11.1 Correlation between ∆zud Index and Adult Livestock Mortality

If to define ΔS, S_{winter}, S_{summer} linear and non linear coefficients in terms of meaning of adult livestock mortality, there is no correlation for camel, whereas for horse and cattle higher than for sheep and goat.

Correlation between ΔS and ΔN per each area is not the same: in the Arkhangai, Bulgan, Zavkhan, Tuv, Uvs Aimags (provinces) R≥0.50; but, in the Bayan-Ulgii, Dornogovi, Dornod, Uvurjhangai, Sukhbaatar and Selenge Aimags tangible dependence was not observed (**Figure 3.14**). It can be seen that mutual dependence between the Selenge, Khentei and Dornod Aimags, where snow does not fall much, is weak. Upon review of the mutual dependence of ΔS and ΔN per each type of cattle (excluding camels), some decrease can be observed in goats and sheep in the Dornogovi, Umnugovi, Dundgovi, including Sukhbaatar and Bayan-Ulgii Aimags, which lay within the desert areas. As for the horses of the steppe areas (the Dornod, Sukhbaatar and Khentei Aimags), mutual dependence is weakening. As for cows, dependence between ΔS and ΔC_{ows} in almost all Aimags (excluding Bayan-Ulgii) remains high, except for probable correlation dependence. (**Figure A3.11.3**).

The main husbandry area for the cattle herds is the mountainous belt of the Khangai, where dependence is tangible. Foraging bases are well supplied, and there are Buriat tribes among the local herders, who have strong herding skills. Correlation dependence is weakening, which is quite normal.

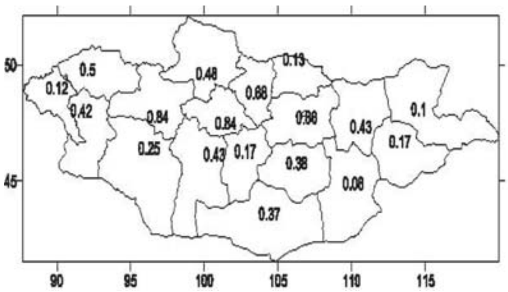

Figure A3.11.2. Dependence (R) between affected perishing horses and camels (ΔN) and heavy snowfalls

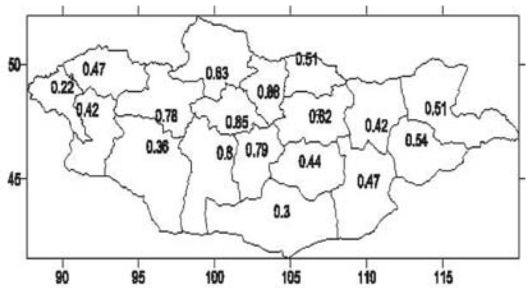

Figure A3.11.3. Dependence (R) between affected perishing cattle (ΔN) and heavy snowfalls index ΔS

Studies suggest that the higher the heavy snowfall index, the more areas will be affected by heavy snowfalls.[27] Fluctuation of ΔN i.e., perishing of the bigger cattle like horses and camels is an index that depends on development of animal husbandry and the weather conditions like droughts in particular year. In other words, the dispersion D of perishing bigger cattle is a sum of two components, D_1, D_2. The rate of perishing of the bigger cattle depends on factors such as cultural development of animal husbandry, material and technical base, pasture land use, labor management, improving quality of the cattle, etc., and the trend should be decreasing. Such trend is represented by the curve of the second integral. (L.Natsagdorj and G. Sarantuya, 2003). From the assessments, it is seen that 89.3% of perishing bigger cattle is caused by the weather condition in particular year.[28]

On one side, desertification is getting intensified and regeneration of pasturelands slows down; on the other side, the number of hot weather days in a year is getting higher, so the number of days for the cattle to graze is getting fewer.[29] As grass and forage for cattle becomes scarce, the cattle lose weigh, strength and can even starve. The herds become vulnerable to the dzud, i.e., heavy snowfalls.

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Cattle are a ruminating animal, which has the biological feature of grazing by wrapping a mouthful of grass in bunch with its tongue. Therefore, cattle are the most vulnerable to heavy snowfalls. During the 2000s, the stock of herds has changed significantly. **Figure A3.11.3**. shows changes in percentage of cattle and goat stocks within a herd.

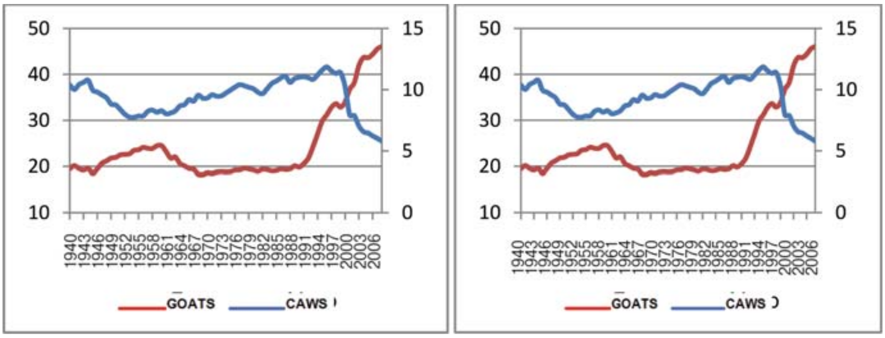

Figure A3.11.4. Stocks of Cattle and Goats within a Herd

Figure A3.11.4 demonstrates that the percentage of cattle stocks within a herd in 1944 was 10.8%. Then in 1944, there were heavy snowfalls that caused 35% of the stocks to perish by the end of 1944. In the 1950s, the stocks were increasing, and by 1996, the stocks reached 11.9%. The stock then decreased and by 2008, the number of stocks fell to 5.8%. As for goat stocks, previously it was approximately 11-12%, but since the 1990s, the stocks have been permanently increasing, and by 2008, the number of stocks reached nearly 46.1% within a herd.

Future Tendency of 'zud'.

In order to predict future trends of the Mongolian dzuds, the HADCM3 model can be applied using GHG emission scenarios SRES A2 and SRES B2. The assessments for the periods of 2020 (2010-2039), 2050 (2040-2069), and 2080 (2070-2099), the monthly average air temperature and the total precipitation should be taken from the national averages as S_{summer}, S_{winter}, ΔS. The equation, comparing the heavy snowfalls index and the rate of perishing of the bigger cattle, is figured out to assess future trends in 21st Century.

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