FOREWORD

Mongolia's harsh climatic conditions create one of the most insurmountable barriers to its economic development, and the anticipated climate change will limit it even further. Therefore, Mongolia has consistently demonstrated its strong support of international initiatives in protection of global climate. Mongolia was one of over 150 countries to sign the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992. The Great Khural (Parliament) of Mongolia ratified this Convention on September 30, 1993.

In order to comply with the obligations and commitments under the UNFCCC, Mongolia has been undertaking certain measures and actions at national level. Mongolia National Action Programme on Climate Change includes a set of measures, actions and strategies that enable vulnerable sectors to adapt to potential climate change and mitigate GHG emissions.

Mongolia is presenting its Initial National Communication to the Conference of the Parties to the UNFCCC to fulfill its commitment as a Party to the Convention. This report includes national GHG inventories, policies and strategies on adaptation to climate change and reduction of greenhouse gases. In addition, the report reflects some country-specific circumstances and climate change concerns.

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Introduction

The government of Mongolia signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12, 1992 at the Earth Summit in Rio and the Great Khural (Parliament) of Mongolia ratified it on September 30, 1993.

This document represents the Mongolia's Initial National Communication (MINC) to the Conference of the Parties to the UNFCCC. This report presents:

(i) The national GHG Inventory compiled for the base year 1994 and other years, according to the IPCC Guidelines for National GHG Inventories (IPCC, 1995) and the Revised 1996 Guidelines (IPCC, 1997);

(ii) Mongolia's GHG mitigation options for reducing GHG emissions in various sectors;

(iii) Impact assessment of climate change and adaptation measures to climate change;

(iv) A short survey of existing policies and measures, and future recommendations;

(v) An overview of research and systematic observation network;

(vi) A summary of education and public awareness and international activities, and technical and capacity building needs

In addition, the MINC reflects some country-specific circumstances and climate change concerns. The country's geographical and climatic conditions, as well as traditional social life style and economic structure, dictate these special circumstances.

The clear, increasing frequency, magnitude, and hence, damages caused by natural disasters in the country due to global climate change pose a direct threat to the livelihood of Mongolia's people. At the same time, Mongolia has specific concerns related to the reduction of glaciers, permafrost area, and snow cover that would cause serious damages to the economy as a result of global warming.

National Circumstances

Geography. Mongolia is a landlocked country in Northeast Asia. Mongolia's territory incluses areas of relatively high altitudes. The northwest and central parts of Mongolia are high mountainous regions, while the eastern part is a vast steppe region. The southern part of the country represents the semi-desert and desert area that is known as the Mongolian Gobi. Forests cover 8.1% of the country's territory, consisting mainly of larch and pine. Saxaul *(Haloxylon Ammodendron)* forests occupy certain areas in the Gobi.

Among the temperate zones of the Northern Hemisphere, few nations compare to Mongolia in terms of the size, diversity, and health of its natural ecosystems. However, as Mongolia undergoes a massive socio-economic transformation, threats to these natural areas, flora and fauna are rapidly mounting.

Land Resources. Mongolia’s total area is 1,566 600 km^2. In general, land use in Mongolia can be broken down into the following categories: 76.5% of the land area is used for agriculture, from which approximately 0.8% is cultivated, 1.6% is used for hay making, and 97.6% is pasture land. Cities and settlement occupy 0.3% of the land area, while 10.4% is reserved for special needs of the state, which include land used for state security and defence purposes, special protected areas, roads, and communication networks of national importance. Forest and shrubland accounts for 9.7% of the land area, and water surface for 1.1%; 1.7% of the land area is wasteland that is not suitable for usage.

Climate. Mongolia has a harsh continental climate with four distinctive seasons, high annual and diurnal temperature fluctuations, and low rainfall. Because of the country’s high altitude, it is generally colder than that of other countries in the same latitude.

Average annual temperatures range between 8.5^{o}C in the Gobi and -7.8^{o}C in the high mountainous areas. The average annual precipitation is low (200-220 mm) and represents a range between 38.4 mm per year in the extreme South (Gobi desert region) and 389 mm per year in limited areas in the North.

Water Resources. Mongolia’s total water resource is estimated at 599 cubic km of water, composed mainly of water stored in lakes (500 cubic km) and glaciers (62.9 cubic km). Eighty-five percent of these water resources are freshwater; Mongolia’s Khovsgol Lake alone contains 93.6% of the country’s total freshwater resources.

Economy. The Mongolian economy is relatively diversified. Agriculture accounts for about 33% of gross domestic product (GDP), industry and construction for 27.5%, and services for about 40% (Statistical Yearbook, 1998). Mining ventures, mainly in copper, provide an estimated 27% of the economy’s export earnings (1998). Mongolia possesses more than 30 million head of livestock (by end of 2000), as well as sizeable reserves of copper, gold, coal, and other minerals. Prospects for the development of petroleum in commercial quantities are encouraging.

Economic development in Mongolia faces serious challenges. Since 1990, Mongolia has been navigating the difficult transition from a centrally-planned to a market-oriented economy, and has overcome considerable geographical obstacles to development, including being landlocked and having an extreme continental climate. Under these difficult circumstances, the Government of Mongolia has committed itself to market reform through an active programme of privatization, trade and investment liberalization, and unification of exchange rates. These policies have been successful to a certain extent: the declining growth rate of 1990 to 1993 has been stabilized since 1994.

Demography. In 1999, the population of Mongolia reached 2.42 million people. Although the population has doubled since 1960, the average population density—1.5 persons per square kilometer--remains the lowest in the world. Some 56.6% of the population live in urban areas. The capital city, Ulaanbaatar, alone is home to 32% of the population.

Health and Education. While Mongolia’s health and education indicators are relatively strong compared to other countries at similar income levels, and while the Government’s expenditures for health and education are high by international standards, social indicators have deteriorated with the transition to a market economy.

A well-developed health service infrastructure exists, and Mongolia compares favorably with other developing nations in terms of life expectancy (66 years) and hospital beds per capita.

The literacy level was estimated 97.8% at the end of 1999.

Environment. Mongolia's natural ecosystems are relatively fragile, given that they are highly susceptible to degradation by both natural and human impacts, and slow to recover. Furthermore, Mongolia's endowment of renewable natural resources is limited. In urban areas, environmental and natural resource issues, such as air quality, water supply, waste disposal, and land degradation, have reached a critical stage. Beyond the cities, other pressing environmental issues include locally-severe environmental degradation from mining and petroleum extraction, natural disasters, and damage to natural heritage (including biodiversity).

Meanwhile, a significant portion of the land resources in Mongolia are threatened by overgrazing, deforestation, erosion and desertification.

Natural Disaster. Due to the precariousness of climate conditions and traditional economic structures, natural disasters -especially disasters of meteorological and hydrological origin- have substantial effects upon the socio-economic conditions of the country. Heavy rains, snowfall, strong winds, sandstorms, snowstorms, hail, and flooding often mean significant damages to life and property in Mongolia. Devastating weather hazards—such as *dzud* and drought--are a well-known affliction of the Mongolian nomadic herder. Dzud is the Mongolian term for an extraordinarily harsh winter that deprives livestock of grazing, a specific phenomena that takes its toll in the winter-spring season as high numbers of livestock die of starvation.

There is a clear indication that the frequency and magnitude of natural disasters are increasing due to global climate change.

Greenhouse Gas Inventories

The GHG inventory includes emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x) and carbon monoxide (CO) for the base year 1994 and other years.

Greenhouse Gases Emissions

Fossil fuel combustion is the largest source of CO_2 emissions in Mongolia, accounting for about 60% of all emissions. The second largest source is from the conversion of grasslands for cultivation (20-27%). Emissions from industrial processes account for less than 1% of all emissions. Total emissions of CO_2 in Mongolia reached 9,064 Gg in the base year 1994, representing a decrease of 10,072 Gg from 1990 emission levels. CO_2 emissions have been increasing since 1996, reaching 8,729 Gg in 1998. The removals are increasing constantly. The removal in 1990 was 9.9% of total emissions; it increased to 39.4% and 44.7% in 1994 and 1998, respectively.

The single largest source of CH_4 is livestock herding. Methane emission from this sector accounts for about 90-93% of Mongolia's total emission. However, the total methane emission from Mongolian livestock are very low compared to other countries. Since

Mongolia's livestock husbandry practices use mainly indigenous breeds with low productivity and small body size, they do not have the same impacts as industrial dairy, pig and poultry production. Additionally, almost all manure is managed on pasture and low crop production ensures there is almost no practice of open burning of agriculture residues

Emissions of nitrous oxide (N_2O), nitrogen oxides (NO_X) and carbon monoxide (CO) occur largely from biomass burning, such as traditional biomass fuel combustion in cook stoves.

The Energy sector produces around 60% of the country's CO_2 and 6-7% of methane emissions. The conversion of grasslands to cultivated land produced the second largest emission source of $CO_{2,}$ and represents 20.6-27.85% of total emission.

Estimates show that removals due to abandonment of lands increased from 1,909 kt of CO_2 (9% of total emission) in 1990 to 6,803 kt of CO_2 (43% of total emission) in 1998, a total of 90-96% of CO_2 removals. However, the use of the IPCC default coefficients likely introduces some uncertainty into these estimates.

Methane emissions from the land disposal of solid waste and the treatment of domestic, commercial and industrial wastewater are estimated.

Even though Mongolia's total GHG emissions is relatively very low, the annual per capita emission of GHG in CO_2-equivalent is relatively high compared to other countries. This phenomenon can be explained by the fact that the country has a very low population (2.4 million) that nevertheless requires very high heating for a long duration of time (9 months a year).

Greenhouse Gas Mitigation

Greenhouse Gases Emissions Projections

Energy: According to the results of modeling final energy demand, CO_2 emission is projected to reach 40,571 Gg by 2020. This is approximately five times greater than the base year level of 8,344 Gg of CO_2.

The analysis of GHG emissions by fuel type for the period 1993-2020 indicates that coal will be the predominant source of CO_2 emissions. CO_2 emissions from burning diesel oil are projected to increase 2.6 times by the year 2020, while gasoline is expected to increase 7 times. This growth is due to the expected expansion of motor fuel demand in the nonferrous sub sector, as well as overall growth of the transportation sector. Heat and electricity demand is expected to reach 6.8 and 10.4 times their base year levels by the year 2020.

According to the projection, CO_2 emissions from heat and electricity generation will be 6.5 times the base year level by the year 2020. In the energy supply sector, energy sources that do not emit GHG, such as hydropower, are expected to have a 2% share of the total electricity generation by 2020.

A comparison of results from the Base Case scenario and the Integrated Mitigation Scenario shows that the implementation of the mitigation scenario has the potential to reduce CO_2 emissions in the energy sector by an average of 25% per year during the period 2000-2020.

Forestry: The scale of forestry as a sink is projected to decrease in 2020 due to urbanization and industrial development in the country. Strategies for reducing future GHG emissions should therefore pay special attention to maintaining the forestry sector.

Agriculture: The CH_4 emission projection for the agriculture sector was based only on livestock growth projections and emission factors.

GHG Mitigation Potentials

Reduction of CO_2 emissions depends on the development of conversion technology and efficiency, and on fuel characteristics. Hence, mitigation options considered in the assessment to reduce CO_2 emissions can be grouped into two categories: (i) energy conservation or efficiency improvements, and (ii) replacing carbon-intensive energy sources with less carbon-intensive sources.

Energy Supply Sector

Fossil fuels: Implementation of Clean Coal Technology is imperative in Mongolia. This technology will not only result in reduction of global CO_2 emissions, but will also have local benefits, such as the reduction of ash disposal in residential areas, the decrease of SO_x emissions, and the improvement of coal transportation efficiency. Practical, cost-effective measures which can improve the coal quality of open pit mines include the following: effective dewatering systems, coal handling plants (or coal washing plants), selective mining, rock separation and other mine planning and operation options.

Coal briquetting technology is also an efficient way to save coal and reduce air pollution. This technology has a relatively high potential for emission reduction.

Combined Heat and Power Plants (CHP): The efficiency of the CHPs in Mongolia is low, especially because internal electricity use is very high (about 20-24% of the gross generation). The main culprit is low-quality coal, which necessitates relatively long coal mill operating hours and losses in the pipelines, increasing the amount of electricity needed to pressurize pumps and other low-efficiency electrical motors. Mitigation options in these power plants include*: r*ehabilitation and refurbishment of existing CHPs; automation of internal heating.

However, these options have a low CO_2 emission reduction potential compared to other mitigation options.

Medium and Small Scale energy conservation: The mitigation options identified in this category are: conversion of steam boilers into small capacity thermal power plants (5x10 MW), changes in design, introduction of modern technology (12x25 MW), installation of electric boilers (40x1MW), installation of new high efficiency boilers (260x1 MW), modernization of stoves and furnaces.

Renewable energy: Wind generation and photovoltaics are the most attractive among renewable energy options. Establishment of small hydroelectric plants could also be important but this is a relatively costly option.

Energy Demand Sector

Industry: The industrial sector is one of the largest energy consumers, consuming about 70% of the electricity supply and 28% of the heat produced. Industrial enterprises are small in number but relatively large in production. The following GHG mitigation options (technologies) were selected on the basis of mitigation studies: motor efficiency improvements, good housekeeping of electricity and heat including energy management, steam-saving technology (steam traps, heat recovery, pipe insulation), introducing dry processing in the cement industry.
The most attractive CO_2 emission reduction options are good housekeeping (including energy management), motor efficiency improvement, and dry processing of cement.

Residential and Service Sectors/District Heating and Built Environment: The following three main options have been identified for the mitigation of GHG emissions from district heating systems and the built environment: installation of thermostat radiator valves and balancing valves, improvement of building insulation; installation of efficient lighting.

Generally, installing energy efficient lighting and improving building insulation were found to be both practical and cost effective. However, relatively high initial costs and some other market barriers are likely to complicate the implementation of these options.

Transportation. The primary mitigation options identified for GHG emission mitigation in the transport sector are *vehicle maintenance and traffic management*. In terms of CO_2 mitigation potential, the most attractive option in the transport sector is the improvement of Vehicle Fuel Consumption Efficiency in Mongolia.

Non-Energy Sector

Agriculture: The potential GHG Mitigation options are as follows: to limit increase of total livestock number; to decrease the number of cattle, which is the main source of methane emission in the livestock sector; to increase productivity of each animal.

Land–use change and Forestry: The following major mitigation options are identified in forestry sector: Natural regeneration; Plantation forestry; Agroforestry; Shelter belt; Bioelectricity. Among these options agroforestry and bioelectricity will have a high priority for meeting national environmental and socioeconomic development goals.

Waste sector: Mitigation potential 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 as recycling .

Climate Impacts and Adaptation Measures

Observed Climate Variability and Change in Mongolia

During the last 60 years, the annual mean air temperature for the whole territory of the country has increased by 1.56^0C. The winter temperature has increased by 3.61^0C and the spring-autumn temperature by 1.4-1.5^0C. In contrast, summer temperatures have decreased by 0.3^0C. This summer cooling has been observed predominantly in June and July. These changes in temperature are spatially variable: winter warming is more pronounced in the high mountains and wide valleys between the mountains, and less so in the steppe and Gobi regions. Also, the Gobi presents an exception to the summer cooling trend.

There is a slight trend of increased precipitation during the last 60 years. The country's average precipitation rate increased by 6% between 1940-1998. This trend is not seasonally consistent: while summer precipitation increased by 11%, spring precipitation decreased by 17%.

Climate Change Projections for Mongolia

Mongolia's future climate changes in the periods 2000-2040 and 2040-2070 were determined on the base of the selected General Circulation Models (GCM) scenarios. The results showed a 3-10^{0}C increase in monthly mean temperature and a small increase in precipitation. All of the models predicted winter warming that would be more pronounced than summer warming, especially after 2040.

In general, temperature increases were given for summer (1.0^{0}C-3.0^{0}C by 2040 and 2.0^{0}C -5.0^{0}C by 2070), for winter (1.4^{0}C -3.6^{0}C by 2040 and 2.2^{0}C -5.5^{0}C by 2070) and for annual mean temperature (1.8^{0}C -2.8^{0}C by 2040 and 2.8^{0}C -4.6^{0}C by 2070).

The simulated results of precipitation change in the 21st century cannot be summarized as easily as the temperature results, because the scenarios showed very different results. For instance, the CCCM model indicated a precipitation decrease in the Gobi while other models indicated an increase. Changes in snowfall were also inconsistent. Annual precipitation was projected to increase by anywhere from 20-40%.

Potential Impacts of Climate Change

The climate change studies conducted in Mongolia concluded that global warming will have a significant impact on natural resources such as water resources, natural rangeland, land use, snow cover, permafrost, major economic activity of arable farming, livestock, and society (i.e. human health, living standards, etc.) of Mongolia.

Natural Zones: According to the results of the studies by the Holdridge life zone classification model, the current distribution of the high mountain and taiga areas is projected to decrease by 0.1-5% by 2040 and by 4-14% by 2070 as the boundary of the high mountain zone shifts northward. The area of the forest steppe that is in the Khangai, Khentei, Khuvsgul, and Altai mountain ranges is estimated to decrease by 0.1-5.2% by 2040 and by 3.7-13.6% by 2070. Changes in the steppe area are not significant (0.1-3) for either projection scale. However, it is expected that by 2040 the dry steppe zone that currently occurs in the eastern part of the country will spread north into areas currently included in the forest-steppe in the Khangai and Khentei mountains, resulting in a decrease in the high mountain and forest-steppe zone and an increase in the steppe area. Furthermore, by 2070 the area covered by steppe may expand to occupy the lower and middle slope of the Khangai and Khentei mountains and the western slope of the Change mountains and the Gobi-Altai mountains area. The desert steppe area may decrease by 2.5-11.8% in 2040 as it is transformed into more steppe-like conditions, but this rate of change will slow by 2070. The desert region may expand into to the Lakes Basin and current desert steppe zones. The desert area is projected to increase by 6.9-23.3% of the actual area by 2040 and by 10.7-25.5% by 2070.

Water resources: The results of an assessment of the impact of climate change on water resources indicate that if annual precipitation drops by 10% while the temperature remains constant, the average river flow might be reduced by 7.5% in the Internal Drainage Basin, by 12.4% in the Arctic Ocean Basin, and by 20.3% in the Pacific Ocean Basin. The findings of GCM scenarios show that water resources will tend to increase in the first quarter of the century and then decrease, returning close to current levels by the mid-21st Century. The general trends of the five scenarios are very similar, but they differ in scale. According to the simulation results, almost one third of the country is defined as a very vulnerable region.

Grassland: Estimates of sensitivity analysis show that if the temperature increases by 3^0C, the carbon and nitrogen in soil organic matter are projected to decrease by 10 and 3%, respectively, and peak-standing biomass may be reduced by 23.5%. Soil C decline is expected to be more dramatic in the desert steppe and desert by 2040, declining by 14.2-48.9% in the desert steppe and 4-6% in other regions. The decline in soil carbon appears to continue until 2070: soil carbon would be lower by 4-26% compared to the current level. In 2040, soil organic N will not change in the Altai Mountains and steppe, increasing by 0.2-9.8% in the forest steppe and high mountains and decreasing by 4.7-22.2% in the Gobi desert. By 2070, soil N will decrease in all regions, except for the Altai Mountains. According to the projection, changes in plant protein will be insignificant in either year.

Peak standing biomass would be higher by 2040 and lower in all regions (except for the Altai Mountains) by 2070. According to these simulation results, climate change would have favourable effects by 2040 and negative effects by 2070 on soil fertility and plant production.

Forestry: Climate change is expected to have significant effects on the re-growth and productivity of forests. The high mountains, tundra and taiga regions are expected to decrease by 0.1-5% in 2020 and 4-14% in 2050. The area of the forest steppe may decrease by as much as 3% in the first quarter and 7% in the second quarter of the 21st Century.The simulation result shows that the total biomass might be decreased by 27.2% for larch, 5.1% for birch, 35.3% for Siberian pine, and 4.2% for Scotch pine.

Animal Husbandry: In general, the impact assessment indicated that temperature increase will have a negative impact on ewe weight gain in all geographical regions because the hot temperature at daytime will cause a reduction of grazing time. According to the simulation and different scenarios of climate change, under unchanged management, ewe live-weight gain may be lower, as the higher temperatures may lead to reduced grazing time in summer of 0.7-2.0 hours per day from May till September. Because intake is determined by forage availability, the reduced time at pasture will lead to lower intakes of 0.1-0.3 kg per day, resulting in lower average daily weight gains of 1-20 gram, depending on the region. This effect will be more pronounced for the forest-steppe zone than for the steppe and Gobi desert. Significantly lower weight gains are predicted for the high mountain regions, and the lowest smallest negative impacts are projected for the steppe area.

The expected higher temperatures in the summer season will have a slightly positive effect in the high mountain region, resulting in reduced weight loss in the winter-spring period, but because of the higher snowfall in the forest and steppe regions, grazing time will be shorter (on average 0.2-0.4 hours per day shorter) with stronger negative consequences. Additional average daily weight loss could be 4-8 grams, leading to an estimated increase in the total weight loss over the winter-spring period of 0.3-0.4 kg.

Animal productivity strongly depends on animal body condition. Therefore, it may be expected that the lower weight at the end of the winter-spring period will also negatively affect the production of milk, wool, and other products. Livestock milk production is likely to be lower, because of the reduced daily intake during the hot period of the summer. A reduction of the cold period may also negatively affect both wool and cashmere production.

Arable Farming: The potential wheat yield is expected to increase by 8-58% by 2040. The maximum increase will occur in the western region (15-58%), and the minimum will occur in the eastern region (8-19%). By 2070, potential wheat yield in most parts of the Central cropland region will decrease by 5-35%. Nevertherless, wheat potential yield is expected to be higher by 8-22% in the western and north-western part of the Central region, by 8-16% in the Dornod region, and by 20-28% in the Western region.

The potato yield may be increased by about 2-26% in 2040 as compared to the current possible potential yield. The maximum rise of potato yield would occur in western areas (13-26%) and the minimum will occur in the Central cropland region (2-8%).

By 2070, the potential potato yield is still projected to be slightly higher (0-14%) than the current level in Eastern and Western cropland regions, but this projected yield will be much less than the yield in 2040. Nevertheless, potential potato yield in Central cropland region might decrease by 1-18%. Mongolia’s yield per hectare is already very low; any small reduction in crop yield will therefore have significant impacts.

In summary, climate change is expected to have positive results on crop yield in the first forty years of the 21st century. However, it should be kept in mind that even though the crop yield will be the same or slightly more than the current yield in the Dornod (eastern) and Western regions, the crop yield in Central region is expected to decrease under a changed climate. Because the Central region is more highly populated (50% of the total population lives in this area), and accounts for as much as 70% of total cropland area, producing 64% of grain crops and 60% of vegetables, the drop in crop yield in this region is more risky than that in other two regions.

Snow Cover: Snow cover studies are important in the case of Mongolia because snow cover in winter has both positive and negative impact on animal husbandry. Long lasting thick snow cover adversely effects animal raising by limiting the pasture size. On the other hand, the snow cover provides a water source in a season when all surface water is covered by thick ice, and in areas that—due to their distance from surface waters—cannot otherwise be used for pasture.

Global warming scenarios indicate that this area may decrease by an average of 33.4% in 2040 and 22.6% in 2070. The number of days with stable snow cover is projected to decrease. Accordingly, in the middle of the 21st century, shortages of wintertime animal watering are expected in the Dornod steppe and the western part of the country, the Orkhon and Selenge river basins, and the Lakes basin.

The Orkhon and Selenge river basin accounts for a major portion of arable land area. Later formation and earlier melting of snow cover would lead to a decrease in soil moisture capacity that could adversely affect crop yield.

Permafrost: Area of permafrost will be decreased significantly if warming trends continue. Accordingly, significant changes will take place in the surface water balance, the soil moisture and temperature regimes, the vegetation cover, and, consequently, in the economy of the country.

Soil Quality and Erosion: According to the results of GCM scenarios for the period of 2000-2070, the annual mean temperature is expected to increase by 2-4^{0}C, consequently leading to an increase in the warm period, a shortening of the period of soil frost, a decrease in the snow cover area, a reduction of permafrost, and an increase in precipitation.

Current desert area is projected to shift to the north, expanding its range. The compounding effect of this desert expansion and the expected increase in the number of livestock in Mongolia is a likely acceleration of desertification and sand movement in desert-steppe and desert zones. By 2040, the soil organic nitrogen is expected to be a little higher in the forest-steppe and steppe zones, and less in the desert-steppe and steppe zone compared to the current level. Soil organic C will likely decrease by 22-26% in the desert and 4-15% in other zones by 2020.

Integrated Impacts: The results of the impact assessment show that climate change certainly affects both natural resources and agriculture production. These impacts are the direct effects of a changed climate on natural zones, permafrost areas, livestock, pastures and water resources, and the indirect effect on the economy.

According to the Cross Impact Assessment, water resources, animal husbandry, and pasture water supply appear to be relay components. Climate change, natural zones, soil erosion, permafrost and snow cover are determined as driving component. These variables have a direct and strong influence on pasture productivity, cropland and other components of ecosystems and infrastructure. Wild animals, tourism, arable land, and pasture productivity appear to be strongly dependent on climate change and the protected areas are an autonomous component.

To sum up, it can be concluded that the effects of past human activities are large and are expected to increase. According to the results of all sectors, the steppe and desert-steppe are more vulnerable to the small changes of climate variables than other regions. The impacts upon these areas may be that water resources will decline, pastures will degrade, land use will change, animal husbandry will decline, and the economy will decline. Thus, more attention should be paid to conserving and restoring natural resources and to ensuring a balanced management of various human activities in the light of future climate change.

Adaptation Measures

Due to Mongolia's high sensitivity to any changes in climate, implementation policies and strategies for adaptation to potential climate change will not only be necessary to meet obligations under the UNFCCC, but will also support national sustainable development activities.

Rangeland and Livestock: Adaptation of Mongolia's native pastoral system could take place autonomously, which usually refers to adjustments made within the system. They could also be planned through adjustments external to the system, and initiated or promoted by public policy.

High priority adaptation measures that could be undertaken by the Government have been identified. These adaptation measures should be focused mainly on: public awareness and education of herdsman; development of rangeland and livestock management systems based on pastoral practice and modern technology; improvement of an forage production systems; use of modern pasture water supply systems; establishment of appropriate risk management system; strengthening of the early warning system within the National Meteorological and Hydrological Services for extreme climate events and weather conditions; development of an insurance system for livestock and crops with respect to natural disasters; improvement of the marketing system of livestock and crop products in coordination with long-term weather forecasts and market signals; improvement of the health care system both for people and animals, etc.

Water Supply and Demand: Taking into account the scarcity of natural water resources and their anticipated decrease resulting from climate change, several adaptation measures are recommended in areas of water resources; residential water supply; pasture water supply; irrigation; water quality; and socio-economy issues.

Arable Farming: Adaptation measures taken to anticipate adverse effects on crop yields should be focused on improvement of land cultivation management system, research on development of new crop varieties that have features such as earlier maturing, higher yields, disease and pest tolerance and drought resistance, and cultivation of alternative crop species; improvement of the infrastructure to facilitate market interactions, solution of problems related to land ownership, etc.

Soil Degradation and Desertification. Several adaptation measures that can prevent soil erosion and degradation in pasture are identified. These are: Improvement of legislative mechanisms for pasture use, focusing on local communities; establishment of a suitable farming and pasture system that is flexible towards climate variations; improvement of pasture water supply in order to avoid the concentration of animals around certain water sources; improvement of the road network; and restoration of the saxaul forest and other forests and planting woody vegetation in degraded area and area sensitive to soil moisture.

Climate Change Response Policy

Mongolia National Action Programme on Climate Change

In order to comply with its obligations and commitments under the UNFCCC, Mongolia has developed its National Action Programme on Climate Change (NAPCC). On 19 July 2000, the Mongolian Government approved this programme, which includes the Government's policies and strategies to deal with climate change related concerns and problems.

The NAPCC is aimed not only to meet the UNFCCC obligations, but also to set priorities for action and integrate climate change concerns into other national and sectoral development plans and programmes. This Action Programme includes a set of measures, actions and strategies that enable vulnerable sectors to adapt to potential climate change and mitigate GHG emissions. The underlying philosophy of these measures is that they should not adversely affect economic development and current lifestyles.

The implementation strategies formulated in this NAPCC include institutional, legislative, financial, human, education and public awareness, and research programs, as well as coordination with other national and sectoral development plans. Existing barriers to implementation of the NAPCC as well as possibilities to overcome such barriers were also identified. Finally, the programme considered several adaptation measures for animal husbandry and rangeland, arable farming agriculture, water resources, soil protection, natural disasters, etc.

Successful implementation of NAPCC depends on the adaptation explicit measure that can meet the requirements of adaptation and mitigation priorities. Therefore a number of projects that have high priority, high effectiveness, cost-beneficial and relatively easy to implementation have been identified.

Existing Barriers and Ways to Overcome Them

Each country has its own specific barriers to the implementation of adaptation and mitigation measures, such as limitations in financial and technical resources, human and institutional capacity, its legislative framework, and public support. The most widely recognized barriers for each area and actions should be addressed.

Legislative Framework

There is still no law nor regulatory mechanism that explicitly addresses climate change related problems. However, some of the existing laws and regulations, especially the environmental protection laws, directly or indirectly relate to emissions of pollutants, including GHG.

One option for the allocation of GHG emission limits among relevant sources and sectors is the introduction of emission permits. The allocation should be based on the inventory of the current emissions of production units and on the assessment of GHG mitigation potential.

In order to implement the adaptation and GHG emission reduction measures, the establishment of special regulations related to climate change response measures—especially GHG mitigation measures—is of critical importance. National strategies to mitigate GHG emissions and adapt to climate change should be reflected in the laws and other legal instruments which regulate the development of relevant economic sectors such as energy, coal mining, agriculture, industry, transport, and infrastructure.

Institutional Framework

Climate change issues should be managed as a unity rather than through a sector-by-sector approach. Such integration does not mean that all responsibilities must be centralized, but that the responsibilities of all essential activities should be made explicit to all institutes and authorities involved. Implementation of the identified measures will also require good coordination among ministries and agencies. Financial assistance and evaluation of achieved results pose other important issues.

The Government has established the inter-disciplinary and inter-sectoral *National Climate Committee (NCC)*, led by the Minister for Nature and the Environment, to coordinate and guide national activities and measures aimed to adapt to climate change. High-level officials such as Deputy Ministers, State Secretaries and Directors of the main Departments of all related ministries and agencies are members of the NCC.

In order to carry out the day to day activities related to implementation of responsibilities and commitments under the UNFCCC and Kyoto Protocol as well as the NCC, and in order to manage activities nationwide and address climate change related problems in various sectors, the *Climate Change Office (CCO*) is established within the National Agency for Meteorology, Hydrology and Environment Monitoring.

Integration Measures with Other Related Programmes and Plans

The NAPCC 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 degree of integration of 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 the 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 activities.

The passing of new laws or the amendment of existing laws—in particular policy or development programmes or plans guiding different economic sectors—should follow national and sectoral strategies and policies related to climate change concerns.

Socio-economic Mechanisms

Social and economic instruments play increasingly important roles in the successful implementation of the NAPCC. Economic instruments could take a limiting (taxes) or promoting (subsidies etc.) approach. Limiting measures include a pollution tax, an input tax, a product tax, export taxes, import tariffs, etc. Promoting measures may include subsidies, soft loans, grants, location incentives, subsidized interest, revolving funds, sectoral funds, ecofunds, greenfunds, tax differentiation or exemption, investment taxes credits, tax relief for environmental equipment or investment, etc.

Financial Sources

In the case of Mongolia, foreign financial sources will play a crucial role in the implementation of the NAPCC because the national banking system is weak and Mongolia's private companies have very small financial reserves. Therefore, activities to expand existing cooperation with international financial sources should be undertaken at the national and sectoral level to secure financial and technological support. Possible sources of such funding are identified.

Research and Systematic Observation

Research

Research activities will be focused on development of climate scenarios at the global and regional level, the potential impacts on ecosystems and society and vulnerability assessment, and possible means and options to adapt to climate change and mitigate the GHG emissions at the national level. In addition, research should lead to regular updates of these findings and outputs using the latest scientific knowledge on global climate change. Based on these findings and analyses, the National Action Programme on Climate Change (NAPCC) should be updated and the implementation of national strategies and policies on climate change should be facilitated.

Systematic Observation

When spread out over the vast territory of Mongolia, the country's systematic observation network is inadequate. Due to limited human, technical, and financial capacities, the existing monitoring stations are incapable of monitoring all the parameters that are needed to carry out relevant climate change studies. There are significant gaps in the datasets. This limits the comprehensive research on climate system dynamics using the GCM scenarios and methodologies suggested by the IPCC and other international research centers. With the close cooperation of international programmes and initiatives, the National Meteorological Service can improve and upgrade its monitoring capabilities.

Education, Public Awareness and International Activity

In order to provide an opportunity for public participation in adaptation and GHG mitigation activities, it is important to educate the public with climate change knowledge using the media, inclusion in school programmes, training to different target groups, and distribution of information materials and leaflets.

The education and public awareness activities should be targeted to specific target groups: (i) *Decision makers; (ii) National technical experts; (iii) Stakeholders; (iv) Public; and (v) Students and school children.*

Pilot projects, and dissemination of their results, will play an important role in tailoring the message about climate change to the target audience. Therefore, it is recommended that pilot projects on adaptation to climate change and on GHG mitigation actions be initiated. These educational experiments will help to demonstrate the advantages of the adaptation and mitigation measures to the consumers, stakeholders and end-users. Furthermore, materials used for educational and public awareness activities should be continuously developed, and a library/database maintaining materials for distribution, such as educational videos, should be set up to facilitate these activities.

International Activity and Special Needs

Relatively weak institutional arrangements, significant vulnerability to climate change, and limited capacity to deal with different problems all combine to make international cooperation especially necessary to aid Mongolia in its development of response actions to address climate change concerns and implementation of Mongolia National Action Programme on Climate Change. Mongolia's specific needs for international cooperation include:

(i) Support in capacity building, training, research and monitoring,

(ii) Support in vulnerability and adaptation assessment and identification of adaptation measures,

(iii) Assistance in the development of GHG mitigation policies and needs for technology transfer,

(iv) Financial and technological assistance in implementation of mitigation and adaptation projects,

(v) Support in climate change education and public awareness activities,

(vi) Assistance to meet national commitments and obligations under the UNFCCC,

(vii) Participation in the global and regional environmental research programmes and activities of the Intergovernmental Panel on Climate Change (IPCC).

Mitigation and adaptation projects that were identified in the NAPCC will require substantial international support and foreign investment. Therefore, successful implementation of national climate change response measures climate change will depend directly on the availability of financial resources and technical assistance. In order to secure this support from abroad, a close cooperation with the international financial mechanisms, bilateral and multilateral programmes and initiatives will be critical.

CHAPTER 1 NATIONAL CIRCUMSTANCES

1.1. Geography

Mongolia is a landlocked country in Northeast Asia located between the latitudes of 41°35’N and 52°09’N and the longitudes of 87°44’E and 119°56’E. Mongolia’s territory reaches relatively high altitudes: while the average altitude is 1,580 meters above sea level, 81.2% of the territory is higher than 1,000 meters, and half of the territory is higher than 1,500 meters (Figure 1.1).

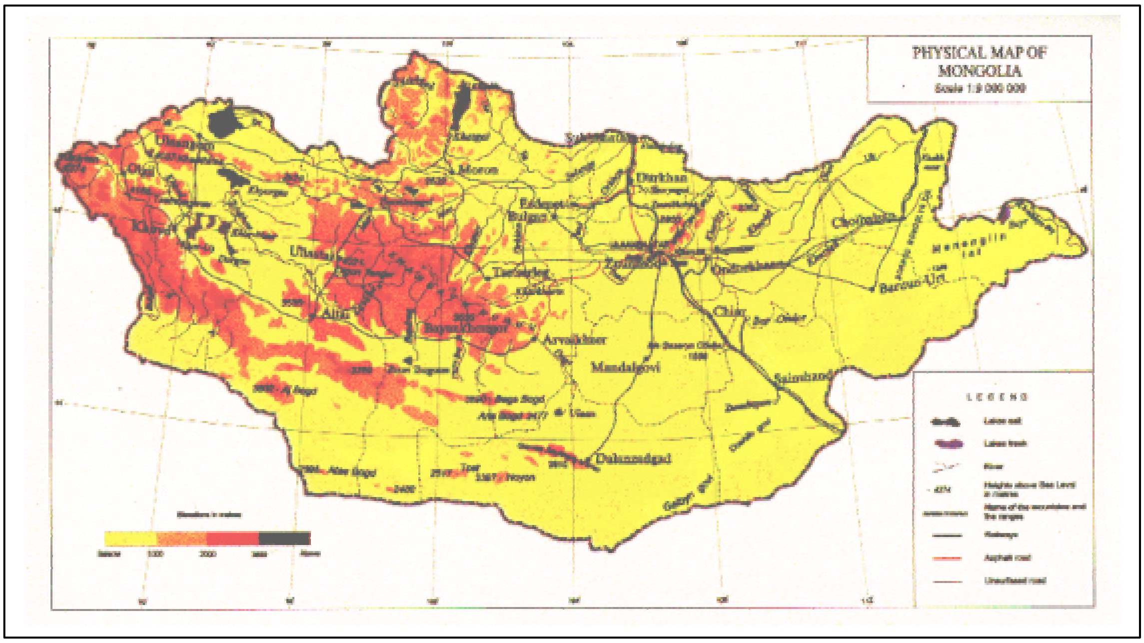

Figure 1.1 Physical Map of Mongolia

Among the temperate zones of the Northern Hemisphere, few nations compare to Mongolia in the size, diversity, and health of its natural ecosystems. However, as Mongolia undergoes a massive socio-economic transformation, threats to these natural areas, flora and fauna are rapidly mounting.

In Mongolia, all natural zones such as high mountains, valleys between the mountain ranges, wide steppe, desert and semi-desert zones are combined. Ecologically, Mongolia occupies a critical transition zone in Central Asia: here the great Siberian taiga forest, the Central Asian steppe, the high Altai mountains and the Gobi desert converge.

The northwest and central parts of Mongolia are high mountainous regions, while the eastern part is a vast steppe region. The southern part of the country represents the semi-desert and desert area that is known as the Mongolian Gobi. Forests cover 8.1% of the country’s territory, consisting mainly of larch and pine. Saxaul *(Haloxylon Ammodendron)* forests occupy certain areas in the Gobi.

1.2. Land Resources

Mongolia's total area is 1,566 600 km^2. The distance between the most western and most eastern points is 2,392 km, and between northern to southern points is 1,259 km. Mongolia is the seventh largest country in Asia and the 18th largest in the world. Also, Mongolia is one of the largest landlocked countries in the world.

In general, land use in Mongolia can be broken down into the following categories: 76.5% of the land area is used for agriculture, from which approximately 0.8% is cultivated, 1.6% is used for hay making, and 97.6% is pasture land. Cities and settlement occupy 0.3% of the land area, while 10.4% is reserved for special needs of the state, which include land for the state security and defense purposes, special protected areas, roads, and communication networks of national importance. Forest and shrubland accounts for 9.7% of the land area, and water surface for 1.1%; 1.7% of the land area is wasteland that is not suitable for usage.

Land resources provide the foundation for Mongolia's economy, including food supply, agriculture, and mining industries. Therefore soil erosion, desertification and other forms of land degradation are considered high priority issues in Mongolia. The amount of degraded area is growing annually. For example, the expansion of strip mines is increasing the deposition of overburden, spills and tailings which degrade land resources. Meanwhile, in urban areas, waste products from domestic and industrial construction are currently deposited directly on the soil surface in overly large, designated dumping sites on the outskirts of cities and towns.

1.3. Climate

The climate of Mongolia is a harsh continental climate with four distinctive seasons, high annual and diurnal temperature fluctuations, and low rainfall. Because of the country's high altitude, it is generally colder than that of other countries in the same latitude.

Average annual temperatures range between 8.5^{o}C in the Gobi and -7.8^{o}C in the high mountainous areas. The extreme minimum temperature is usually between -31.1^{O}C and -52.9^{O}C in January and the extreme maximum temperature ranges from +28.5^{O}C to +42.2^{O}C in July. The average annual precipitation is low (200-220 mm) and represents a range between 38.4 mm per year in the extreme South (Gobi desert region) and 389 mm per year in limited areas in the North. Most precipitation occurs in the months of June, July and August; the driest months occur between November and March. Droughts in the spring and summer periods occur about once every five years in the Gobi region, and once every ten years over most other parts of the country. Mongolia receives an average of 3,000 hours of sunshine annually, which is well above the amount received by other countries of the same latitude. Mean annual precipitation and temperature ranges are shown in Figures 1.2 and 1.3.

Climate change studies in Mongolia clearly demonstrate that Mongolians should be concerned about climate change resulting from anthropogenic GHG emissions (Dagvadorj D., 1994, 1999). These studies suggest that over the last 60 years the average temperature in Mongolia has increased by about 1.56°C. Temperature increases are more dramatic in winter months: the highest temperature increases (3.6°C) were observed in the winter season, while temperatures in the summer months decreased, in contrast to the global and regional trends. Changes in temperature have also demonstrated spatial variation with strong winter warming in the mountain areas and less in the steppe and Gobi deserts areas.

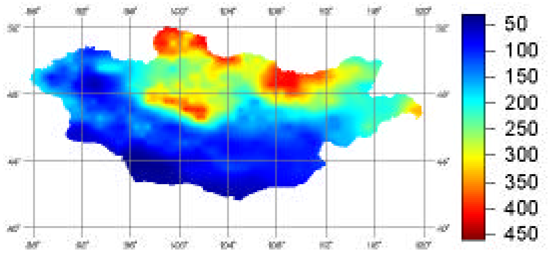

Figure 1.2 Annual Precipitation Amount, mm

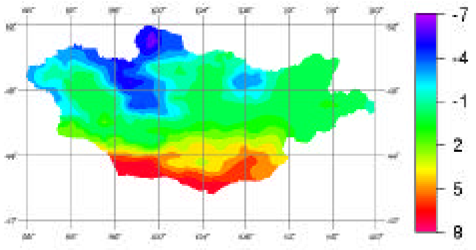

Figure 1.3 Annual temperature, °C

In addition, the annual precipitation has been observed to decrease from the 1940s to about the mid-1980s, but has since shown signs of increasing in all areas except the Gobi desert region. Some scientists believe that the severity and frequency of agricultural drought in the Gobi desert area and floods in the central and northern parts of the country may increase with climate change.

1.4. Water Resources

Mongolia's total water resource is estimated at 599 cubic km of water, composed mainly of water stored in lakes (500 cubic km) and glaciers (62.9 cubic km). Surface and ground water contribute only four and two percent of total additional water resources. Eighty-five percent of these water resources are freshwater; Mongolia's Khovsgol Lake alone contains 93.6% of the country's total freshwater resources. (Myagmarjav et al, 1999). The headwaters of some of the word's largest rivers, such as the Yenisei, Lena and Amur, are found in Mongolia's mountain ranges. Therefore, these river water resources have international significance. Almost 60% of the runoff formed in the Mongolian territory drains into Russia and China.

Domestically, surface and ground water resources play vital roles in Mongolia's economy, supporting agriculture, forestry, fisheries, livestock production, industrial and domestic water demand and sanitation operations. Economic water resource development depends not only on the water resource variability from year to year or season to season, but also on variability over geographic regions. Annual average specific discharge varies from 0.01 l/sec sq.km in desert areas to around 20 l/sec sq.km in mountain ranges. Renewable water resource varies from 23 cub. km in a low flow year to 69.5 cub. km in a high flow year. Annual average precipitation is 220 mm, of which 90.1% evaporates, leaving only 9.9% to form surface runoff and partially recharge ground water aquifers. These aquifers are used extensively for domestic water supply and livestock and pasture watering in steppe and desert areas.

Another major problem in arid and semi-arid regions concerns poor water quality resulting from relatively high salinity. In addition to seasonal freezing and droughts, high salt content further limits the use of some water resources in Mongolia.

1.5. Economy

The Mongolian economy is relatively diversified. Agriculture accounts for about 33% of gross domestic product (GDP), industry and construction for 27.5%, and services for about 40% (Statistical Yearbook, 1998). Mining ventures, mainly in copper, provides an estimated 27% of the economy's export earnings (1998). The industrial sector includes wool and cashmere processing, leather goods production, food processing, construction, and, in recent years, garment manufacturing. Mongolia possesses more than 30 million head of livestock (by end of 2000), as well as sizeable reserves of copper, gold, coal, and other minerals. Prospects for the development of petroleum in commercial quantities are encouraging. Key economic indicators are given in Table 1.1 (Statistical Bulletin, 1990-1998).

Table 1.1. National Indicators

Criteria	1990	1994	1995	1996	1997	1998
Population (thousand)	2,103.3	2,280,0	2,312.8	2,347.1	2,379.6	2,413.0
Relevant areas (thousand km^2)	1,564.1	1,564.1	1,564.1	1,564.1	1,564.1	1,564.1
GDP (mil. tugricks)	10,465	283,263	550,254	646,559	832,635	817,393
GDP per capita (mil. tugricks)	5,042	125,393	239,877	277,505	352,319	341,106
Share of industry in GDP (percentage)	35.6	30.5	27.8	20.6	24.1	24.1
Share of services in GDP (percentage)	11.5	10.5	11.2	14.7	13.9	14.0
Share of agriculture in GDP (percentage)	15.2	36.9	36.8	36	33.5	32.8
Land area used for agriculture purposes (thousand km^2)	1,257	1,185	1,185	1,185	1,289	1,291
Urban population as percentage of total population	43.1	53.9	50.4	49.7	49.6	49.6

Livestock population (thousands))	25,856.9	26,808.1	28,572.3	29,300.1	31,292.3	32,897.5
Forest area* (km^2)	106.8	106.8	106.8	106.8	106.8	106.8
Life expectancy at birth (years)	-	63	65	-	-	66
Literacy rate		97				

Source: Mongolian Statistical Yearbook, 1999 and 2000

Economic development in Mongolia faces serious challenges. Since 1990, Mongolia has been navigating the difficult transition from a centrally planned to a market oriented economy, and has overcome considerable geographical obstacles to development, including being landlocked and having an extreme continental climate. Under these difficult circumstances, the Government of Mongolia has committed itself to market reform through an active programme of privatization, trade and investment liberalization, and unification of exchange rates. These policies have been successful to a certain extent: the declining growth rate of 1990 to 1993 has been stabilized since 1994.

Mongolia's exports are concentrated in mineral-based commodities, which accounted for 61% of total exports in 1996. Exports from related livestock industries accounted for 20%, down from 27% in 1992.

Agriculture. Throughout the history of Mongolia, nomadic livestock husbandry -a typical example of a pastoral system- has been the only viable economic activity in the region. More than any other industry, animal husbandry has shaped the way of life of Mongolian society, and has dominated the Mongolian economy. This sector employs 47.9% of the total population, produces 34.6 % of agricultural gross production, and accounts for 30% of the country's export. Intensive livestock activities, such as pig, poultry, and dairy production, do not play a major role in the livestock sector of Mongolia.

Traditionally, crop production has not been a significant agricultural activity in Mongolia. Intensive land cultivation only began in 1958. In total, about 1.3 million hectares of arable land have been cultivated for cropping. The main crops are spring wheat, potatoes and other vegetables. Prior to 1990 crop production was sufficient to cover the total domestic demand for flour, potatoes and vegetables; surpluses were exported.

During the last 10 years, both cropping area and yield have declined due to lack of finances and technical and managerial problems. Today, national arable farming meets only 50% of the domestic flour demand and between 10-40% of the domestic potato and vegetable demand. The remaining demand is met by imports (MAP-21, 1998).

Industry. Industrial development in Mongolia began in the 1920s. Over the last few decades, heavy industries such as power, mining, fuel and others have been established and developed. Exports of copper and molybdenum concentrate supply 60% of the national export income. Since livestock husbandry plays a central role in the economy, industries related to the processing of agricultural raw materials (e.g., leather and skin processing, cashmere, wool preparation and fabrics manufacture, biochemical industry, etc.) have also benefited from development.

Transport and communication. Mongolia's transport sector is underdeveloped and is unable to fulfil its role in stimulating economic growth and national integration. Isolation of certain regions of the country and significant physical distance from international markets present the greatest obstacles to be overcome. As of 1990, auto-transport accounted for 70.0% of total freight and 98.3% of total passenger transportation (A Transport Strategy for Mongolia, 1999).

Energy. Mongolia's largest contributor to GHG emissions is the energy sector. The country's cold continental climate necessitates the burning of high amounts of fuel, usually wood or domestically-mined, low-energy coal that contributes to a high rate of carbon dioxide (CO_2) release on a per-capita basis. Estimated national CO_2 emission for 1990 was 19.1 million tonnes or roughly 9.5 tonnes per-capita. This estimated figure is larger than that of the great majority of developing countries and exceeds the world average. According to current estimates of population and economic growth, Mongolia may experience a three-fold increase in energy demand by the year 2020.

Mongolia'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 has the highest emissions of greenhouse gases per unit of energy, is abundant in Mongolia, with recoverable reserves estimated at 50 billion tonnes. Coal comprises the bulk of Mongolia's energy production, generating 80% of the country's power and heat, with oil products (mainly diesel oil) accounting for the remainder. Currently, Mongolia has no domestic oil or natural gas production. All oil products are imported, mostly from Russia. Petroleum products account for 19% of the total commercial energy use, consumed mostly in the transport sector.

Between 1993 and 1990, primary energy supply decreased by 30%, a statistic which is can be explained by economic constraints in the transition period and a subsequent decrease in industrial production and activities. However, some stabilization trends have been observed from 1993 onwards.

In the non-commercial sector, primary energy sources are fuelwood and animal dung. Apart from these traditional biomass fuels, renewable energy is not a substantial primary energy source in Mongolia. Frigid Mongolian winters pose a severe obstacle to tapping Mongolia's sizable hydro potential.

The existing power sector of Mongolia consists of the Central Energy System (CES), with five coal-fired Combined Heat and Power Plant (CHP) and 18 provincial enterprises that operate isolated energy systems. Overall, the power sector of Mongolia has a net installed capacity of about 1,066.0 MW, but its firm capacity was running at only 65% (approximately 541 MW) in 1994. The CHP uses extraction and condensing turbine types. Part of the steam is extracted from the turbines for meeting heat requirements (steam and hot water).

Isolated power systems range from 60 kW to 7.2 MW diesel engine generators. Both hot water and space heating are supplied by manually stoked, coal-fired shell- and tube-heat-only boilers. Boiler capacities range from 0.4 to 10 Gcal/hr at approximately four bars of steam pressure. Due to harsh, cold climate conditions in wintertime, heat is a major energy use. Heat supply accounts for 40% of gross energy consumption.

The industrial sector is one of the largest energy consumers, consuming about 70% of the electricity supply and 28% of the heat produced. Industrial enterprises are small in number but relatively large in production. For example, Erdenet Copper Mining Industry, which provided about 12% of national tax revenue and one-third of national income tax revenue in 1997, accounts for about 36% of the country's electricity use and about 15% of the peak power demand.

The transport sector relies mainly on imported petroleum products to meet energy needs. Total energy consumption in the transport sector reached 15,682.78 GJ in 1993. Even though the economic activity of public and freight transportation declined between 1990 and 1995, the number of vehicles increased, almost tripling in the same period (from 15,000 vehicles in 1990 to 45,000 vehicles in 1995).

Residential sector energy consumption accounts for 11% of coal, 48% of heat and about 25% of the electricity demand in 1993. In addition, households consumed an additional 21,182 GJ of non-commercial energy in 1993. Energy use in the service and agricultural sectors was comparatively low: 9,430 GJ and 1,431 GJ in 1993, respectively. In addition, off-road machinery operated for agricultural purposes consumes motor fuels. Only a very small amount of electricity is consumed for irrigation purposes.

Public services, including government offices and buildings, schools, hospitals, and other non-commercial facilities, are owned by the Government of Mongolia. Space heating and lighting comprise the main energy uses in this sector, which are provided by the district heating system and the electric grid.

1.6. Demography

In 1999, the population of the Mongolia reached 2.42 million people, representing a natural (net) increase of 16.1 persons per 1000 inhabitants. Although the population has doubled since 1960, the average population density—1.5 persons per square kilometer--remains the lowest in the world. Still, this density is highly variable, ranging from a high of 162 persons per square kilometer in Ulaanbaatar to a low of 0.3 people in the Umnogobi aimag (province). Some 56.6% of the population lives in urban areas. The capital city, Ulaanbaatar, alone is home to 32% of the population.

Until the 1990s, Mongolia's population growth rate was one of the highest in Asia at 2.1-2.5 % per year. However, the last decade has seen a decrease to the current annual rate of 1.4%. Population growth since 1918 is given in Figure 1.4

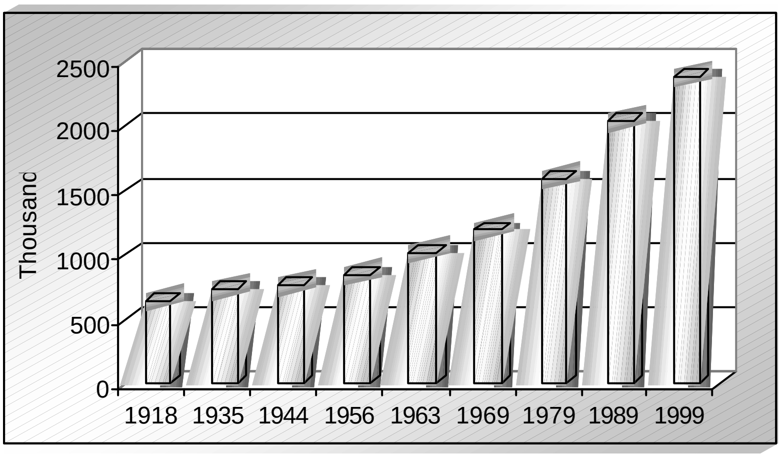

Figure 1.4 Dynamics of population growth

1.7. Health and Education

While Mongolia's health and education indicators are relatively strong compared to other countries at similar income levels, and while the Government's expenditures for health and education are high by international standards, social indicators have deteriorated with the transition to a market economy (Table 1.1).

Social services were given a high priority in the past and this legacy has continued into the present, to some extent. A well-developed health service infrastructure exists, and Mongolia compares favorably with other developing nations in terms of life expectancy (66 years) and hospital beds per capita. Now, the Government recognizes the need for budgetary reform to ease the financial burden of health care by improving the efficiency of public health services and introducing a new health insurance system.

Until 1990, Mongolia came close to universal coverage of basic education. Since the transition, however, rising school fees and herding families' increased need for labor due to the privatization of livestock have reduced enrollment, especially among the poor. There is evidence, however, that social indicators have started to improve again, and the Government aims to restore universal basic education within the nearest few years. The literacy level was estimated 97.8% at the end of 1999. In 1997, the enrollment rate for primary and secondary schools stood at about 75.8%.

1.8. Environment

Mongolia's natural ecosystems are relatively fragile, given that they are highly susceptible to degradation by both natural and human impacts, and slow to recover. Furthermore, Mongolia's endowment of renewable natural resources is limited. In urban areas, environmental and natural resource issues, such as air quality, water supply, waste disposal, and land degradation, have reached a critical stage. Beyond the cities, other pressing environmental issues include locally severe environmental degradation from mining and petroleum extraction, natural disasters, and damage to natural heritage (including biodiversity).

The air quality issue in Mongolia is essentially an urban issue. Primary sources of urban air pollution are vehicles, the large, soft coal-fired thermal electric power plants, industry, and the soft-coal-fired cooking and heating stoves used individual dwellings. Urban air quality problems are exacerbated by the seasonal occurrence of a stationary temperature inversion over the urban areas, usually lasting from late fall to early spring, and accompanied by low winds. Air pollutant levels during these temperature inversion period frequently reach levels exceeding health-based criteria in many urban areas.

Meanwhile, a significant portion of the land resources in Mongolia are threatened by overgrazing, deforestation (including loss of forests to fire and insect damage), erosion and desertification. For example, crop cultivation is an important cause of soil erosion. Mongolian climatic condition makes the high levels of soil loss often associated with tilling almost inevitable; this loss is aggravated by the inadequate use of soil protection techniques. Between 1960 and 1989, the area under cultivation in Mongolia increased greatly (estimates range from 300 to 900%), mostly for wheat fields. Since that time, an estimated 60% of those fields have been abandoned, leaving them subject to wind and water erosion. Expanding industrial activities in recent years have effected similar degradation, ranging from erosion due to increased overland vehicular traffic and improper waste disposal in mining enterprises. Additionally, dimate change, which is expected to cause a gradual reduction in annual precipitation in Gobi desert areas, is likely to be a contributing factor to desertification. Concerning water resources, a rapid rise in water demand inspired by increased levels of economic activity in key watersheds has resulted in the reduction of water levels in lakes, river flow, and the ground water table. At the same time, domestic and industrial wastewater discharge has intensified contamination of surface waters.

In the area of forestry, the Commonwealth Forestry Review estimates the country's total standing forest area in 1994 at 17.5 million ha, covering some 8.1% of the territory of the country. About two-thirds of the total forest area is found in north central Mongolia. The Gobi region, in southern and southwestern Mongolia, contains arid forest and shrubland, 90% of which is represented by saxaul species. Mongolia’s forest composition is as follows: 60.7% larch, 16% saxaul *(Haloxylon Ammodendron)*, 7.8% cedar, 4% scotch pine, 7.3% birch, and 4.2% other species (fir, aspen and others) and shrubs.

In a dramatic decade full of challenges and transformation, from socialism to democracy, from centrally-planned economy to free market system, the management of natural resources has posed additional challenges to Mongolia’s leaders. Today, Mongolia is at a turning point in its history, politically, economically, in terms of international relations, and also with respect to the use and protection of its environment. The decisions made and initiatives taken (especially with assistance from the international community) on environmental issues at this juncture will no doubt set the tone for environmental and natural resource policy in Mongolia throughout the country's new phase of development.

1.9. Natural Disaster

Despite tremendous progress in science and technology, weather is still the custodian of all spheres of life on earth. This is especially true in a the territory of Mongolia, a region that is very vulnerable to natural disasters. Due to the precariousness of climate conditions and traditional economic structure, natural disasters- especially disasters of meteorological and hydrological origin -have substantial effects upon the socio-economic conditions of the country. Heavy rains, snowfall, strong winds, sandstorms, snowstorms, hail, and flooding often bring substantial damages to life and property of Mongolia. For instance: in the two year period between 1998 and 1999, the total economic damage caused by natural disasters such as strong wind, blizzard, hail and thunderstorms, floods and extremely hot weather conditions was estimated as 30 billion Togrogs, or about 3% of GDP.

Devastating weather hazards—such as a dzud and drought--are a well-known afflication of the Mongolian nomadic herder.

Dzud is the Mongolian term for an extraordinarily harsh winter that deprives livestock of grazing, a specific phenomena that takes its toll in the winter-spring season as high numbers of livestock die of starvation. This particular disaster struck twice in the last two cold seasons (1999/2000, 2000/2001), costing the livestock and livelihoods of many Mongolian herders. As a result of the dzud in 1999/2000, 2.4 million livestock were killed and economic losses reached to 91.7 billion Tugricks by 1 June 2000. Social costs of the dzud are difficult to estimate.

Droughts in the spring and summer periods occur about every five years in the Gobi desert area, and once in every ten years over most of the parts of the country.

There is a clear indication that the frequency and magnitude of natural disasters are increasing due to global climate change. For example, the average spring precipitation has dropped by 17% during the last 60 years, a fact which has likely contributed to the increased number of fire outbreaks and burned areas in recent springs. The magnitude of this increase probably also fluctuates with the changing intensity of the El Niño/Southern Oscillation (ENSO). Increasing human presence in the fire-afflicted forest and steppe zones contribute to the increasing risk as well. Economic damage from fire is reaching several billion Togrogs. The ecological and social impacts have not yet been assessed, although forest and steppe fires are known to be a big contributor of GHG emissions.

Another major cause of morbidity and mortality in Mongolia is vector borne disease. Rodents, bats and pests contribute to the transmission of infectious diseases and environmental degradation. Their populations are known to fluctuate in response to global and local climate change. For example, the periodic population explosions of Brandt’s vole in Mongolia poses a serious threat to the pasture's carrying capacity (Batjargal, 1992). Additionally, with the rise of global temperatures, an increase in food-borne trematode infections may pose a serious threat to public health.

CHAPTER 2 NATIONAL GREENHOUSE GAS INVENTORIES

2.1. Introduction

Mongolia prepared its first greenhouse gases (GHG) inventory in 1996 for the base year 1990 under the US Country Studies Programme. This inventory was updated within the Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS), a regional project implemented by the Asian Development Bank. As part of the enabling activities of preparation of the Initial National Communication (GEF/UNEP), the GHG inventories were updated to 1998.

The GHG inventory includes emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x) and carbon monoxide (CO) for the base year 1994. Emissions of other greenhouse gases, such as NMVOCs and PFCs, have not been included in the inventory. Because of the historical, geographical, climatic and economic circumstances of Mongolia, some sources of GHG--such as methane emissions from oil and gas systems, emissions from savanna and agricultural residues burning, methane from rice cultivation, and use of fertilizers on agricultural soil--are not applicable, and were also not included. Also, because 1994 was a year of economic downturn in Mongolia, GHG emissions are compared to the entire period from 1990-1998 to balance out this trend.

At the same time, some country-specific sources of GHG, such as mining, are considered as a source of CO_2 because they require the conversion of grasslands to mine sites this purpose. Alternately, steppe and forest fires in Mongolia, which are often caused by humans, are sources of gases such as carbon dioxide, carbon monoxide, methane, nitrogen and nitrous oxides. However, while such fires are believed to be a significant source of GHG in Mongolia, they were not included in the national emission totals because the IPCC Guidelines do not consider this an anthropogenic source at this time.

2.2. Methodologies

The Mongolian GHG inventories follow the methodologies recommended by the IPCC (IPCC, 1996). The main obstacle in calculating GHG inventories was the lack of reliable data. Data were obtainable for fuel consumption, cement production, domestic animal population, area of cultivated land and some factors for the energy content of Mongolian coal and the oxidation coefficient of fuel burned for power generation. In other cases, new values had to be established for the calculation of emissions. For example, in the calculation of emissions from fuel combustion the value “0.92” is used for the fraction of oxidized carbon for solid fuels. Similarly, values had to be established for the annual growth rate of logged forests and for planted forests. These are “0.6 t dm/ha” and “0.2 t dm/ha” respectively.

In most cases, specialized data, such as emission factors and country-specific emission ratios of gases, have not been calculated for Mongolia. Therefore, the IPCC recommended default values are used in the GHG inventory calculations.

2.3 Greenhouse Gases Emissions

2.3.1. Total emissions

The anthropogenic activities associated with the largest sources of carbon dioxide in Mongolia are combustion of fuel for power generation, heat production and conversion of grasslands to crops. The most significant source of methane is enteric fermentation in livestock. Emissions of nitrous oxide, nitrogen oxides and carbon monoxide are insignificant relative to total emissions of carbon dioxide and methane.

The primary sources and sinks included in the inventory for the base year 1994 are shown in Table 2.1.

Table 2.1. Greenhouse Gas Emissions, 1994 (Gg)

Module **Submodule**	**CO_2**	**CH_4**	**N_2O**	**NO_X**	**CO**
Total National Emissions	**9,064**	**269.1**	**0.1**	**2.6**	**93.1**
1. ALL ENERGY	**8,570**	**17.9**	**0.1**	**2.6**	**93.1**
A. Fuel Combustion					
Energy industries: CO_2	8,570				
Traditional Biomass: non-CO_2		13.1	0.1	2.6	93.1
B. Fugitive Fuel Emissions					
Solid Fuels		4.8			
2. INDUSTRIAL PROCESSES	**95**				
3. AGRICULTURE		**246.9**	**NA**	**NA**	**NA**
Livestock		246.9			
4. LAND USE CHANGE & FORESTRY	**399**				
A. Changes in Forests & Other Woody Biomass Stocks					
Annual Growth	-224				
Biomass Harvest	2,359				
B. Grassland Conversion (Soils)	3,940				
C. Abandonment of Managed Lands	-5,675				
5. WASTE	**NE**	**4.2**	**NE**	**NE**	
A. Solid Waste Disposal on Land		3.4			
B. Wastewater Treatment					
Industrial		0.4			
Domestic & Commercial		0.4			
Bunker Fuel Emissions	**48**				

Notes: *NA - not applicable*
NE - not estimated
Subtotals by each sector are shown in bold.

The net emissions of major GHG for the period 1990-1998 are given in Table 2.2. Values for CH_4 and N_2O in CO_2-equivalent along with the relevant Global Warming Potentials (GWP) for the same period are provided in Table 4.3 and in Figure 2.1. In general terms, emission trends follow Mongolia's economic growth. Constant increase of CO since 1991 mirrors the increased use of traditional biomass fuels since that time. The sharp decrease of GHG total emission observed between 1990 and 1995 is mostly due to socio-economic slowdown and subsequent recovery. Subsequent expansion of coal extraction and liquid fuel import is thought to be responsible for the increase of CO_2 and CH_4 emissions after 1996 (Table 2.2).

Table 2.2. Net emissions of GHG in 1990-1998, (Gg)

Year	CO_2	CH_4	N_2O
1990	19,136	268,4	0,1
1991	15,705	262,3	0,1
1992	13,511	259,4	0,1
1993	11,990	251,4	0,1
1994	9,064	269,1	0,1
1995	7,853	289,3	0,1
1996	8,305	299.5	0.1
1997	8,527	313.5	0.1
1998	8,729	325.7	0.1

Table 2.3. Net GHG emissions in CO_2-equivalent (Gg)

Years	CO_2		CH_4		N_2O		Total
	CO_2 - equivalent net emis.	Percentage of total CO_2 eq. emission	CO_2 - equivalent net emis.	Percentage of total CO_2 - eq. emission	CO_2 - equivalent net emis.	Percentage of total CO_2 eq. emission	
GWP	1		21		310		
1990	19,136	77.2	5,636.4	22.7	31.0	0.1	**24,803.4**
1991	15,705	73.9	5,508.3	25.9	31.0	0.2	**21,244.3**
1992	13,511	71.1	5,447.4	28.7	31.0	0.2	**18,989.4**
1993	11,990	69.3	5,279.4	30.5	31.0	0.2	**17,300.4**
1994	9,064	61.4	5,651.1	38.4	31.0	0.2	**14,746.1**
1995	7,853	56.2	6,075.3	43.6	31.0	0.2	**13,959.3**
1996	8,305	56.8	6,289.5	43.0	31.0	0.2	**14,625.7**
1997	8,527	56.3	6,583.5	43.5	31.0	0.2	**15,141.1**
1998	8,729	56.0	6,839.7	43.8	31.0	0.2	**15,599.9**

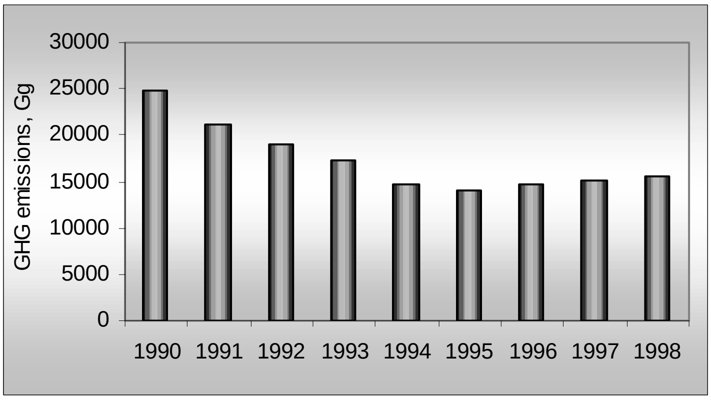

Figure 2.1. Net emissions of GHG in CO_2-equivalents

Even though Mongolia's total GHG emissions is relatively very low, the annual per capita emission of GHG in CO_2-equivalent is relatively high compared to other countries. This phenomenon can be explained by the fact that the country has a very low population (2.4 million) that nevertheless requires very high heating for a long duration of time (9 months a year). Mongolia's population growth and changes in per capita emission of GHG in CO_2-equivalent for the period 1990-1998 are shown in Figure 2.2.

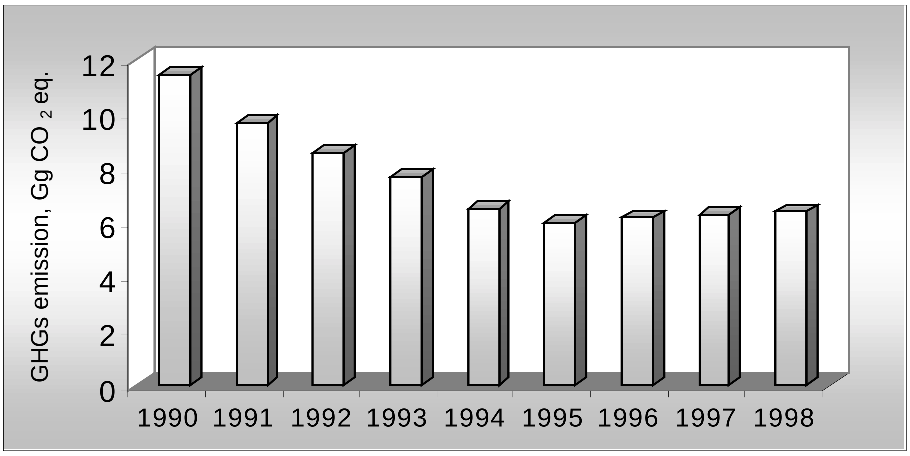

Figure 2.2. Dynamics of per capita emissions of GHG, Gg CO_2-equivalent

Consistent with global trends, the energy-related sector is the largest contributor of GHG emissions in Mongolia. GHG emissions by sector/source are presented in Figure 2.3.

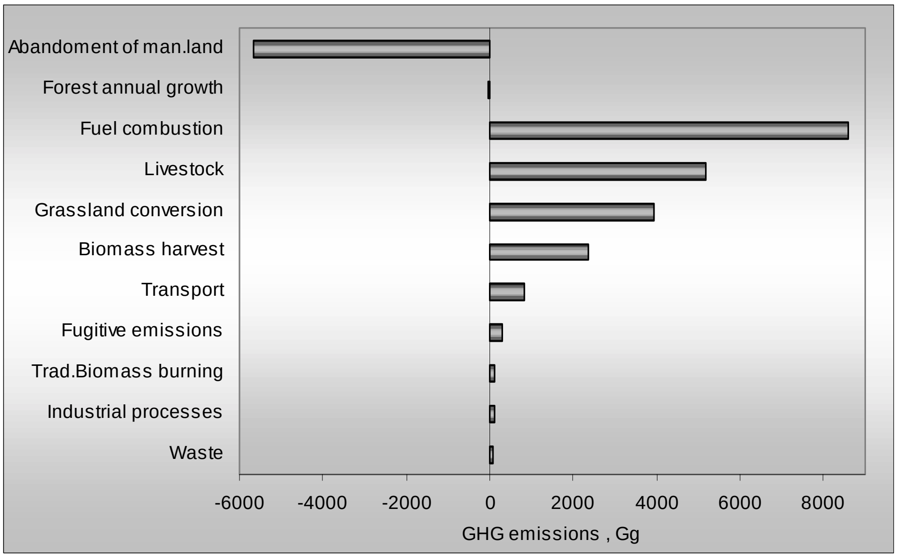

Figure 2.3 The GHG emissions by sector/source for 1994

2.3.2. Emissions of CO_2

Total emissions of CO_2 in Mongolia reached 9,064 Gg in the base year 1994, representing a decrease of 10,072 Gg from 1990 emission levels. CO_2 emissions have been increasing since 1996, reached 8,729 Gg in 1998. The removals are increasing constantly. The removal in 1990 was 9.9% of total emissions and it increased till 39.4% and 44.7% in 1994 and 1998, respectively. The summary of CO_2 emissions and removals are provided in Table 4.4.

Fossil fuel combustion is the largest source of CO_2 emissions in Mongolia, accounting for about 60% of all emissions. The second largest source is conversion of grasslands for cultivation (20-27%). Emissions from industrial processes account for less than 1% of all emissions. The sectoral distribution of carbon dioxide for 1994 is shown in Figure 2.4: sectoral distribution has not exhibited significant change during the study period.

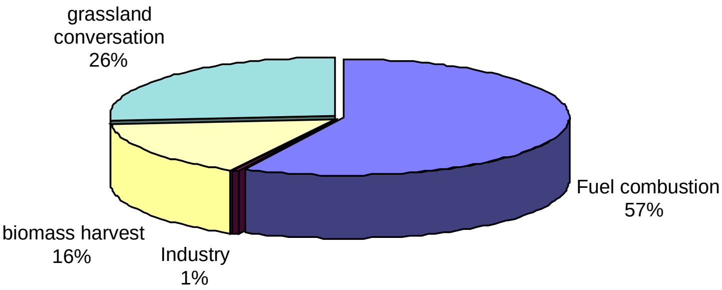

Figure 2.4 CO_2 emissions by sector for 1994

Table 2.4. CO_2 emission and removal, 1990-1998, (Gg)

Categories	1990		1991		1992		1993		1994		1995		1996		1997		1998	
	E/R	%	E/R	%	E/R	%	E/R	%	E/R	%	E/R	%	E/R	%	E/R	%	E/R	%
Emission																		
1.Energy: Combustion	13,349	62.8	11,968	63.0	10,410	60.1	9,832	58.7	8,570	57.3	8,046	56.4	8,883	57.9	9,210	59.2	8,963	56.82
2.Industry	301	1.4	173	0.9	119	0.7	81.2	0.5	95.0	0.6	95.0	0.7	95.7	0.6	100.8	0.6	98.1	0.62
3.Forests: Biomass harvest	3,234	15.2	2,527	13.3	2,461	14.2	2,462	14.7	2,359	15.8	2,195	15.4	2,696	17.6	2,486	16.0	2,828	16.93
4.Grassland Conversion	4,363	20.6	4,325	22.8	4,325	25.0	4,376	26.1	3,940	26.3	3,940	27.5	3,665	23.0	3,768	24.2	3,884	24.62
Total emission	**21,247**	**100.0**	**18,993**	**100.0**	**17,315**	**100.0**	**16,751**	**100**	**14,964**	**100.0**	**14,276**	**100.0**	**15,340**	**100**	**15,566**	**100**	**15,774**	**100**
Removal																		
1.Forests: Annual Growth	-202	9.6	-208	6.3	-214	5.6	-219	4.6	-224	3.8	-229	3.6	-233	3.3	-237	3.4	-243	3.5
2.Abandonment of Managed Lands	-1,909	90.4	-3,080	93.4	-3,590	94.4	-4,543	95.4	-5,675	96.2	-6,193	96.4	-6,802	96.7	-6,802	96.6	-6802	96.5
Total removal	**-2,111**	**100.0**	**-3,288**	**100.0**	**-3,804**	**100.0**	**-4,762**	**100**	**-5,899**	**100.0**	**-6,422**	**100.0**	**-7035**	**100**	**-7,039**	**100**	**-7045**	**100**
Net emission	**19,136**		**15,705**		**13,511**		**11,990**		**9,064**		**7,853**		**8,305**		**8,527**		**8,729**	

Note: E/R- Emission and Removal
% - Percentage of total emission and removal

2.3.3. Emissions of CH_4

Methane (CH_4) is the second largest emission of GHG in Mongolia. Since 1990, the amount of methane emissions has been increasing slightly (Table 2.5), as well as the percentage share in total emission, since 1990. Five sources of CH_4 were studied: *Traditional Biomass Fuel Combustion, Coal Mining, Livestock, Landfills, Wastewater.* During the study period, emissions from traditional biomass fuel combustion and livestock were observed to increase, while those from other sources remained almost the same.

The single largest source of CH_4 is livestock herding. Methane emission from this sector accounts for about 90-93% of total emission.

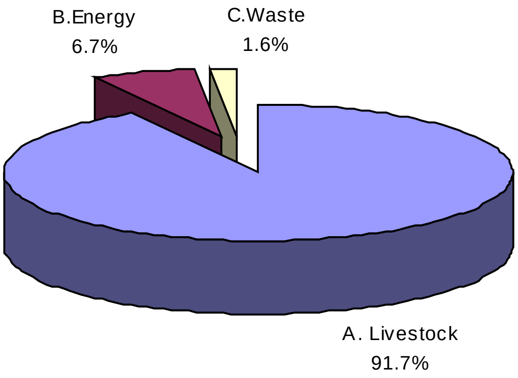

Figure 2.5. Methane emissions by sectors, 1994

Table 2.5. Methane emissions, (Gg)

Year		Traditional biomass fuel combustion	Coal Mining	*Livestock*	Landfills	Wastewater	Total
1990	emission	11.4	9.3	243.5	3.4	0.8	**268.4**
	%	*4.2*	*3.5*	*90.7*	*1.3*	*0.3*	
1991	emission	10.9	8.4	238.8	3.5	0.7	**262.3**
	%	*4.2*	*3.2*	*91*	*1.3*	*0.3*	
1992	emission	12.1	6.6	236.3	3.5	0.8	**259.4**
	%	*4.7*	*2.5*	*91.1*	*1.4*	*0.3*	
1993	emission	12.3	5.5	229.2	3.5	0.9	**251.3**
	%	*4.9*	*2.2*	*91.2*	*1.4*	*0.3*	
1994	emission	13.1	4.8	246.9	3.4	0.8	**269.1**
	%	*4.9*	*1.8*	*91.7*	*1.3*	*0.3*	
1995	emission	13.3	4.6	267.2	3.5	0.9	**289.3**
	%	*4.6*	*1.6*	*92.3*	*1.2*	*0.3*	
1996	emission	14.4	4.4	276.4	3.4	0.9	**299.5**
	%	*4.8*	*1.4*	*92.3*	*1.1*	*0.3*	

1997	emission	14.5	4.6	290.2	3.4	0.8	**313.5**
	%	*4.6*	*1.5*	*92.6*	*1.1*	*0.3*	
1998	emission	14.7	4.6	302	3.5	0.8	**325.7**
	%	*4.5*	*1.4*	*93*	*1.1*	*0.2*	

2.3.4. Emissions of other gases

Emissions of nitrous oxide (N_2O), nitrogen oxides (NO_X) and carbon monoxide (CO) occur largely from biomass burning, such as traditional biomass fuel combustion in cook stoves. Emissions of gases from this source are shown in Table 2.5. Other activities that could emit these gases, such as savanna burning or the burning of agricultural residues, are not applicable for Mongolia. Accidental forest fires, largely human induced, do significantly contribute to these emissions in Mongolia.

Total emissions of these gases from biomass fuel burning have increased slowly over the period from 1990 to 1998, as shown in Table 4.6.

Table 2.6. N_2O, NO_X, CO emissions, 1990-1998, (Gg)

GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO_X	2.3	2.3	2.5	2.5	2.6	2.7	2.9	2.96	2.98
CO	80.9	79.2	86.7	87.8	93.1	94.5	102.1	103.8	104.8

2.4. Greenhouse Gas Emission by Sources

2.4.1. Emissions from Energy

The Energy sector is the largest contributor to GHG emissions in Mongolia. Activities in this sector include fuel combustion at Power and Heat Plants (PHP), coal production (mining and post-mining activities such as transportation and storage), and coal and biomass combustion in private houses (stoves) for heating purposes.

The Energy sector produces around 60% of the country's CO_2 and 6-7% of methane emissions. GHG emissions in CO_2 -equivalent from the energy sector are given in Table 2.7, emissions contributions from different enterprises in energy and transport sectors are shown in Figure 2.6.

Table 2.7 GHG emissions in CO_2 -equivalent from energy sector, (Gg)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fuel combustion at PHP	13,349	11,968	10,410	9,832	8,570	8,046	8,318	9,224	9,962
Traditional Biomass Burning	270.4	259.9	285.1	289.3	306.1	310.3	302.4	305.1	308.3
Coal mining	195.3	176.4	138.6	115.5	100.8	96.6	92.4	96.6	97.2
Total	13,815	12,404	10,834	10,237	8,977	8,453	8,713	9,626	10,368

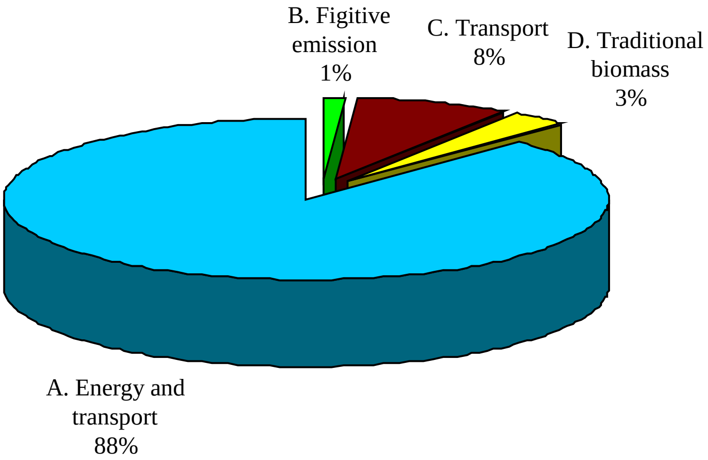

Figure 2.6 GHG emissions share of different activities in energy sector, 1994

Fuel Combustion: The main type of fossil fuel used in Mongolia is coal. Ninety per cent of all mined coal is burned at the PHP; the remaining 10% is consumed in private homes. Natural gas is neither produced in Mongolia nor imported for domestic consumption. Oil products (kerosene, gasoline, etc.) are imported and used for transport and at PHP. Combustion of fossil fuels is the greatest source of carbon dioxide in Mongolia. Emissions from mobile sources were accounted in the energy sector as the combustion of petroleum products (Table 2.8).

Table 2.8 CO_2 emissions from combustion of petroleum products, (Gg)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998
Transportation	3,144	1,284	997.1	1,317	814.4	792.6	2030	2006	2116

According to IPCC methodology, emissions from international aviation (bunkers) are not to be included in national totals of CO_2 but reported separately (See Table 2.9). Emissions in this sector have increased since 1996 due to new opened airways to Japan, Korea and Germany.

Table 2.9. Emissions from International bunkers, (Gg)

Fuel type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Jet kerosene	30.99	33.42	49.43	52.39	47.66	47.66	63.7	73.2	64.4

Traditional Biomass Burning: Traditional biomass fuel (fuelwood, dung) is almost entire limited to combustion in cook-stoves, and thus emissions of non-CO_2 greenhouse gases have been estimated for such traditional biomass burning. Other possible biomass burning activities, such as the burning of agricultural residues or on-site burning of cleared forests, are not applicable for Mongolia. Emissions of carbon dioxide from the burning of biomass for energy purposes is reported separately but not included in the national carbon dioxide total as recommended IPCC so as to avoid double-counting with emissions estimated in the Land Use and Forestry sector.

Fugitive emissions: Because methane gases are often released during coal mining activities, coal mining and post-mining activities. However, these emissions are not significant compared to methane emissions from agriculture, comprising only 1.6-3.5% of all methane emissions.

2.4.2. Emissions from Industrial processes

Known emissions—that is, missions resulting directly from a production process, but not as a result of energy consumed during the process--are often created as a by-product of various non-energy related activities The production processes studied in this sector are cement and lime production, since other industrial activities that do emit GHG as part of the production process, such as inorganic or organic chemicals (nitric or adipic acids, fertilizers, etc.), are not present in the Mongolian economy. Total GHG emissions in CO_2-equivalent from cement and lime processing are given in Table 2.10.

Table 2.10 GHG emissions in CO_2 -equivalent from cement and lime processing, (Gg)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cement production	219.7	113.1	66.1	41.0	42.8	54.2	52.8	55.6	54.3
Lime production	80.9	59.9	53.2	40.2	52.1	40.4	42.9	45.2	43.8
Total	**300.6**	**173.0**	**119.3**	**81.2**	**94.9**	**94.6**	**95.7**	**100.8**	**98.1**

Emissions from this sector exhibited a sharp decrease since 1990 because of the decline of the cement industry; subsequent economic recovery after 1994 also effected a slight, steady increase in cement production-related emissions.

2.4.3. Emissions from Agriculture

The GHG inventory includes emissions from enteric fermentation and manure management in domestic animals. Enteric fermentation in domestic livestock is a major source of methane in Mongolia, accounting for 90-93% of total country's methane emissions. However, the total methane emission from Mongolian livestock is very low compared to other countries. Since Mongolia's livestock husbandry practices use mainly indigenous breeds with low productivity and small body size, they do not have the same impacts as industrial dairy, pig and poultry production. Additionally, almost all manure is managed on pasture and low crop production ensures there is almost no practice of open burning of agriculture residues

According to estimates, methane emissions from agriculture decreased by 1-3% per year from 1990-1993, increased by 7-8% in 1994-1995, and by 4% in 1996-1998. This emission pattern mirrors the change in livestock numbers over the same period.

2.4.4 Emissions from Land Use Change and Forestry

This segment of the inventory includes emissions and uptake of GHG from sources of forest and other woody biomass stocks, forest and grassland conversion to cultivated land, and abandonment of managed lands.

According to the estimates, the emissions from Land Use Change and Forestry decreased sharply during the study period because of a clear decline in the total volume of forest logging and forest areas burnt. At the same time, the removal was increasing constantly in the period 1990-1998. This is mostly due to a drastic increase in the abandonment of managed land.

Changes in Forests and other Woody Biomass Stocks: About 8.1% of Mongolia's territory is covered by forests. Anthropogenic influences on forests include both the cutting and planting of trees, and particularly, the clearing or conversion of forest into cropland in Mongolia. In 1990, 1,415 thousand cubic meters of roundwood were logged by commercial harvest while 4,401.5 ha was afforestated. In 1998, the commercial harvest fell to 711.2 thousand cubic meters of roundwood, and the afforested area increased to 5,299.6 ha. Thus, forest removal increased the emission from 202 Gg of CO_2 in 1990 and to 242.7 Gg of CO_2 in 1998.

Grassland Conversion: The practice of land cultivation for agricultural purposes in Mongolia is relatively recent. Mongolia began to cultivate land only after 1958 by converting grasslands into cropland. The area of arable land continued to increase until the end of 1980s, with a total of 1,400 kha of grasslands converted between 1958 and 1990. This conversion of grasslands to cultivated land produced the second largest emission source of $CO_{2,}$ and represents 20.6-27.85% of total emission (Table 2.4).

Abandoned Lands: Abandonment of cultivated lands has accelerated recently, as marginal lands have been taken out of production during economic crises. About 140 thousand hectares of land have been abandoned during the last 25 years. These abandoned lands slowly revert back to grasslands. Our estimates show that removals due to abandonment of lands increased from 1,909 kt of CO_2 (9% of total emission) in 1990 to 6,803 kt of CO_2 (43% of total emission) in 1998, a total of 90-96% of CO_2 removals. However, the use of the IPCC default coefficients likely introduces some uncertainty into these estimates.

Forest and Steppe Fires: Forest and steppe fires are large sources of GHG emissions in Mongolia, but according to the IPCC GHG Inventory methodology, there is no distinction between anthropogenically- and naturally-inducted forest fires. Lack of precipitation and dry, windy weather conditions in spring and fall create the preconditions for fires in Mongolia, but human carelessness is the primary catalyst of accidental forest and steppe fires. The area of burned forests depends on annual climatic conditions, and varies significantly. For example, there were 101 forest fires in 1992 in which 1,668.4 thousand ha was burned, while there were 219 forest fires in 1997 in which 16,201.4 thousand ha was burned. This is about 10 times larger than in 1992. The IPCC methodology for calculating emissions from the on-site burning of forests is used for estimation emissions from forest and steppe fires.

Emissions from forest and steppe fires are summarised in Table 2.11 and represent up to 72% of total CO_2 emissions. However, as noted above, they have not been included in the total national emissions, as per the IPCC guidelines. If forest and steppe fires were included as an anthropogenic source it would be the most significant carbon dioxide source in Mongolia. As an example, the GHG emissions from forest and steppe fires for the period 1990-1995 are given in Table 2.11.

Table 2.11. Emissions of GHG from forest fires, 1990-1995, (Gg)

Years	CO_2	CH_4	N_2O	NO_X	CO
1990	15,444	67.4	0.5	16.8	589.7
1991	1,521	6.6	0.1	1.7	58.1
1992	9,290	40.5	0.3	10.1	354.7
1993	4,871	21.3	0.2	5.3	186.0
1994	2,804	12.2	0.1	3.0	107.0
1995	808	3.5	0.0	0.9	30.8

2.4.5. Emissions from Waste

The inventory of GHG emissions from the waste sector was produced according to the IPCC GHG methodology. Estimated methane emissions from the land disposal of solid waste and the treatment of domestic, commercial and industrial wastewater are shown in Table 2.12.

Table 2.12 GHG emissions equivalent in CO_2 from waste, (Gg)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998
Landfills	71.4	73.5	73.5	73.5	71.4	73.5	71.4	71.4	73.5
Wastewater Treatment	16.8	14.7	16.8	18.9	16.8	18.9	18.9	16.8	16.8
Total	**88.2**	**88.2**	**90.3**	**92.4**	**88.2**	**92.4**	**90.3**	**88.2**	**90.3**

Landfills: Waste recycling is not carried out on a significant scale in Mongolia; nor is methane recovery practiced. There are no statistics on waste quantities and specific management practices; therefore, the amount of landfilled waste and the volume of emissions from landfills are estimated based on the IPCC methodology for urban populations using default solid waste generation rates for developing countries as a starting point. However, two adjustments were made to these values to more accurately reflect the conditions in Mongolia. First, the IPCC default assumption was that 80% of urban wastes are landfilled, a value which seemed very high for Mongolia, particularly given the prevalence of open dumping and the tendency to burn waste in the open. Therefore, this assumption was reduced to 40% of all urban waste. Secondly, the landfilled methane generation rate was taken as 50% for the country.

Wastewater Treatment: Emissions from industrial, domestic, and municipal wastewater treatment were estimated according to the IPCC Guidelines, which rely on estimates of the urban population and other default values. One major adjustment was made to the Biological Oxygen Demand factor for the wastewater (0.0004 kg/l), which was specified based on the results of research conducted in Mongolia.

CHAPTER 3 GREEN HOUSE GAS MITIGATION ISSUES

3.1 Introduction

Under the UNFCCC, Parties to the Convention make a commitment to develop national programs and policy measures to respond to climate change. One of the key responses that countries can make is to implement measures to reduce atmospheric accumulation of GHG.

In compliance with this UNFCCC commitment, Mongolia conducted a mitigation analysis to: (1) provide policy makers with an evaluation of technologies and practices that can both mitigate climate change and contribute to national development objectives, and (2) identify policies and programmes that could enhance their adoption.

Potential options and opportunities for GHG emissions mitigation in Mongolia were identified in the course of preparation of the Initial National Communication, between 1998 and 2000. These mitigation options were identified according to case studies, analysis of results of the GHG emissions inventory, and its projection up to 2020 (Greenhouse Gases Mitigation Potentials in Mongolia, 2000; ALGAS Mongolia 1998; USCSP Report, 1996).

According to the GHG inventory, its share in the national total emissions accounted for 56% in 1990, and is expected to exceed 90% by 2020 (ALGAS, 1998). The result of analysis shows that the country's primary source of GHG emissions mitigation is the energy sector. Thus, in preparing mitigation strategies, Mongolia has given the most attention to reducing emissions in the energy sector. Because there will likely be some lag time between the implementation of the measures and the appearance of their effects, the mitigation assessment for the energy sector focused on long-term policies for reducing GHG emissions.

3.2 Greenhouse Gases Emissions Projections

3.2.1 Energy

The Baseline Projection of CO_2 emissions from the energy sector was calculated using MEDEE/S-ENV (demand side) and EFOM-ENV (supply side) models. These models were used to obtain a Business-As-Usual (BAU) Projection of CO_2 emissions for the energy sector. The BAU, or base case projection of energy demand, was estimated as the highest energy demand based only on expected economic development. No consideration was made for any energy saving policies or environmental protection measures that might be implemented. The CO_2 emissions projection by sector is shown in Table 3.1. As this table demonstrates, the transport sector, producing 50% of the demand total emissions, is the largest emitter of CO_2, followed by the industry and household sectors with 26% and 12% respectively. Because of lack of the data needed to complete MEDEE/S-ENV and EFOM-ENV models, the year of 1993 was taken as the base year for the mitigation analysis, which differs from the inventory base year.

According to the results of modeling final energy demand, CO_2 emission is projected to reach 40,571 Gg by 2020. This is approximately five times greater than the base year level of 8,344 Gg of CO_2.

The analysis of GHG emissions by fuel type for the period 1993-2020 indicates that coal will be the predominant source of CO_2 emissions. Coal consumption is shown to increase as a result of expanding building material production, which is expected to increase about 9 times by 2020 from its 1993 base year value.

CO_2 emissions from burning diesel oil are shown to increase 2.6 times by the year 2020, while gasoline is expected to increase 7 times. This growth is due to the expected expansion of motor fuel demand in the nonferrous sub sector, as well as overall growth of the transportation sector. Heat and electricity demand is expected to reach 6.8 and 10.4 times their base year levels by the year 2020. In terms of CO_2 emissions by sector, the industrial sector is the largest emitter, producing 50% of total emissions, followed by the transportation, service and household sectors with 22%, 20%, and 7%, respectively.

Table 3.1. Energy sector CO_2 emission projections, 1993-2020, Baseline scenario, (Gg)

	1993	2000	2010	2020
Heat and Power generation				
Combined Heat and Power plant (CHP)	3,601	5,154	9,440	23,529
Heat Only Boiler (HOB)	1,445	1,648	2,497	3,798
Diesel	101	117	186	266
Power generation, total	5,147	6,919	12,124	27,592
Demand sector				
Industry	962	785	1,367	3,316
Household	976	1,162	1,264	1,618
Service	-	-	-	-
Transport	1,132	1,329	3,261	7,332
Agriculture	127	198	343	712
Demand, total	3,197	3,475	6,236	12,978
Total	**8,344**	**10,394**	**18,360**	**40,571**

Source: Sustainable Development Scenarios for the 21 century of Mongolia using modeling methods, Ulaanbaatar, 1998.

According to the projection, CO_2 emissions from heat and electricity generation will be 6.5 times the base year level by the year 2020. In the energy supply sector, energy sources that do not emit GHG, such as hydropower, are expected to have a 2% share of the total electricity generation by 2020.

CO_2 emission projections under the Integrated Mitigation Scenario (IMS) are shown in Table 3.2. IMS is the integration of five alternative mitigation scenarios evaluated for their effectiveness in mitigating GHG emissions.

A comparison of results from the Base Case scenario and the IMS shows that the implementation of the mitigation scenario has the potential to reduce CO_2 emissions in the energy sector by an average of 25% per year during the period 2000-2020.

Table 3.2. CO_2 emission projections from energy sector, 1993-2020, Integrated Mitigation Scenario, (Gg)

Heat and Power generation	**1993**	**2000**	**2010**	**2020**
Combined Heat and Power plant (CHP)	3,601	3,284	5,252	14,004
Heat Only Boiler (HOB)	1,445	1,563	2,400	3,669
Mine Month Power Plant (MMPP)	-	-	388	388
Diesel	101	114	170	250
Heat and Power generation, total	**5,147**	**4,962**	**8,210**	**18,311**
Energy Demand	**3,197**	**3,038**	**5,408**	**10,720**
Total	**8,344**	**8,000**	**13,618**	**29,031**

Source: Sustainable Development Scenarios for the 21st century of Mongolia using modeling methods, Ulaanbaatar, 1998.

3.2.2 Forestry

Total GHG emissions projections up to the year 2020 from the forestry and land-use sector are given in Table 3.3. This table shows that net carbon and CO_2 emissions from these sectors are expected to change significantly in the twenty-year period. Since virgin forests are predominant in Mongolia, it is not surprising that the forestry and land-use sector is projected to act as a net sink for CO_2 in the period 1993-2020. The scale of forestry as a sink is, however, projected to decrease in 2020 due to urbanization and industrial development in the country. Strategies for reducing future GHG emissions should therefore pay special attention to maintaining the forestry sector.

Table 3.3. Forestry sector GHG Emission Projection

Module	**Net Emission/ (Gg of CO_2)**	
	1993	**2020**
Carbon uptake from changes in forest and other woody biomass stocks	– 3,720	– 592
Carbon emissions from forest and grassland conversions	+ 1,796	+ 2,156
Carbon uptake in abandonment of managed lands	–1,211	– 2,552
Net CO_2 emissions from forestry sector	– 3,135	– 988

3.2.3 Agriculture

The CH_4 emission projection for the agriculture sector was based only on livestock growth projections and emission factors. Table 5.4 shows expected trends in emission from 1993 to 2020.

Table 3.4 Agricultural sector GHG Emissions Projections

	1993	2000	2010	2020
CH_4 Emissions from Livestock, Gg	229	294	344	401

3.3. GHG Mitigation Potentials

Although Mongolia's levels energy production and energy use is low compared to other developed countries, these levels remain the country's main source of air pollution and GHG emissions. The energy sector alone accounts for roughly 64% of Mongolia's GHG emissions. Today, over 250 steam boilers burn approximately 400,000 tonnes of coal every year. Even in urban areas, some 48% of the population live in *gers* (Mongolian traditional tent houses) or other buildings with manual heating which consume approximately 200,000 tonnes of coal and over 160,000 cubic meters of wood per year. During the cold seasons the atmospheric content of carbon monoxide exceeds the permissible level by 2-4 times. Therefore, methods of energy production, energy use, and efficiency must change dramatically.

Stabilization of GHG concentrations in the atmosphere will require substantial and rapid changes in the world's energy systems and technologies in order to reduce future emission rates. Reduction of CO_2 emissions depends on the development of conversion technologies and efficiency, and on fuel characteristics. Hence, mitigation options considered in the assessment to reduce CO_2 emissions can be grouped into two categories: (i) energy conservation or efficiency improvements, and (ii) replacing carbon-intensive energy sources with less carbon-intensive sources.

The mitigation assessment for Mongolia is based mainly on pre-feasibility case studies of different aspects of energy and non-energy sectors. The mitigation analyses include industrial processing, fossil fuels, renewable energy, thermal power plants, medium- and small-scale energy conversion, district heating, the built environment and transportation, and non-energy sectors such as waste management and forestry.

3.4. Mitigation Options

3.4.1 Energy Supply Sector

The combined effects of a cold continental climate and reliance on fuels such as wood and low-energy domestic coal contribute to a high rate of carbon dioxide (CO_2) release per capita from the energy sector. This rate shows signs of worsening: according to current estimates of population and economic growth rates, Mongolia can expect a three-fold increase in energy demand by the year 2020, along with the resultant increases in CO_2.

The mitigation options analyzed in the energy supply sector are focused on:

- Fossil fuels
- Combined Heat and Power Plants
- Medium and Small scale energy conservation

- Renewable energy

The main criteria used to select GHG mitigation options or measures for the current case study were as follows:

- Possibilities for integration with national and sectoral development plans and sustainable programs
- The availability of resources, including possible foreign assistance and investments
- Technical potential to mitigate emissions
- Implementation feasibility
- Cost-effectiveness

These criteria are consistent with existing national policies, and with other projects being developed that are related to climate change issues. The case studies have been prepared to gain more insight into:

- The potential of the option: possibilities for replication in Mongolia
- The financial feasibility (at the pre-investment level)
- The GHG mitigation cost (US$ per tonne of avoided CO_2)
- The institutional setting: who are the potential project sponsors in charge of implementation? Which actors are likely to win or to lose?
- The implementation barriers. What are the barriers? What measures should be taken? By whom? Which government institutions can facilitate the implementation and how?
- The financing requirements and possible financing sources

Selected GHG mitigation options for each energy supply sector are described below.

Fossil fuels

Coal is the primary energy source in Mongolia at present, accounting for about 95% of total solid fuel consumption. Because the vast coal reserves of Mongolia dwarf its oil, gas, and other energy sources, coal is expected to remain the primary energy source in the foreseeable future. Suitable geological conditions make open cast mining the most economically feasible method of recovery in Mongolia. This technique has been progressively developing in Mongolia since the 1960s, and is now used to recover more than 90% of the country's coal from shallow depth mines.

In 1998, total coal production was 5,6 milllion tonnes; according to various projections, total coal demand in Mongolia is expected to exceed 7 -8 million tonnes by 2005. The large-scale Baga nuur, Sharyn gol and Shivee-Ovoo coal mines provide all of the coal used by thermal power plants in the central region to supply the country's main industries and most of the small consumers in the main urban centers. Smaller coal mines in the various provinces of the country provide the energy source for local heat systems and local consumers. Over half of total coal production is used to generate electric power with the remainder supplying central heating plants, industry, and individual households.

GHG emissions from coal mining*:* A variety of GHG emisisons sources are associated with coal mining and post-mining activities, including coal transportation, processing and utilization. For example, as coal seams are fractured during miing, methane is released because the increased surface area allows more CH_4 to desorb from the coal.

At present, a detailed calculation of CH_4 emissions for Mongolian coal mines and coal deposits is not possible, as coal gas investigations have not yet been conducted. Only data for the Nalaikh coal deposit was available, reporting CH_4 and CO_2 contents at 5 m^3/tonne and 4.5 m^3 /tonne, respectively.

Judging from general geological conditions, the present mining situation and Mongolian coal characteristics, fugitive CH_4 emissions at Mongolian coal mines are relatively moderate. According to world experiences, GHG emission from coal mining activities is estimated at 7% of total emissions stemming from coal production and use.

Mitigation options: Mongolia's present coal supply system does not provide for coal quality control and preparation systems at mine sites. Only operations for coal mining and long distance delivery to consumers exists. About 70% of all coal produced in Mongolia is transported more than 150 km by railway from mine mouth to consumer.

Coal quality often does not meet the minimum standard requirements, because rock and inert matter is not properly screened out of the mined coal. In many cases, such contaminated coal causes emergency situations at the thermal power plants. Better quality control at mine sites and installation of 'selective' crushers and screening equipment is recommended to reduce the amount of contaminated material transported to the power stations. Meanwhile, better management of mine drainage systems is necessary to reduce the moisture content of the coal. Mongolia would do well to follow the example of many countries around the world that use coal-washing technology at the mine site.

In addition, the implementation of Clean Coal Technology is imperative in Mongolia. This technology will not only result in reduction of global CO_2 emissions, but will also have local benefits, such as the reduction of ash disposal in residential areas, the decrease of SO_x emissions, and the improvement of coal transportation efficiency. Practical, cost-effective measures which can improve the coal quality of open pit mines include the following:

- *Effective dewatering systems*
- *Coal handling plants (or coal washing plants)*
- *Selective mining, rock separation and other mine planning and operation options*

Coal briquetting technology is also an efficient way to save coal and reduce air pollution. This technology has a relatively high potential for emission reduction.

Combined Heat and Power Plants

The existing power sector of Mongolia consists of the Central Energy System (CES) with five coal-fired Combined Heat and Power Plant (CHP) and 18 provincial enterprises that operate isolated energy systems. Overall, the power sector of Mongolia has a net installed capacity of about 1,066.0 MW, but its firm capacity was only 65% in 1994. Extraction and condensing type of turbines are used in the CHP. Part of the steam is extracted from the turbines for meeting heat requirements (steam and hot water).

Figures for 1998 indicate that the CHP's own use for electricity was 22.3% and for heat production was around 15%. Transmission and distribution losses were approximately 12%. Total CO_2 emissions by the CHP sector in 1998 amounted to 6,372 Gg. Therefore, CHPs contribute significantly to total national GHG emissions. Hence the reduction of the CHPs own use should be seriously examined for greenhouse gas mitigation.

Energy use and GHG emissions: The energy sector is Mongolia's largest GHG emission source; within this sector, the CHP subsector is the largest contributor, generating some 70.6% of the total net emissions of CO_2-equivalent in the energy sector. Projections for future fuel types indicate that coal will continue to be the country's main fuel source.

Mitigation options: The efficiency of the CHPs in Mongolia is low, especially because internal electricity use is very high (about 20-24% of the gross generation). The main culprit is low-quality coal, which necessitates relatively long coal mill operating hours and losses in the pipelines, increasing the amount of electricity needed to pressurize pumps and other low-efficiency electrical motors. Mitigation options in these power plants include:

- *Rehabilitation and refurbishment of existing CHPs*
- *Automation of internal heating*

However, these options have a low CO_2 emission reduction potential compared to other mitigation options. The estimation of specific mitigation costs for selected technology and power plants is shown in Table 3.5.

Table 3.5 CO_2 emission reduction potential and Specific Mitigation Costs (SMC)

Name of CHP	Technology option	CO_2 emission reduction, tonne/year	Cost of saved energy[1] thous. US$/year	NPV[2] thous. US$	SMC[3] US$/tonne CO_2
Ulaan-Baabar CHP No2	2x35* boilers rehabilitation	9,000	40.2	2,694	20
	2x75 boilers refurbishment	8,500	37.2	6,717	53
	Automation of plant internal heating	200	0.9	113	38
	Average for the plant	17,700	78.3	9,524	37
Ulaan-baabar CHP No3	2x220 boilers rehabilitation	28,300	124.2	19,055	45
	6x75 boilers refurbishment	15,000	66.6	19,493	87
	Automation of plant internal heating	1,600	7.2	945	33
	Average for the plant	44,900	198.0	39,494	59
Ulaan-baabar CHP No 4	4x420 boilers rehabilitation	25,500	111.6	54,157	142
	4x420 boilers refurbishment	10,500	45.6	19,615	125
	Automation of plant internal heating	1,700	7.2	1,145	45
	Average for the plant	37,700	164.4	74,940	133
Darkhan CHP	9x75 boilers rehabilitation	28,100	123.0	29,064	69
	6x75 boilers refurbishment	18,600	81.6	11,379	41
	Automation of plant internal heating	1,000	4.8	663	44

	Average for the plant	47,700	209.4	41,107	57
Erdenet CHP	7x75 boilers rehabilitation	27,200	121.8	24,225	59
	7x75 boilers refurbishment	7,700	34.5	14,600	128
	Automation of plant internal heating	400	1.8	285	64
	Average for the plant	28,700	128.5	39,110	74
Choibalsan CHP	3x35 boilers refurbishment	7,600	33.5	4,600	41
	Automation of plant internal heating	700	3.1	249	24
	Average for the plant	8,300	36.6	4,490	39

[*] Two boilers with capacity 35 tonne/hour steam each.

*[1] (9000*6)/(1.36*1000)=40.2 (Cost of coal is assumed 6 US$/ton)*

[2] Calculated by standard module (Discount rate is 10%)

*[3] 2694/(15*9000)=20 (Lifetime is 15 years) Specific Mitigation Costs (SMC) are costs per ton of CO_2 mitigated.*

Both the net present values (discount rate 10%) and the specific mitigation costs are highly positive in all cases. This implies that the implementation costs will be much higher than the benefits of the energy saved. Thus, implementation of the above mentioned options will invoke large net economic costs and will contribute only relatively small amounts of total GHG mitigation, on an average of 185,000 tonne CO_2 per year. From an economic point of view, none of the considered mitigation options in the CHP sub sector should be selected.

Medium and Small Scale energy conservation

In areas without centralized district heating systems fed by CHPs and Heat Plants, small boilers and simple furnaces are used as stand-alone heating sources. The average load of the steam boilers is 25-30 MW, and the average annual coal consumption is between 20 and 25 thousand tonnes. Currently, these boilers operate now at 30% of their maximum capacity. Meanwhile, the cost of heating increases every year.

Small heat boilers use 2.2 million tonnes (30%) of coal annually for heating in over 340 residential areas all over the country. A typical boiler in a provincial administrative unit uses 800-1200 tonnes of coal a year with a maximum load of 0.8-1.2 MW. Such boilers provide heating for schools, hospitals, kindergartens and other public institutions. The heating efficiency is quite low (40-50%) because of the outdated, inefficient design of the buildings.

Individual households use between 4 and 2.5 tonnes of coal and wood annually, producing 30 GJ of heat for heating and cooking. Their efficiencies are only 25-35%.

Mitigation options: Some independent study results show that the efficiency of the boilers and furnaces stands to be increased by 75-80% by improving their performance, and by simply retrofitting or replacing them with modern types. The mitigation options identified in this category are:

- Convert steam boilers into small capacity thermal power plants (5x10 MW)
- Change in design, introduction of modern technology (12x25 MW)
- Install electric boilers (40x1MW)
- Install new high efficiency boilers (260x1 MW)
- Modernize stoves and furnaces

This option is highly feasible in Mongolia. The Government of Mongolia has a policy to encourage energy and resource conservation. The resultant emissions reduction would be substantial, and local benefits may be significant as well. The specific mitigation costs of small- and medium-scale energy conversion options are given in Table 3.6.

Table 3.6 Specific mitigation costs of small- and medium-scale energy conversion options

	Medium sized steam boilers		Small sized heat boilers		Household stoves and furnaces
Options	converting steam boilers into small capacity thermal power plant (5x10MW)	Change in design, Introduction of modern technology (12x25MW)	Install electric boilers, 40x1MW	Install new boilers with high efficiency, (260x1MW)	Modernization, (250 000 stoves and furnaces)
Annual economy of coal consumption, tonne / year (Q=14500 kJ/ kg)	+12,500	-69,000	-39,200	-260,000	-287,000
Annual economy of other fuel, tonne/ year	-15,000	-	-	-	-250,000
Saving money of fuel, thous. US$/ year	18,000	1,450	820.0	5,460	9,870
Investment, thousand, US$	55,000	6,000	2,000	8,800	18,800
NPV , thous, US$	-42,600	+503.0	-1,108	-11,900	-18,300
Reduction of CO_2 emissions '000 tonne / year	190.0	91.0	54.6	340.0	920.0
Estimation of specific mitigation costs CO_2, US$ / tonne CO_2	-4.50	+1.11	-4.0	-7.0	-4.0
Operation time without additional investment cost (life time), year	8	5	5	5	5

Source: Calculated results

Renewable energy

Renewable energy resources: It is increasingly important that environmentally clean renewable resources such as solar, wind, and hydro energy are used instead of coal, oil and organic fuels. Mongolia is located in a region with abundant sunshine, receiving an average of 2,250 to 3,300 hours each year. It is estimated that the southern part of the country receives a daily average of radiation between 4.3-4.7 kWh/m^2/day. The distribution of average solar radiation on Mongolia is as follows:

- above 1600 kWh/m^2 - 17%,
- 1400-1600 kWh/m^2 - 25%,
- 1200-1400 kWh/m^2 - 51%,
- below 1200 kWh/m^2 - 7%.

The total annual radiation intensity equals $2.2*10^{12}$ MW in Mongolia. There are more than 130 meteorological stations, which have systematically observed the wind speed and direction for at least 15 years. About 28% of the Mongolian territory has wind speeds above 4 m/s (150 w/m^2), 32.3% has wind speeds between 2-4 m/s (100-50 w/m^2), and 10.5% has wind speeds lower than 2m/s (50 w/m^2). Nowadays herdsmen use 3,500 transformable electric stations with 50-, 100- or 200-Watt capacity.

There are about 3,800 small rivers with a total length of 65 thousand km in Mongolia. The average annual flow is $3.46*10^{10}$ m^3 and the hydro energy potential is estimated at 6,200 MW. Mongolia's hydropower resources have not been fully investigated yet, but the fact that rivers are completely frozen for five to six months out of the year limits the potential hydro power generating period.

There are 43 geothermal sites in the Altai, Khangai and Khentii mountains where infrastructure is not yet developed. These areas are suitable for holiday homes, sanitariums and greenhouse heating.

Mitigation options: Wind generation and photovoltaics are the most attractive among renewable energy options. Establishment of small hydroelectric plants could also be important but is a relatively costly option. Broad introduction of renewable energy sources will not only help to mitigate GHG emissions, but will also increase the degree of electrification, especially in remote areas. CO_2 emission reduction potential and cost effectiveness for some identified renewable energy options are given in Table 3.7.

Table 3.7. CO_2 emission reduction potential and cost effectiveness of renewable energy options

	CO_2 emission reduction potential, KTN *	Investment cost, million US$	Cost effectiveness US$/ tonne CO_2**
Small hydropower development	1,467.0	232.5	10.3
Wind generator	359.0	30.9	2.4
PV Solar system	194.0	7.5	4.5

*Note: * cumulative emissions in projected period 1993-2020 based on EFOM model runs ** incremental cost*

Source: National report on Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS), Mongolia, Ulaanbaatar, 1998.

3.4.2 Energy Demand Sector

A number of options have been identified to reduce energy consumption in the three energy demand sectors: industry, the residential and service sector, and transport. In general, the identified demand side options show considerable CO_2 mitigation potential.

Industry

Energy use and GHG emissions*:* The industrial sector is one of the largest energy consumers, consuming about 70% of the electricity supply and 28% of the heat produced. Industrial enterprises are small in number but relatively large in production. For example, Erdenet Copper Mining Industry, which provided about 12% of total tax revenue and one-third of income tax revenue in Mongolia in 1997,accounts for about 36% of the country's electricity use and about 15% of the peak power demand.

According to the GHG inventory of 1990, the industry sector contributes 6% to the total CO_2 emissions. These emissions stem from direct and indirect (through energy companies) use of coal and diesel. If GHG emissions from the heat and electricity generation sectors were allocated to the other sectors in proportion to their share of electricity and heat allocation, the total emission generated by industries sector would rise from 6% to 23% (Table 3.8). The projection of CO_2 emissions of industries is given in Table 3.9.

Table 3.8. CO_2 Emissions by industry sector including heat and electricity share, 1990, Gg

Sectors	Indirect Use			Direct Use	TOTAL
	Heat	Electricity	Subtotal		
Total	6,804	2,542	9,346	4,264	13610
Industry	1,023	1,279	2,302	824	3,126
Industry, %	15%	50%	24.6%	19%	23 %

Source: Primary GHG Inventory Result, 1990, NTE Team Mongolia, ALGAS Project, 1997

Table 3.9 Projection of CO_2 emissions from industry including power and heat, Baseline Scenario, 1993-2020, Gg

	1993	2000	2010	2020
Power generation, total	5,147	6,920	12,124	27,592
Demand sector, total	3,197	3,475	6,232	12,978
Industry	962	785	1,367	3,316
Industry, % of total demand	30	22	22	26

Source: Sustainable Development Scenarios for the 21 century of Mongolia using modeling methods, Ulaanbaatar, 1998.

Mitigation options: The following GHG mitigation options (technologies) were selected on the basis of mitigation studies:

- *Motor efficiency improvements*
- *Good housekeeping of electricity and heat including energy management*
- *Steam saving technology (steam traps, heat recovery, pipe insulation*
- *Introducing dry processing in the cement industry*

The most attractive CO_2 emission reduction options are good housekeeping (including energy management), motor efficiency improvement and dry processing of cement. CO_2 emissions and reduction potential in selected options are given in Table 3.10.

Table 3.10. CO_2 mitigation potential for selected options

	Energy saving potential in 2020, GJ/year	Total system cost reduction* 1000 US$	Cumulative CO_2 emission reductions, ‘000 tonne	Specific mitigation cost, US$/tonne CO_2
Motor efficiency improvement	4,279.3	-7,473.0	5,540.0	-1.4
Steam saving technology (steam traps, heat recovery, pipe insulation)	791.4	-7,346.0	1,370.0	-5.4
Good housekeeping (including	2,989.6	-330,098.0	5,670.0	-58.2

energy management)				
Dry process of cement production	3,722.4	420.0	3,410.0	0.1
Total, average	11,782.7		15,990.0	

** Difference between total system costs of alternative scenario and baseline scenario*
Source: EFOM Model Run Result, May 1999.

Residential and Service Sectors/District Heating and Built Environment

Energy use and GHG emissions*:* District heating systems exist in all major cities and towns in Mongolia. The capital, Ulaanbaatar, with a population of 615,000, has three combined heat and power (CHP) plants. Ulaanbaatar is the coldest capital in the world with winter temperatures dropping as low as 40°C below zero requiring 7,655 degree-days[1] of heating (World Bank, 1998). About 1,800 non-residential buildings and 1,200 residential buildings with 45,000 apartments housing 260,000 people are connected to the district heating system. Around 70 industrial consumers receive steam through separate steam pipeline networks. Space heating is provided for seven months a year while hot water and steam are available throughout the year.

Currently, most households and about 30% of the service and commercial buildings have incandescent bulb lamps and the rest use fluorescent bulbs. The lighting demand of households and service sectors accounted for 380 GWh in 1993.

Households and service sector enterprises consume most of the heat: more than 90% of the total heat consumption in the base year (1993). Their share is expected to increase after 2000. That is, heat consumption for households in 2020 will almost have doubled compared to 1993.

As shown in Table 3.11, CO_2 emissions from heat generation in 1993 was 6,439 Gg, while electricity generation only reached 1,928 Gg (Dorjpurev J, et al, 1996).

Table 3.11. Estimated and projected CO_2 emissions from heat and electricity generation for residential and service sectors, 1993-2020, Gg

	1993	2000	2010	2020
Electricity generation	1,928	2,495	2,894	19,628
Heat generation	4,511	6,678	7,923	41,374
Total	6,439	9,173	10,817	61,002

Source: EFOM-ENV Model Result, NTE Team Mongolia, ALGAS Project, 1997

Mitigation options*:* The following three main options have been identified for the mitigation of GHG emissions from district heating systems and the built environment.:

- Installation of thermostat radiator valves and balancing valves.
- Improvement of building insulation.
- Implementation of efficient lighting.

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[1] Degree-days are the accumulated differences between the temperature below which heating is required (defined as 17°C) and the average temperature of the day measured in centigrades over the whole year. For comparison Denmark has around 3,000 degree-days and Germany around 2,000.

Generally, installing energy efficient lighting and improving building insulation were found to be both practical and cost effective. However, relatively high initial costs and some other market barriers are likely to complicate the implementation of these options. CO_2 mitigation potential for the selected options is given in Table 3.12.

Table 3.12. CO_2 mitigation potential for the selected options

Option	CO_2 Reduction Potential *, Gg	Total System Cost reduction, mill. US$	Cost-effectiveness, US$/tonne
District heating system loss reduction	12,744	21.85	-1.71
Building insulation improvement	9,079	15.72	-1.73
Lighting efficiency improvement	4,349	10.78	-2.48
Total	26,172	48.35	-

*Note: * cumulative emissions in projected period 1993-2020, ** incremental cost*
Source: EFOM-ENV Model Result, NTE Team Mongolia, ALGAS Project, 1997

The priority and cost-effectiveness of energy supply and demand sector mitigation options are summarized in Table 3.13. This table demonstrates that demand side management in industry is the most cost-effective option.

Table 3.13. Priority and cost effectiveness of mitigation options

Sectors	Options	CO_2 reduction Potential (Gg/year in 2010)	Cost $/tonne
Energy supply sector			
Medium and small scale energy Conservation	*Modernization of stoves and furnaces*	920.0	-4.00
	Install boilers new design with high efficiency (260x1 MW)	340.0	-7.00
	Converting steam boilers into small capacity thermal power plant (5x10 MW)	190.0	-4.50
	Install electric boilers (40x1MW)	54.6	-4.00
	Change in design, introduction of modern technology (12x25 MW)	91	1.11
Improving of coal quality	*Coal briquetting*	400	23
	Application of effective mining technology and facilities, including selective mining, dewatering system coal handling plant etc.	350	11
Renewable energy	*Small hydropower development*	54	10.32
	Wind generator	13	2.41
	PV Solar System	7.2	4.46
Coal Power Plant	*Rehabilitation and refurbishment of CHP*	0.185	1145
	Automation of UBCPP-2 internal use	0.0055	500
Energy demand sector			
Industry	*Good housekeeping/Demand Side management*	310	-58.21
	Motor efficiency improvements	245	-1.35
	Dry process of cement industry	147	0.12

	Steam saving technology	69	-5.36
District heating and built environment	*Building insulation improvements*	336	-1.73
	Improvements of district heating system in buildings	235	-1.71
	Lighting efficiency improvements	160	-2.48
TOTAL		**5298.4**	

Transportation

Energy use and GHG emissions: In 1990, auto-transport accounted for 70% of the total freight and for 98.3% of the passenger transportation (A Transport Strategy for Mongolia, 1999). The second highest emissions from the energy-using sector are caused by the transport sector, generating 2,061 Gg of CO_2-equivalent emissions or 15.1% of the total. GHG emissions from the transport sector are given in Tale 3.14.

Table 3.14. GHG emissions from transport sector, 1990, Gg

Fuel Combustion	CO_2	CH_4	N_2O	NO_x	CO	CO_2-Equivalent	Percentage of total CO_2-equiv.
A. Transport	2,061.0	0.43	0.061	21.53	135.33	2,088.94	100.0
Road	1,848.0	0.42	0.057	17.72	134.02	1,874.49	89.7
Railways	144.0	0.01	0.004	3.53	1.19	145.45	7.0
Domestic Aviation	69.0	0.002		0.28	0.12	69.042	3.3

Source: Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS): Mongolia, 1998

Mitigation options: The primary mitigation options identified for GHG emission mitigation in the transport sector are *vehicle maintenance and traffic management*. In terms of CO_2 mitigation potential, the most attractive option in the transport sector is the improvement in Vehicle Fuel Consumption Efficiency for Mongolia.

3.4.3 Non-Energy Sector

Agriculture

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 emission in Mongolia and contributes 90-93% of total country's methane emission.

Mitigation options: The potential options (ALGAS, 1998) are as follows:

- to limit increase of total livestock number
- to decrease the number of cattle, which is the main source of methane emission in the livestock sector
- to increase productivity of each animal

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

Land–use change and Forestry

Forest resources: Forested areas occupy 8.1% (17.5 million hectare) of Mongolia's total territory. Most of the forests are located in northern and central part of mountain regions. According to the national Forest Law passed in 1995, the forested area is divided into three zones: special, protected and industrial. Special forests account for about 6% of total forest land, including the upper forest boundaries and protected areas of National Conservation Parks. Protected forests account for 48% of the total forest and include green zone, 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. Distribution of tree species in Mongolia is shown in Table 3.15.

Table 3.15. Distribution of tree species in Mongolia

Tree species	Forest area, ha
Siberian larch *(Larix Sibirica)*	7,728,300
Scotch pine *(Pinus Silvestris)*	503,300
Siberian pine *(Pinus Sibirica)*	1,986,000
Spruce *(Picea Obovata)*	27,800
Fir *(Abies Sibirica)*	2,300
Birch *(Betula Platyphylla)*	930,500
Poplar *(Populus)*	35,400
Willow *(Salix)*	8,500
Saxaul *(Haloxylon Ammodendron)*	2,025,800
Total	19,247,900

Source: Asia Lest-cost Greenhouse Gas Abatement Strategy (ALGAS): Mongolia, 1998

Mitigation options: The following major mitigation options are identified in forestry sector:

- *Natural regeneration,*
- *Plantation forestry,*
- *Agroforestry,*
- *Shelter belt,*
- *Bioelectricity*

Among these options agroforestry and bioelectricity will have a high priority for meeting national environmental and socioeconomic development goals (ALGAS, 1998).

Waste sector

Waste management: Before the 1940s, the quantity of municipal wastes generated in Mongolia was limited because the population density was low and modern consumerism was absent. This may still be partially true in the rural areas of the country. By since the 1950s, the content and quantity of municipal waste disposal has changed significantly with the development of agriculture, urbanization and industrialization, doubling in quantity every 10 years.

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. Roughly one-third of Mongolia's population live in the capital city. At present, Ulaanbaatar generates about 1,100-1,300 m^3 or 800-1,000 tonnes of solid waste per day, of which 50% originates from households, 30% from commercial and industrial enterprises and 20% from other sectors. All collected wastes of Ulaanbaatar city are disposed in three landfills (Dari ekhiin ovoo, Ulaanchuluut, Moringiin davaa) without any further processing. The management of municipal wastes is emerging as a problem of prime importance.

Mitigation options: Mitigation potential 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 as recycling*

3.5. Implementation Strategies

There are numerous implementation strategies and measures that can be adopted to overcome barriers and reach the goal of a reduction in GHG emissions, but the key strategy should focus on:

Institutional integration: As stated before, energy problems are becoming increasingly complex and will require inter-sectoral coordination for comprehensive implementation. Responsibilities for policymaking and implementation are usually dispersed among several departments, such as the energy authority, power plant, local government, and provincial authorities. Thus, the problems in the energy sector should be managed as a unit, rather than as sectoral divisions; responsibility should be clearly defined. For example, as sketched above, the leading organizations in all sectors will be Ministry for Nature and Environment (MNE) and Ministry of Infrastructure (MI), while the acting organizations will be supply organizations such as Coal Mining, Power Plants, Heat and Hot Water distributing companies, and other industries according to the sector in which a selected option is to be implemented. Research institutions (RI) and community group representatives (GCR) will also have important roles to play.

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 be more clearly prioritized at the national planning level, and that they 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.

Provide legislative base: In order to assume the role of promoter and facilitator, the government should define the legislative and administrative frameworks. An elaboration of implementation strategies according to the identified mitigation options in the energy sector is given in Table 3.16. It should be taken into account that these options are sectoral specific, and that in many cases implementation of one option depends on the performance of others. The main benefits and GHG reduction costs as well as implementation potential of the mitigation options are given in the table. The feasibility of implementing the selected options varies. Implementation of some options will require a large initial investment in expensive, modern technologies. Other GHG mitigation options will be easily implemented by improving existing technologies and its management.

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 small and medium sized boilers, providing households with heat and hot water in cities and provinces.

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 increase of the national electrification rate.

Table 3.16. Elaboration of mitigation options in different sectors.

	Main benefits	GHG mitigation cost per tonne, US$	Estimated Investment cost mln. US$	Possible funding sources	Leading organization	Implemen-tation feasibility	Leading actors	Cooperating organizations
Fossil fuel sector								
Improve Coal Mining Technology	Ec	11	35	Foreign, national loan and grant aid	MNE, MI	High	Coal mining companies	RI
Coal briquetting	En, Sl	23	30	Japanese grant aid	MNE, MI	High	IPC	IPC
Renewable Energy								
Small and micro hydropower development	Sl	10.32	230	Foreign, national loan and grant aid	MNE, MI	Medium	LGO, IPC	IPC, RI
Photovoltaic (PV) Solar System	Sl	4.46	7.5	-“-	MI	Medium	Renewable Energy Cooperation	IPC, RI
Wind generation system	Sl	2.41	3.9	-“-	MI	Medium	Renewable Energy Cooperation	IPC, RI
Central Power Plants								
Rehabilitation and refurbishment of existing CHPs	En,Ec,Sl	1145	152.4	-“-	MNE, MI	Medium	Energy Authority	Foreign and National IPC
Automation of plant internal heating	Sl	500	0.9	-“-	MI	High	Power Plant	-“-
Medium and small scale energy conversion								
Converting steam boilers into small capacity thermal power plant (5x10 MW)	En,Sl	-4.50	55	-“-	MNE, MI	Medium	LGO	IPC
Change in design, introduction of modern technology (12x25 MW)	Ec	1.11	6	-“-	MNE, MI	Medium	-“-	-“-
Install electric boilers (40x1MW)	En,Ec,Sl	-4.00	2	-“-	MNE, MI	High	-“-	-“-
Install boilers new design with high efficiency (260x1 MW)	En,Ec	-7.00	8.8	-“-	MNE, MI	Medium	-“-	-“-

Modernization of stoves and furnaces	En,Ec,Sl	-4.00	18.8	National loan	MNE, MI	Low	-“-	-“-
District heating and built environment								
Installation of thermostat radiator valves and balancing valves.	Ec,Sl	-1.71	12	Foreign, national loan and grant aid	MNE, MI	Medium	District Heating Company	FFO, GCR
Improvement of building insulation	Sl	-1.73	33	Foreign, national loan and grant aid	MI, City Government	Low	-“-	-“-
Implementation of efficient lighting	Sl	-2.48	3.7	National investment	MI, City Government	High	-“-	-“-
Industry sector								
Motor efficiency improvements	Ec	-1.35	2.5	National investment	MI, MFA	Medium	Industry	
Good housekeeping of electricity and heat including energy management	En,Ec, Sl	-58.21	-		MI, MFA	High	Industry	
Steam saving technology (steam traps, heat recovery, pipe insulation)	Ec	-5.36	1	National investment	MI, MFA	High	Industry	
Introduction of dry processing in the cement industry	Ec	0.12	20	Japanese investment	MI,MFA	Medium	Cement Industry	
Waste management								
Recycling	En, Ec			Foreign, national loan and grant aid				
Storage and Collection system	En.Ec			-“-	MNE, City Government	Medium	Public Service Company	FFO, GCR
Incineration	Sl			-“-	MNE, City Government	Medium	-“-	-“-
Improve solid waste disposal facilities	En,Ec			National investment	MNE, City Government	Medium	-“-	-“-

Where: En-environmental, Ec-economic, Sl-social, LGO-Local government organization, IPC-Interested private company, FFO- Federation of flat owners, GCR- Group of Communities Representative, RI- Research Institutions

CHAPTER 4 CLIMATE CHANGE, ITS IMPACTS AND ADAPTATION MEASURES

4.1. Introduction

Already in Mongolia, harsh climactic conditions create one of the most insurmountable barriers to economic development; the anticipated climate change will limit it even further. The outputs of the country's major economic sectors, such as animal husbandry, rainfed arable farming, and the mining industry, are very sensitive to climate variability. About 200 thousand animals are lost every year because of heavy snow and frost. The cold period lasts 5.5-6 months and houses require heating for an average 220 to 225 days. Finally, different types of permafrost, which occur in 63% of Mongolia's territory, and seasonal soil freezing have resulted in a 40% increase in buildings costs. During the last 40 years, Mongolia's ecosystems have clearly changed as a result of climate change and human activities. Desertification, soil erosion, and water resource and bio-diversity degradation are just a few examples of these changes.

Since Mongolia is located in the transition zone between the Siberian taiga and the Central Asia desert, the country is very sensitive to a shift of geo-climate zones that can be caused by climate change. Already, the frequency of extreme events such as droughts, *dzud* (severe winter weather), floods, dust storms, thunderstorms, heavy snowfall, flash floods etc. has significantly increased during the past 30 years. Economic losses due to these extreme events are estimated to be 1 to 3 billion Tugricks per year. In 1999-2000, abnormal weather phenomena caused a loss of 104 billion Tugricks, or almost 10% of GDP. The frequency of forest and steppe fires is increasing because of the extremely dry springs. Clearly, climate change issues are as important to Mongolia as for coastal countries. In the coming century, climate change will probably radically change the traditional way of living that was established in Mongolia thousands of years ago.

It is estimated that Mongolia's population will increase to 4.1-4.3 million between 2020-2025. With this increase in population will come increased demand for energy and food production: energy consumption may increase by a factor of five by 2020 compared to 1993, and the number of domestic animals may reach 41.7 million by 2010 (MAP-21, 1998). The result will be increased pressure on the environment. High priority must be given to research on climate change in Mongolia because it will have significant impacts on both the environment and the economy.

4.2. Observed Climate Variability and Change in Mongolia

Long, cold winters, short summers, small amounts of precipitation, high temperature fluctuations and a relatively high number of sunny days characterize the Mongolian climate. January is the coldest month, with average temperatures of -15^0C to -35^0C and a minimum temperatures dipping down to -50^0C (the coldest temperature recorded in Mongolia was -56^0C at the Uvs lake area, reported in December 1972). The maximum temperature can reach 35^0C-43^0C. July 1999 was the hottest month recorded.

Mongolia's annual mean temperature ranges from –7.8^{0}C to +8.3^{0}C. The mean is -4^{0}C in the Altai, Khangai, Khentei and Khuvsgul mountain regions, –8^{0}C in the mountains and big river valleys, +2^{0}C in the desert-steppe, and +6^{0}C in the southern Gobi. The zero annual temperature isotherm line mirrors the 46^{0}N latitude line, which separates the mountainous area from the Gobi-desert area. Permafrost soils are distributed in areas with annual mean temperature lower than -2^{0}C. The average temperature in January is -25^{0}C in the river valleys, -15 to -20^{0}C in the Gobi, and -12 to -15^{0}C in the southern Gobi. Summer and winter temperature distribution on Mongolia's territory are shown in Figure 4.1-4.2.

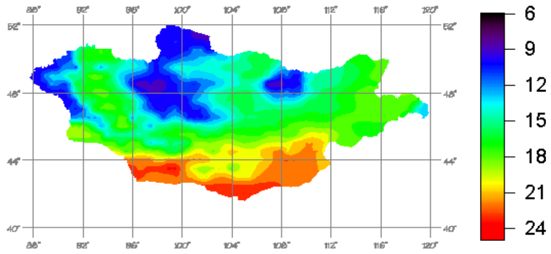


FIGURE 4.1. SUMMER MEAN TEMPERATURE DISTRIBUTION

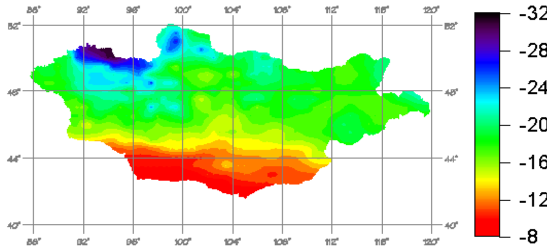


FIGURE 4.2. WINTER MEAN TEMPERATURE DISTRIBUTION

Precipitation varies over both time and space. The annual mean precipitation is 300-400 mm in the Khangai, Khentei and Khuvsgul mountain regions, 150-250 mm in the steppe, 100-150 mm in the steppe-desert, and 50-100 mm in the Gobi-desert (Figure 4.3-4.4). About 85-90% of annual precipitation falls as rain in the summer. The mountain range smoothly changes into steppe and desert from north to south. Accordingly, amounts of heat and wind increase while the precipitation and soil moisture decrease.

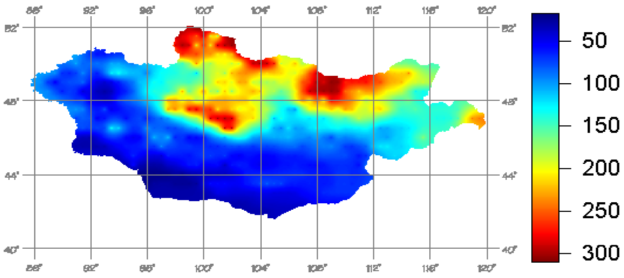


FIGURE 4.3. DISTRIBUTION OF SUMMER PRECIPITATION

Annual evapotranspiration is not high and is almost equal to the annual precipitation. In the Khangai, Khentei, and Khuvsgul mountains, where vegetation and soil moisture are more abundant, annual evapotranspiration is more than 300 mm. Evapotranspiration is 250-300 mm in the mountain valleys and forest-steppe, 150-250 mm in the steppe, and 150 mm or less in the Gobi-desert. The potential evapotranspiration is 700 in the mountain regions, 700-800 in the mountain river valleys, 800-900 in the forest-steppe and 900 mm in the steppe.

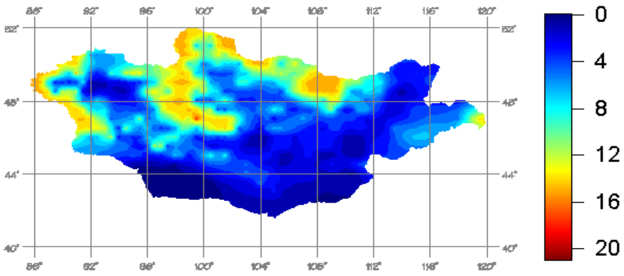


FIGURE 4.4 DISTRIBUTION OF WINTER PRECIPITATION

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. Accordingly, the number of days in which snow cover is present is about 150 in the mountain region, 100-150 days in the forest-steppe, 50-110 days in the steppe zone, 50 and less in the Gobi-desert. The average depth of snow cover is not much—about 5 centimeter in mountains (the maximum is over 30), 2-5 centimeter in the steppe (the maximum is 15-20 centimeter)—but winters without snow cover are very rare and have occurred only in the Gobi region.

The dynamics of the air temperature and precipitation in the last 60 years (measured since 1936 by Mongolia's systematic observation system) have been analyzed on the basis of observed data from 25 meteorological stations evenly distributed over the country. Meteorological records show that the mid- 1940s, 1970s and 1980s and the ends of 1950s were relatively cold and the mid- 1940s and 1980s were relatively dry periods.

During the last 60 years, the annual mean air temperature for the whole territory of the country has increased by 1.56^{0}C. The winter temperature has increased by 3.61^{0}C and the spring-autumn temperature by 1.4-1.5^{0}C. Particularly in March, May, September and November, the temperature has increased rapidly. In contrast, summer temperatures have decreased by 0.3^{0}C. This summer cooling has been observed predominantly in June and July (Figure 4.5).

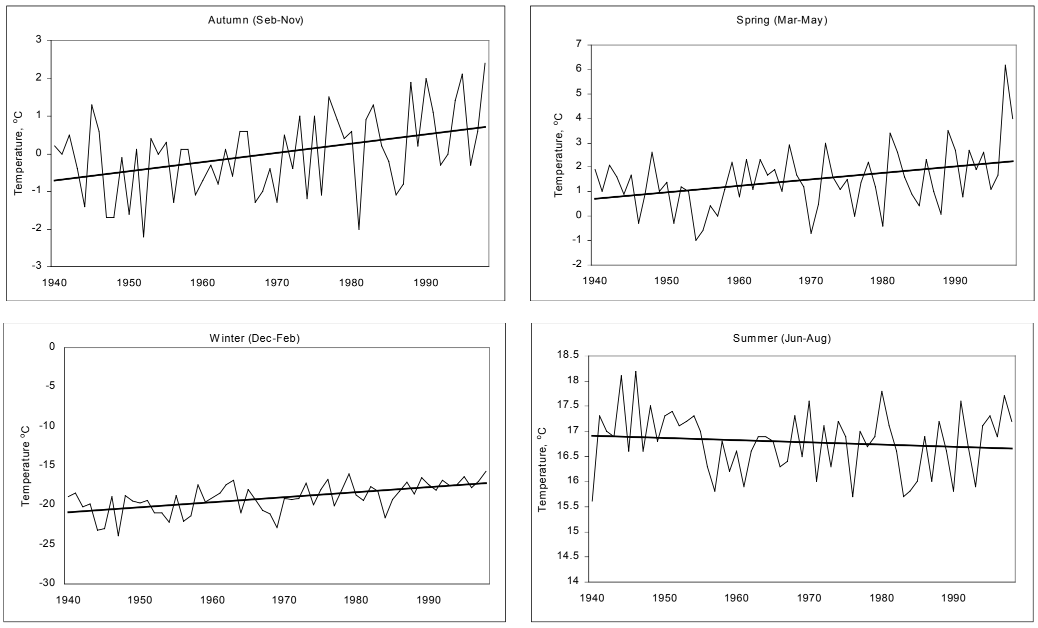


FIGURE 4.5 SEASONAL TEMPERATURE CHANGES IN LAST 60 YEARS

These changes in temperature are spatially variable: winter warming is more pronounced in the high mountains and wide valleys between the mountains, and less so in the steppe and Gob regions. Also, the Gobi presents an exception to the summer cooling trend.

As can be seen from Figure 4.6, there is a slightly trend of increased precipitation during the last 60 years. The country's average precipitation rate increased by 6% between 1940-1998. This trend is a not seasonally consistent: while summer precipitation increased by 11%, spring precipitation *decreased* by 17%. The spring dryness occurs mainly in May. There are not many changes in the precipitation in April and a little increase in the precipitation in May. The rapid increases in temperature and considerable decrease in precipitation in the spring sowing period have significant negative impacts on crop growth.

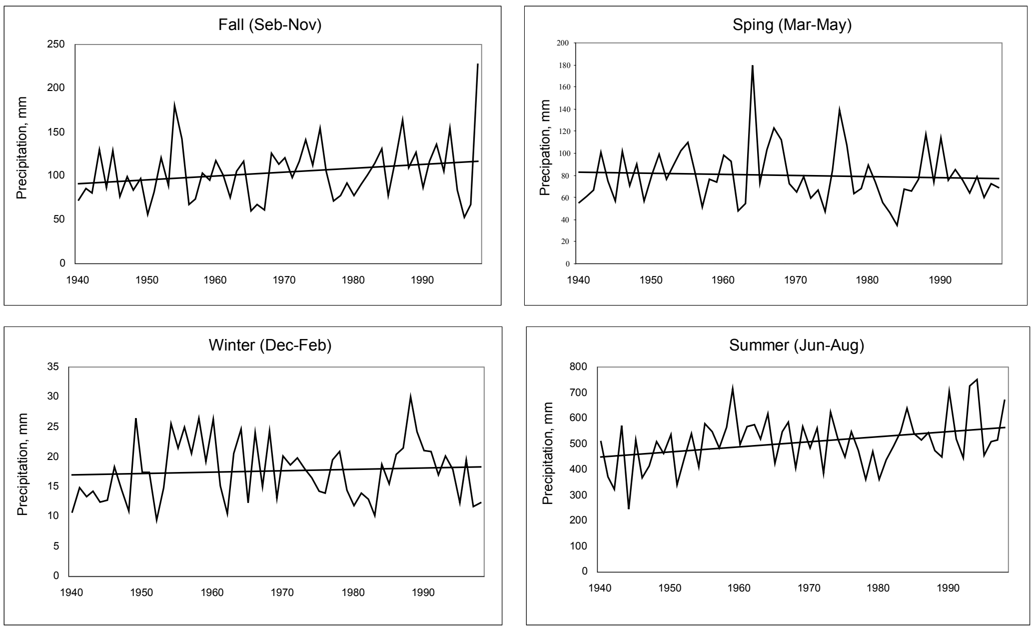


FIGURE 4.6. SEASONAL PRECIPITATION CHANGES IN LAST 60 YEARS

4.3. Climate Change Projections for Mongolia

The scenarios of General Circulation Models (GCM) were used to examine the impact of increased GHG concentrations on future climate of Mongolia. The results of GCM scenarios have been downscaled from the database of IPCC Working Group I.

The scenario of IS92a, which takes only GHG concentrations, was used by the research group. The five scenarios selected for the current study were the Max Plank Institute of Hydrology and Meteorology of Germany (ECHAM4) model (Cubash et al., 1992), the Canadian Climate Center Model (CCCM) (Boer et al.1992), the United Kingdom Meteorological Office and Hadley Center (HADLEY) model (Murohy & Mitchel, 1995), the Geophysical Fluid Dynamics Laboratory (GFDL) model (Manabe et al., 1992), and the Division of Atmospheric Research Private, Australia (CSIROMK-2) model (Table 4.1).

Mongolia’s future climate changes in the periods 2000-2040 and 2040-2070 were determined on the base of the GCM scenarios listed above. The results showed a 3-10^{0}C increase in monthly mean temperature and a small increase in precipitation.

Table 4.1. Mongolia Climate Data and the GCM scenarios used for current study

Source	Author	Resolution (lat. x long)	Scena-rios	Data Type	Baseline Year
Mongolia Climate Data	Institute of Meteorology and Hydrology of Mongolia	0.5x0.5	1961-1990	tem. pre.	1961-1990
CSIROMK-2	Division of Atmospheric Research AUSTRALIA	5.6x3.2	2040 2070	tem. pre.	1961-1990
CCCM1	Canadian Centre for Climate Modelling & Analysis CANADA	3.75x3.75	2040 2070	tem. pre.	1961-1990
ECHAM4	Deutsches Klimarechenzentrum Bundestrasse GERMANY	2.8x2.8	2040 2070	tem. pre.	1961-1990
GFDL-R15	Geophysical Fluid Dynamics Laboratory USA	7.5x4.5	2040 2070	tem. pre.	1961-1990
HADLEY	Hadley Centre, UK Met Office, UK	3.75x2.75	2040 2070	tem. pre.	1961-1990

Note: TEM.-temperature; PRE.-precipitation

The CCCM model predicted the maximum increase in temperature, the CSIRO and the HADLEY2 models predicted the minimum increase, and the ECHAM4 and the GFDL modeled a medium increase in temperature. All of the models predicted winter warming that would be more pronounced than summer warming, especially after 2040. Some scenarios, such as the CCCM, showed stronger warming in high mountain regions than at low altitudes.

In general, temperature increases were given for summer (1.0^{0}C-3.0^{0}C by 2040 and 2.0^{0}C -5.0^{0}C by 2070), for winter (1.4^{0}C -3.6^{0}C by 2040 and 2.2^{0}C -5.5^{0}C by 2070) and for annual mean temperature (1.8^{0}C -2.8^{0}C by 2040 and 2.8^{0}C -4.6^{0}C by 2070).

The simulated results of precipitation change in the 21st century cannot be summarized as easily as the temperature results, because the scenarios showed very different results. For instance, the CCCM model indicated a precipitation decrease in the Gobi while other models indicated an increase. Changes in snowfall were also inconsistent. Annual precipitation was projected to increase by anywhere from 20-40%.

Since Mongolia has many types of landscape, the country was divided into the following six regions according to their landscape characteristics in order to clearly describe the changes at certain locations:

I region	88^0- 98^{0}E	and	46^0-52^{0}N
II region	98^0-108^{0}E	and	46^0-52^{0}N
II region	108^0-118^{0}E	and	46^0-52^{0}N
IV region	88^0- 98^{0}E	and	42^0-46^{0}N
V region	98^0-108^{0}E	and	42^0-46^{0}N
VI region	108^0-118^{0}E	and	42^0-46^{0}N

Region I represents the coldest region and includes the Lakes Basin. Region II represents wettest region and includes the Khangai and Khuvsgul mountainous and arable land areas. Region III receives moderate amounts of precipitation and includes the steppe and the Khentei mountains. Region IV represents the driest and hottest climate region, covering the Altain-Gobi and Gobi-Altain mountains. Region V is the Gobian zone, and region VI the Dornod-Gobian zone.

The observed monthly mean temperature and monthly precipitation of these regions are given in Table 4.2 and 4.3 respectively.

Table 4.2. Monthly mean temperature in different region (^{0}C)

Region	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
I	-24.3	-21.7	-11.9	-0.2	8.3	14.1	14.4	13.2	8.0	-0.7	-11.9	-20.4	-2.8
II	-21.7	-18.9	-10.3	-0.6	7.1	13.0	14.0	12.2	6.8	-1.0	-11.8	-18.6	-2.5
III	-20.1	-18.0	-9.2	1.3	9.6	15.6	17.6	16.1	9.4	1.2	-10.6	-18.1	-0.4
IV	-15.3	-12.3	-5.2	4.8	13.3	17.8	20.0	19.4	12.3	3.3	-7.1	-13.5	3.1
V	-14.5	-10.9	-3.6	6.1	13.5	19.2	21.8	19.6	13.4	4.5	-6.9	-13.0	4.2
VI	-18.1	-14.5	-5.4	5.1	12.3	19.1	22.0	19.8	12.9	4.0	-7.2	-15.4	2.9

Table 4.3. Monthly precipitation in different regions (mm)

Region	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
I	3.0	3.1	3.4	7.0	14.3	23.2	39.7	28.0	14.6	6.7	4.4	3.4	150.7
II	3.3	3.3	3.8	8.9	22.7	56.4	81.9	69.5	25.9	9.9	4.7	3.6	293.6
III	1.8	2.0	2.7	7.4	21.1	47.1	75.5	66.5	25.7	9.0	4.0	2.6	265.4
IV	1.1	1.5	1.7	3.2	11.1	11.3	16.5	15.6	6.2	3.2	2.0	1.5	74.9
V	0.7	1.2	1.8	2.9	10.9	11.6	24.9	20.7	9.4	3.3	1.6	0.7	89.7
VI	1.0	1.0	2.3	3.3	11.1	19.4	35.9	35.7	13.1	4.6	1.9	1.1	130.3

According to the GCM scenarios results for 2040, the precipitation will increase by 120-150% in the Regions II and III, 130-170% in Region V and 150-220% in the remaining regions. In 2040-2070, the precipitation in Regions I and IV will be higher by 200-240% according to the CSIRO and CCCM models, while in other regions, precipitation will be the same or a little less than the level of 2040.

A changed climate, with increased temperatures and precipitation by 2040, could be attractive for agricultural activities. However, if after 2040 the temperature continues to increase while precipitation amounts remain the same (or even decrease a little), the development of agriculture will be negatively influenced.

4.4. Potential Impacts of Climate Change

The degree of global climate change impacts will depend on the levels of changes in climate parameters as well as the country-specific conditions derived from its social, cultural, geographical and economic background. Socio-economic development of Mongolia heavily depends on the agricultural sector, for which the climate is the most important influential factor. Thus, a vulnerability and impact assessment of natural resources and key economic sectors like agriculture is an important component in sustainable development of Mongolia.

The climate change studies conducted in Mongolia concluded that global warming will have a significant impact on natural resources such as water resources, natural rangeland, land use, snow cover, permafrost, major economic activity of arable farming, livestock, and society (i.e. human health, living standards, etc.) of Mongolia. *(V&A Assessment, 1996, and Climate change and its impacts in Mongolia, 2000)*

The most important findings from the climate change impact assessments are discussed below.

4.4.1. Natural Zones

Mongolia's environment has a large range of features. The country's northern territory is dominated by mountain ranges that are partly covered by forests. There, dominant species are Siberian larch (*Larix Sibirica*), Siberian pine (*Pinus Sibirica*) and Scotch pine (*Pinus Sylvestris*). The country's southern part encompasses desert, desert-steppe and steppe areas with low mountains, rolling hills, hillocks and is covered by sparse vegetation. The western part of the country is a cradle of snow-capped high mountains with glaciers elevated 4,000 to 5,000 meters above sea level. Vast plains and unfragmented grasslands (Figure 4.7) characterize the eastern part of Mongolia.

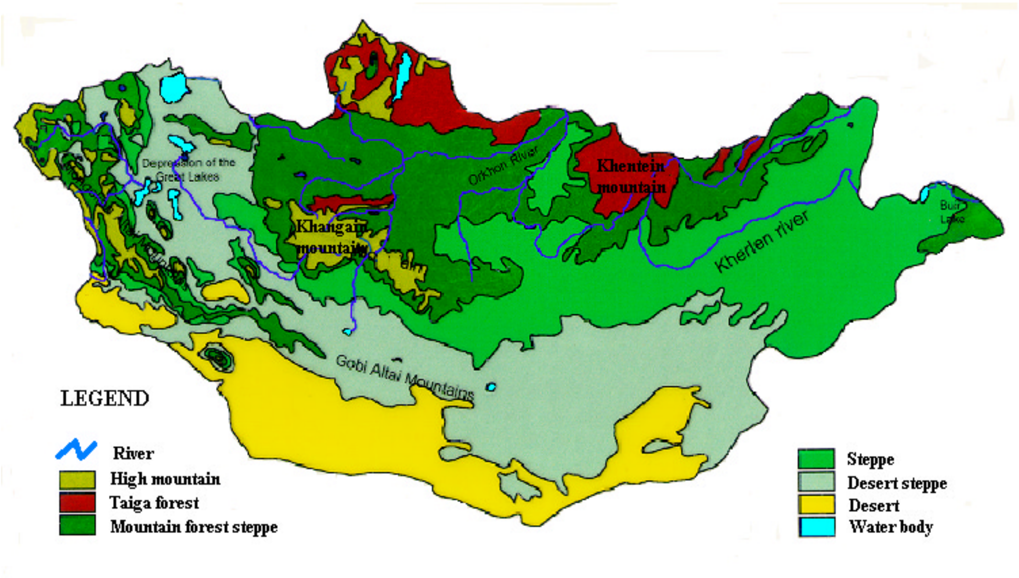


FIGURE 4.7. NATURAL ZONES OF MONGOLIA

The natural zones in Mongolia are expected to change as a result of climate change. The Holdridge life zone classification model is used for impact assessment (Batima et al, 2000). The estimated distribution of natural zones by 2040 and 2070 is given in Figure 4.8.

According to the study results, the current distribution of the high mountain and taiga areas is projected to decrease by 0.1-5% by 2040 and by 4-14% by 2070 as the boundary of the high mountain zone shifts northward. The area of the forest steppe that is in the Khangai, Khentei, Khuvsgul, and Altai mountain ranges is estimated to decrease by 0.1-5.2% by 2040 and by 3.7-13.6% by 2070. Changes in the steppe area are not significant (0.1-3) for either projection scale. However, it is expected that by 2040 the dry steppe zone that currently occurs in the eastern part of the country will spread north into areas currently included in the forest-steppe in the Khangai and Khentei mountains, resulting in a decrease in the high mountain and forest-steppe zone and an increase in the steppe area. Furthermore, by 2070 the area covered by steppe may have expanded to occupy the lower and middle slope of the Khangai, Khentei mountains and the western slope of Change mountains and the Gobi-Altai mountains area. The desert steppe area may decrease by 2.5-11.8% in 2040 as it is transformed into more steppe-like conditions, but this rate of change will slow by 2070. The desert region may expand into to the Lakes Basin and current desert steppe zones. The desert area is projected to increase by 6.9-23.3% of the actual area by 2040 and by 10.7-25.5% by 2070.

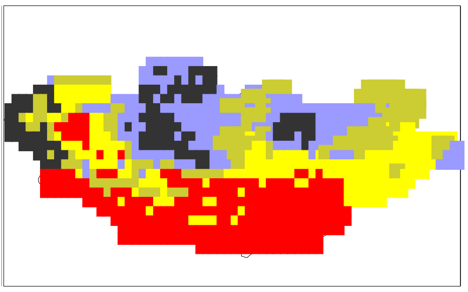
4.4.2. Water resources

Climate dictates the amount of water, its quality and hydrological processes in the aquatic environment, and the stages of evolution of ecosystems that depend on climatic and hydrologic conditions. It is estimated that water resources in Mongolia amount 599 km^3 from which lakes, glaciers and rivers account for 83.7%, 10.5% and 5.8% respectively (B.Myagmarjav et al, 1999). The annual water use is about 0.5 km^3 (MAP 21, 1999), which appears to be a small amount compared to the water resources. However, water resources are unequally distributed over the country: in the northern part of the country the available water per capita is 4-5 times more than the world average, in the southern part of the country, the available water per capita is 10 times less that the world average (B.Myagmarjav et al, 1999).

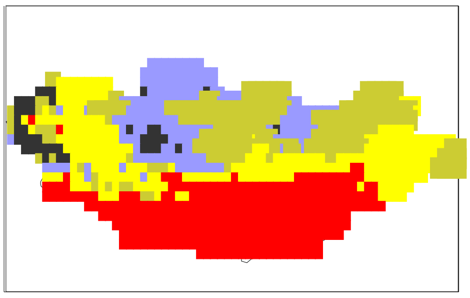
The rivers in Mongolia have their origin in three large mountain ranges: Mongol-Altai, Khangai-Khuvsgul and Khentein. The rivers are divided into three main basins, depending on their drainage system: the Arctic Ocean Basin (AOB), the Pacific Ocean Basin (POB), and the Internal Drainage Basin (IDB) of Central Asia.

Mongolia's open surfaces waters, such as rivers, lakes and springs, are used for drinking as well as for agricultural water in rural areas. Surface freshwater is a finite and vulnerable resource. Rivers provide the main source of water in mountainous regions, but in some areas, such as the steppe and the Gobi, ground water is the only source for daily use.

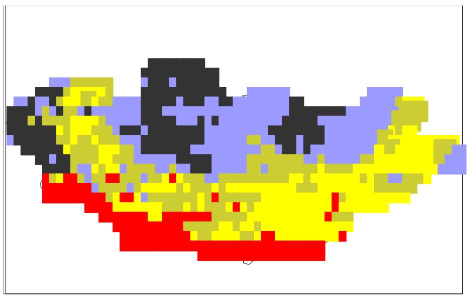
The results of an assessment of the impact of climate change on water resources indicate that if annual precipitation drops by 10% while the temperature remains constant, the average river flow might be reduced by 7.5% in the Internal Drainage Basin, by 12.4% in the Arctic Ocean Basin, and by 20.3% in the Pacific Ocean Basin. If, apart from the precipitation decrease, average temperature increases of 1^oC, 2^oC and 3^oC are taken into account, an additional flow reduction of 3-11% is expected. In other words, it appears that for each degree (^oC) of temperature increase, there would be a 2-6% annual flow decrease.



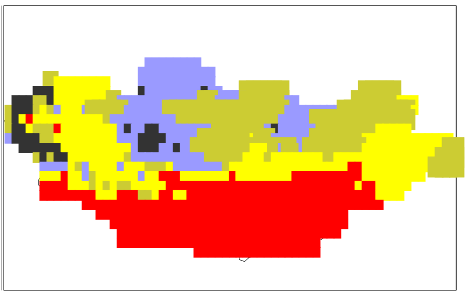
CCCM 2040



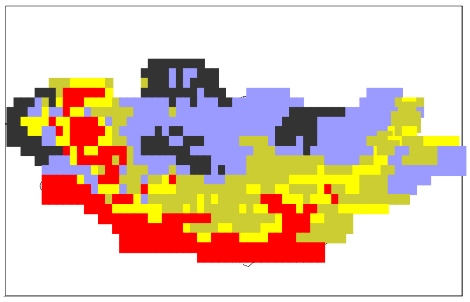
CCCM 2070



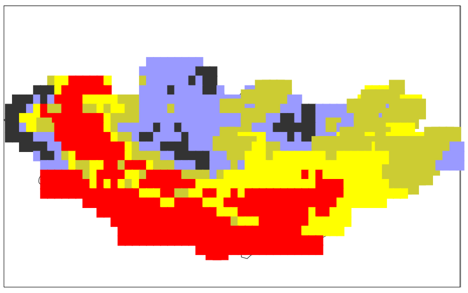
CSIROMK 2040



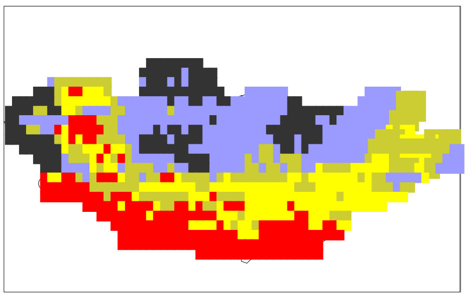
CSIROMK 2070



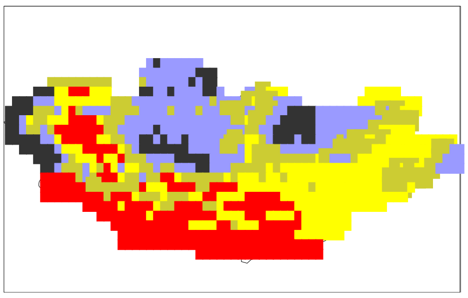
ECHAM 2040



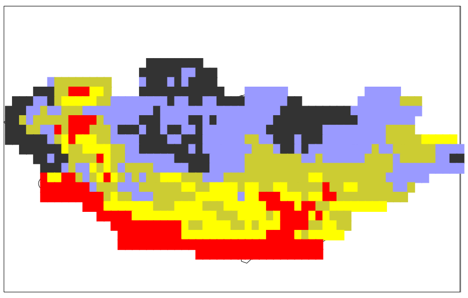
ECHAM 2070



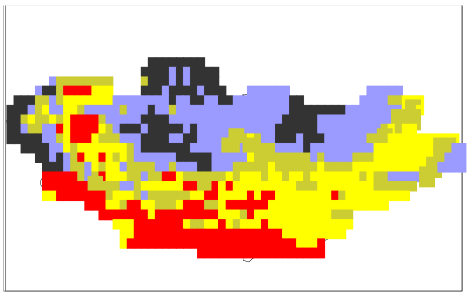
GFDL 2040



GFDL 2070



HADLEY 2040



HADLEY 2070

⬛ High mountains and taiga 🟪 Forest steppe 🟩 Steppe
🟨 Desert steppe 🟧 Desert

The findings of the five scenarios (CCCM, CSERIO, ECHAM, GDFL, HADLEY) of GCM show that water resources will tend to increase in the first quarter of the century and then decrease, returning close to current levels by the mid-21st Century. The general trends of the five scenarios are very similar, but they differ in scale. The CCCM gives the higher range in river runoff changes. As an example of surface water resource changes, the river flow changes by CCCM scenario is shown in Figure 4.9. The pattern of river flow change over time strongly correlates with the patterns of climate change parameters, such as temperature and precipitation. Thus it can be concluded that continued climate warming would lead to a decrease in the water availability of the country.

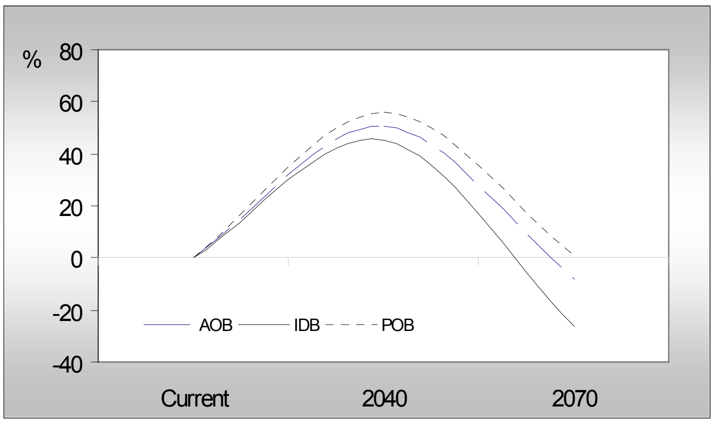


Figure 4.9. The changes of river flow by CCCM

According to the simulation results, almost one third of the country is defined as a very vulnerable region. All rivers in this region are seasonal, meaning that they only flow during the rainy season. Nearly 90% of the lakes have an area of less than 1 km^2 and their area and volume depends strongly on precipitation. Moreover, the projected river flow reduction after the first quarter of new century is more rapid than in rivers in the remaining regions of the country. The residential water demand can be met by ground water in towns, villages, and settlements, but the pasture water supply will be the most difficult problem to solve, particularly in arid and semiarid areas.

4.4.3. Grassland

Some 97% of Mongolia's total area is covered with rangeland. Of the 125.8 million hectares of native pasture land suitable for pastoral livestock, 4.5% are in the high mountains, 22.9% in the forest steppe, 28% in the steppe, 28.4% in the desert steppe, and 16.2% in the Gobi desert region (Tserendulam et al, 1986). Pasture yields are strongly affected by climate and weather conditions that vary from year to year, and with altitude and latitude. Pasture productivity plays an important role in the management of both domestic animal and wildlife populations. Annual mean peak standing biomass varies from 100 to 1000 kg ha^{-1}, and decreases from north to south as a function of the features of the natural regions. Peak pasture production in the Khangai and Khentii mountainous region and the forest steppe exceeds 500 kg/ha, while it ranges from 100 to 700 kg per hectare in the steppe and Altai mountainous region and dips well below 200 kg per hectare in the Lakes basin and Gobi desert. As an example of the variety of pasture yields over time: fodder production in 1999 was estimated at about one third of that in 1986.

Research conducted to assess pasture productivity under conditions of climate change confirms significant negative impacts (Bolortsetseg et al 1996). Estimates of sensitivity analysis show if the temperature increases by 3^0C, the carbon and nitrogen in soil organic matter are projected to decrease by 10 and 3%, respectively and peak-standing biomass may be reduced by 23.5%.

The Century 4.0 model was used to study the impact of climate change on rangeland production. (Bolortsetseg et al, 2000). Projected changes in soil organic C and N, peak biomass, and plant protein by different scenarios (CCCM, CSIRO, ECHAM, GFDL and HADLEY) for different geographical zones are shown in Table 4.4. The numbers in this table demonstrate the average of five scenarios.

Table 4.4. Soil organic C and N, peak biomass and plant protein changes under climate change, %

N	Natural zone	Soil organic C change, %		Soil organic N change, %		Peak biomass, change %		Plant protein change, %	
		2040	2070	2040	2070	2040	2070	2040	2070
1	Forest steppe and high mountains	-6	-11	3	-2	10	-12	-0.1	0.4
2	Steppe	-6	-15	0	-6	10	-18	-0.1	0
3	Altai mountains	-4	-4	0	1	50	34	-0.1	0.3
4	Desert steppe and desert	-22	-26	-12	-16	6	-13	0	0.1

Soil C decline is expected to be more dramatic in the desert steppe and desert by 2040, declining by 14.2-48.9% in the desert steppe and 4-6% in other regions. The decline in soil carbon appears to continue until 2070: soil carbon would be lower by 4-26% compared to the current level. In 2040, soil organic N will not change in the Altai Mountains and steppe, increasing by 0.2-9.8% in the forest steppe and high mountains and decreasing by 4.7-22.2% in the Gobi desert. By 2070, soil N will decrease in all regions, except for the Altai Mountains. According to the projection, changes in plant protein will be insignificant in either year.

Higher temperatures increase the rate of microbial decomposition of organic matter, adversely affecting soil fertility in the long run (Parry, 1990). Moreover, potential evapotranspiration increases because of warming. This effect is expected to be relatively small in the early period, but after 2040, the soil moisture deficit will be considerably larger than that at present because of the higher evaporative demand of the vegetation. Therefore, peak standing biomass would be higher by 2040 and lower in all regions (except for the Altai Mountains) by 2070. According to these simulation results, climate change would have favourable effects by 2040 and negative effects by 2070 on soil fertility and plant production.

An important effect of the higher temperatures will be the extension of the growing season for plants. This extension may not come because Mongolia pasture production is limited more strongly by soil moisture availability than by air temperature. Therefore, higher temperatures could lead to higher evapotranspiration rates, to the point where reduced water availability to the vegetation will restricts the length of the growing season. Any soil-water deficiencies are most likely to occur in the warmer, drier regions of the Gobi and desert. The negative balance of moisture capacity will definitely limit both the length growing season and the degree of pasture productivity. Obviously, the shifts in natural zones will have direct effects on rangeland production and plant communities, and indirect influences upon livestock production and, thereby, the entire Mongolian economy.

4.4.4. Forestry

Mongolia's total forested area is 17.5 million hectares, including 12.7 million hectares of closed forest. Forests cover 8.1% of the total land area. The Mongolian forests are recognized as very important for protection of soil, rangeland, water resources, wildlife, and climate formation in the Central Asian region. But the forest area is being reduced at an accelerated rate. In arid regions, shrubs and brush from sparse woodlands are used for fuel wood without any form of long-term management. Woodlands are cleared at increasing distances from the settlements. Meanwhile, forest fires, which occur frequently in dry seasons, are the principal cause of deforestation.

Climate change is expected to have significant effects on the re-growth and productivity of forests. As mentioned above, climate scenarios indicate that the forest area might decrease due to expansion of the steppe and desert zones. The high mountains, tundra and taiga regions are expected to decrease by 0.1-5% in 2020 and 4-14% in 2050. The area of the forest steppe may decrease by as much as 3% in the first quarter and 7% in the second quarter of the 21st Century (MAP 21, 1999).

The forest gap model (FORET) was used to estimate future changes in the species composition and productivity of specific sites. The main tree species in the northern forests in Mongolia, are larch, cedar, pine and birch. Biomass dynamics of these species were calculated according to the GCM climate change scenarios, in which carbon dioxide would be doubled. The result shows that the total biomass might be decreased by 27.2% for larch, 5.1% for birch, 35.3% for Siberian pine, and 4.2% for Scotch pine.

Mongolia's forests provide a multitude of mitigative functions with respect to climate change and other environmental problems, including carbon sinks, renewable sources of energy, watershed protection, and protection against soil erosion. Many of these functions have been lost, or will be lost, due to the extreme pressure exerted on Mongolia's forest resources. Therefore, it is necessary to take appropriate measures to protect the forests not only related to climate change, but also for environmental sustainability.

4.4.5. Animal Husbandry

Mongolian nomadic livestock husbandry has been the only viable economic activity throughout the country's history. It has shaped the ways of life of Mongolian society, and has dominated its economy (Erdenetsogt, 1996). Currently, this sub-sector employs 47.9% of the total population, produces 34.6% of the agricultural gross production and accounts for 30% of the country's export.

The total number of Mongolian livestock has increased steadily since the privatization of livestock in the 1990s and was estimated at 30.4 million heads on December 2000. Although native Mongolian animal breeds are characterized by an excellent adaptation to the harsh environment, and resistance to various kinds of diseases, about 2.4-10% of the total population dies each year because of severe weather conditions. The native breeds have small body sizes and a low productivity, and so their performance is substantially below that of non-Mongolian breeds.

Mongolian livestock comprises about 1.4% of the world's total sheep, 2.6% of the total goats, 0.8% of the cattle, 4.8% of horses, and 0.8% of camels. About 4.2% of the world's camels, are Bactrians, of which 44.4% are in Mongolia.

About half of Mongolia's livestock are sheep, which provide half of all meat. For this reason, the climate change impact assessment focused on sheep weight. In general, the impact assessment indicated that temperature increase will have a negative impact on ewe weight gain in all geographical regions because the hot temperature at daytime will cause a reduction of grazing time. According to the simulation of EKZNJTZ model (Tuvaansuren, 1997) and different scenarios of climate change, under unchanged management, ewe live-weight gain may be lower, as the higher temperatures may lead to reduced grazing time in summer of 0.7-2.0 hours per day from May till September. Because intake is determined by forage availability, the reduced time at pasture will lead to lower intakes of 0.1-0.3 kg per day, resulting in lower average daily weight gains of 1-20 gram, depending on the region. This effect will be more pronounced for the forest-steppe zone than for the steppe and Gobi desert. Significantly lower weight gains are predicted for the high mountain regions, and the lowest smallest negative impacts are projected for the steppe area. For instance, the average ewe weight at the end of autumn may be 2.2 kg lower in the high mountains, 1.4 kg in the forest steppe, 0.8 kg in the Gobi region, and 0.2 kg in the steppe. Figure 4.10 presents the deviations from the current average autumn ewe weights for the different geographical regions.

The expected higher temperatures in the summer season have a slightly positive effect in the high mountain region, resulting in reduced weight loss in the winter-spring period, but because of the higher snowfall in the forest and steppe regions, grazing time will be shorter (on average 0.2-0.4 hours per day shorter) with stronger negative consequences. Additional average daily weight loss could be 4-8 grams, leading to an estimated increase in the total weight loss over the winter-spring period of 0.3-0.4 kg.

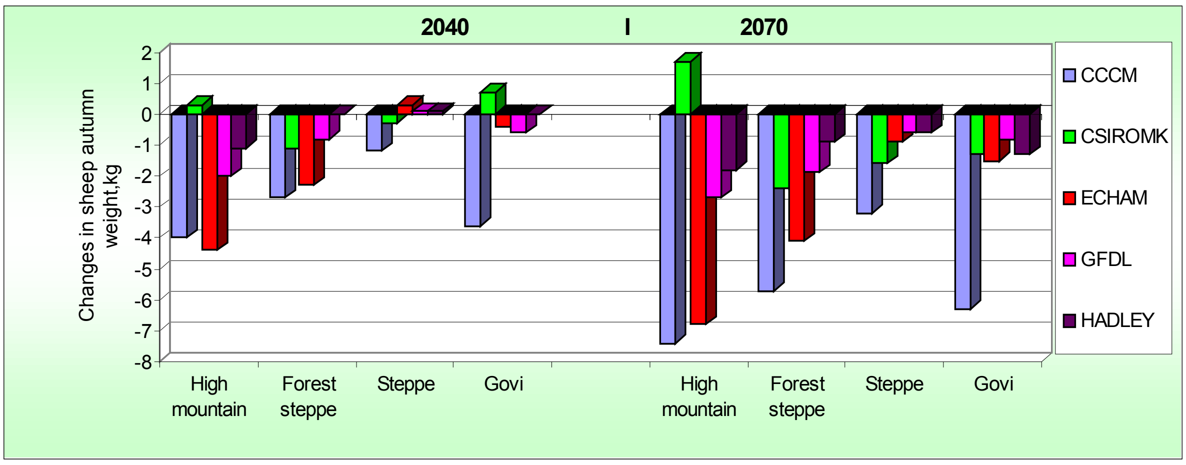


FIGURE 4.10. PREDICTED DEVIATION FROM THE VALUE UNDER CURRENT CLIMATE CONDITIONS OF EWE WEIGHT AT THE END OF AUTUMN (IN KG) IN 2040 AND 2070 PERIODS, FOR THE VARIOUS SCENARIOS

Animal productivity strongly depends on animal body condition. Therefore, it may be expected that the lower weight at the end of the winter-spring period will also negatively affect the production of milk, wool, and other products. Moreover, since ewe weight will decrease, the birth rate may also potentially decline. Related effects will be reduced lamb weight, and increased lamb mortality rate. By contrast, the weaning weight and the growth rate of the lamb may also increase, as warmer temperatures earlier in the spring will result in earlier grass growth. Livestock milk production is likely to be lower, because of the reduced daily intake during the hot period of the summer. A reduction of the cold period may also negatively affect both wool and cashmere production.

It is estimated that the total population of Mongolia will be doubled by 2020. According to the results of the climate change projections, the pasture and livestock productions will decrease as a result of climate change in the 21st century. At the same time, the natural grassland capacity will be limited while the livestock population is expected to increase rapidly. Clearly, balanced agriculture policy and strategies are needed in the 21st century to provide for both the demands of increased agriculture production and sustainable development.

4.4.6. Arable Farming

Mongolia began to cultivate virgin lands at the end of the 1950s. The main policy objective of this development was to achieve self-sufficiency in grain production. The successful implementation of this policy has led to an agricultural sector with proper technologies, mechanization, and crop/seed varieties that went well with the country's soil and climate.

There are three main regions: Central, Dornod and Western for arable land development according to the geographical, landscape, soil productivity, climate and other factors that are suitable for crop land farming in Mongolia (Figure 4.11).

Cultivated arable land occupies about 1.3 million hectares. Prior to 1990, the levels of production were sufficient to cover the total domestic demand of flours, potatoes and vegetables; surpluses were exported.

During the last 10 years, both yield and cropping area has declined significantly due to the lack of finances, and technical and managerial problems. Current national arable farming meets only 50% of the domestic flour and 10-40% of the domestic potato and vegetable demand. The remainder is imported (MAP-21, 1998).

Agricultural yield depends heavily on weather conditions. Weather phenomena, especially in their extremes, have detectable impacts on decreasing per hectare yield. For example, the earlier snowfall in 1997 prevented the timely harvesting of crops, while an extremely hot period of more than two weeks in 1998 resulted in crops dessicating before maturity. Therefore, the Mongolian agricultural sector should be prepared to respond to climate change. Impact assessment of climate change on cropland focused mainly on

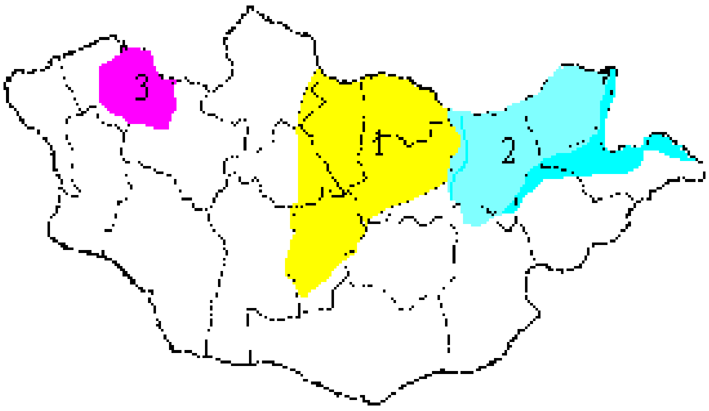


FIGURE 4.11. REGIONS OF ARABLE LAND (1-CNETRAL, 2-EASTERN, 3- WESTERN)

wheat and potato crops.

The potential wheat yield is expected to increase by 8-58% by 2040. The maximum increase will occur in the western region (15-58%), and the minimum will occur in the eastern region (8-19%). The ECHAM (19-53%) and HADLEY (12-58%) scenarios predicted the highest increases.

By 2070, wheat potential yield in most parts of the Central cropland region will decrease by 5-35%. Nevertherless, wheat potential yield is expected to be higher by 8-22% in the western and north-western part of the Central region, by 8-16% in the Dornod region, and by 20-28% in the Western region. The maximum decrease of wheat potential yield from current levels was predicted by GFDL (30%) and CCCM (35%); the minimum was predicted by CSIRO (5%). Predicted changes of wheat potential yield by 2070 are shown in Figure 4.12.

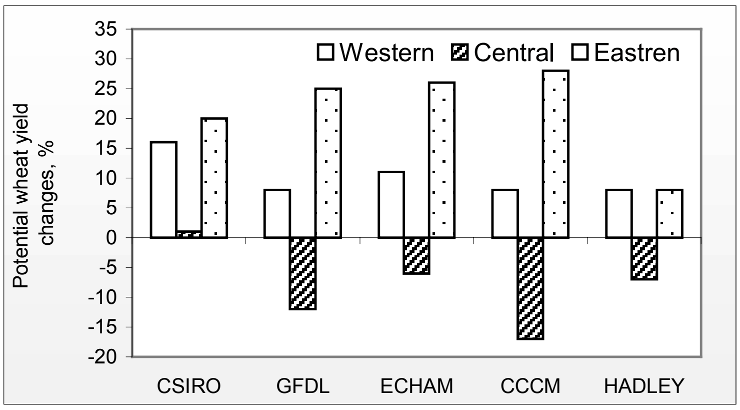


FIGURE 4.12. SPRING WHEAT POTENTIAL YIELD CHANGES IN 2070

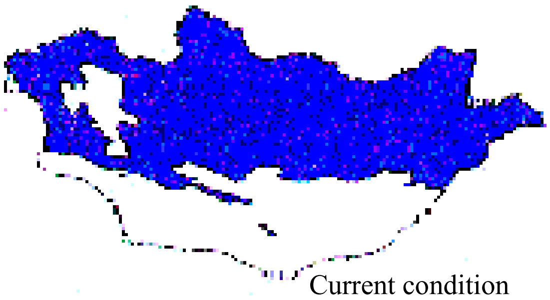
The potato yield may be increased by about 2-26% in 2040 as compared to the current possible potential yield. The maximum rise of potato yield would occur in western areas (13-26%) and the minimum will occur in the Central cropland region (2-8%).

By 2070, the potential potato yield is still projected to be slightly higher (0-14%) than the current level in Eastern and Western cropland regions, but this projected yield will be much less than the yield in 2040. Nevertheless, potential potato yield in Central cropland region might decrease by 1-18%. Mongolia's yield per hectare is already very low; any small reduction in crop yield will therefore have significant impacts.

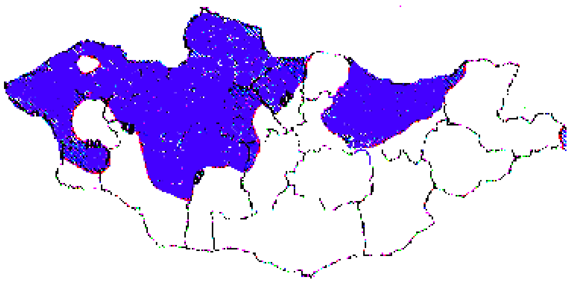
In summary, climate change is expected to have positive results on crop yield in the first forty years of the 21st century. However, it should be kept in mind that even though the crop yield will be the same or slightly more than the current yield in the Dornod (eastern) and Western regions, the crop yield in Central region is expected to decrease under a changed climate. Because the Central region is more highly populated (50% of the total population lives in this area), and accounts for as much as 70% of total cropland area, producing 64% of grain crops and 60% of vegetables), the drop in crop yield in this region is more risky than that in other two regions.

4.4.7. Snow Cover

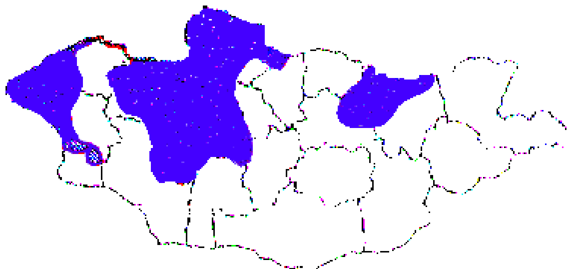
Snow cover studies are important in case of Mongolia because snow cover in winter has both positive and negative impact on animal husbandry. Long lasting thick snow cover adversely effects animal raising by limiting the pasture size. On the other hand, the snow cover provides a water source in a season when all surface water is covered by thick ice, and in areas that—due to their distance from surface waters—cannot otherwise be used for pasture.



Current condition



Condition of 2040



Condition of 2070

FIGURE 4.13. SNOW COVER CHANGES BY ECHAM

The existence of snow cover is examined based on the location of the zero temperature isoline, because the boundary of the area with stable snow cover for over 50 days almost exactly follows the isoline of air zero temperature. Currently, the area with annual mean temperature of less than zero accounts for about 51% of the country's territory.

Global warming scenarios indicate that this area may decrease by an average of 33.4% in 2040 and 22.6% in 2070. The changes in snow cover estimated by ECHAM for 2040 and 2070 are shown in figure 4.13.

The number of days with stable snow cover is projected to decrease. Accordingly, in the middle of the 21st century, shortages of wintertime animal watering are expected in the Dornod steppe and the western part of the country, the Orkhon and Selenge river basins, and the Lakes basin.

The Orkhon and Selenge river basin is the major part of arable land area. Later formation and earlier melting of snow cover would lead to a decrease in soil moisture capacity that could adversely affect crop yield. Therefore, in order to overcome the future climate impacts, crop technology and pasture water supply strategies will have to adapt to these new conditions.

4.4.8. Permafrost

Permafrost covers about 63% of Mongolia's territory. It is classified into seven categories: *continuous, discontinuous, widespread, rarespread, sporadic, pereletka, and seasonal.*

Clear changes in the permafrost conditions have been recorded in Mongolia during the last decades. In the last 10-24 years, the annual mean permafrost temperature in the Byrenkhaan mountain area, the Khuvsgul region, the Therkhyin valley, and the Baganuur region has increased by 0.01°C per year and the depth of melting has increased by 0.4-0.6 centimeter per year. The depth of freezing of the ground in Ulaanbaatar has decreased by 20-30 centimeters in the last 28 years (Tumerbaatar, 1996). Permafrost phenomena such as melting mound, thermocrast, and icing have been occurring more frequently. As a result, the formation of marshes in areas that were previously pasture has increased.

The Mongolian permafrost is thinner, has a higher temperature, and a wider distribution than the permafrost in Russian Siberia, Canada, and Alaska. Hence, it is very sensitive to air temperature increases and human activities.

Permafrost changes calculated by GFDL scenario are shown in the Figure 4.14. As can be seen from this figure, the area of permafrost will be decreased significantly if the trends continue. Accordingly, significant changes will take place in the surface water balance, the soil moisture and the temperature regimes, the vegetation cover, and, consequently, in the economy of the country.

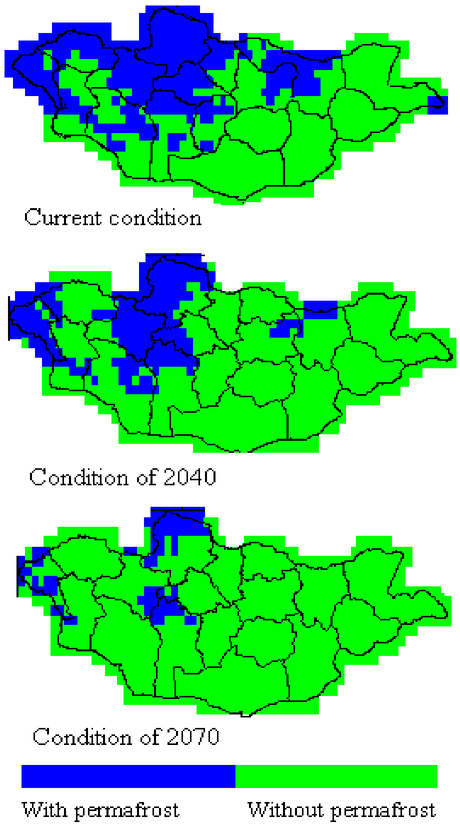


FIGURE 4.14. CHANGES IN PERMAFROST AREA ESTIMATED BY GFDL SCENARIO

4.4.9. Soil Quality and Erosion

The structure of the profile, properties, and distribution of the soil in Mongolia reflects the features of different ages and is determined by a series of sheets of different origin, granulation, texture and thickness, depending upon the exposure, location in the mountain slope profile, and local climate. Generally, the Mongolian soil is divided into two main zones according to the Central Asian bio-soil climate. The northern mountainous region is characterized by the dark chestnut and chestnut soil with relatively high fertility. There variety in number and species of flora and fauna are 3-4 times as much as in the southern desert-steppe, where dominate light brown, steppe-brown and gray brown soils dominate.

The density of population in Mongolia is relatively low: there are about 53.8 hectare of land for each person, more than 20 times the world average.

Mongolia can be characterized as an arid or semi-arid region. Thus, the whole territory of the country is at risk for soil degradation and desertification. Both are caused by overgrazing, scarcity of vegetation, and sand movement on pasture. In this report, soil erosion will be discussed as a general process, while soil degradation refers to cropland.

Both natural and human activities cause soil erosion in Mongolia. It is difficult to differentiate between these two factors. Natural factors include dust and sand storms, and surface washing by summer rainfall with intensities of more than 2-5 mm/min in the mountains. Human factors often intensify soil erosion caused by natural factors. They include pasture overgrazing, use of certain vehicles, and climate change.

About 97.4% of Mongolia's territory—some 125.7 million hectares—are used for pasture. Seventy percent of this land is overgrazed to some extant. According to the studies by Janchivdorj (1999), 78.2% of total land of Mongolia is susceptible to desertification, of which 59.4%, or 929.6 thousand square kilometers, is very sensitive. In the last 40 years of intensive development, grass yield has decreased by 5 times and flora species by 6 times in overgrazed pastures. Particularly intensive desertification caused by overgrazing has taken place in the desert, desert-steppe, and steppe zones. These zones constitute more than half of total pastures in Mongolia. Between 1970-1990, flora species reduced from 33 to 18 and grass yield from 0.32 tonnes to 0.23 tonnes in desert and desert-steppe zones (Janchivdorj, 1999).

According to the results of GCM scenarios for the period of 2000-2070, the annual mean temperature is expected to increase by 2-4^{0}C, which in turn can lead to an increase in the warm period, shortening of the period of soil frost, decrease of the snow cover area, the reduction of permafrost, and increased precipitation.

As mentioned before, the current desert area is projected to shift to the north, widening its area. The compounding effect of this desert expansion and the expected increase in the number of livestock in Mongolia is most likely to accelerate desertification and sand movement in desert-steppe and desert zones. According to some feasibility studies, cropland field soil degradation is likely to be doubled compared to the current condition (Bolortsetseg, 2000). For example, the active nitrogen in soils of desert-steppe and steppe will probably decrease 12-16% in the period between 2020 and 2050. By 2040, the soil organic nitrogen is expected to be a little higher in the forest-steppe and steppe zones, and less in the desert-steppe and steppe zone compared to the current level. Soil organic C will likely decrease by 22-26% in the desert and 4-15% in other zones by 2020.

In order to protect the land from degradation and erosion, it is important to create vegetation cover and increase humus content through accumulation of organic matter. Also, the establishment of an acceptable and effective national policy and management system on land use practices is fundamental for a sustainable soil protection program in Mongolia.

4.5. Integrated Impacts

So far, the potential impacts of climate change on various sectors were discussed. However, in many cases, changes in some environmental or economic sector will affect other sectors. Integrated impact assessment provides a more or less systematic framework to structure the present knowledge and review the issues that can facilitate a more systematic search for urgent and practical responses.

The results of the impact assessment show that climate change certainly affects both natural resources and agriculture production. These impacts are the direct effects of changed climate on natural zones, permafrost areas, livestock, pastures and water resources, and the indirect effect on the economy.

The main barrier to conducting a comprehensive quantitative analysis of integrated impacts of climate change is the lack of an objective method. However, some considerations are given in the "Cross Impact Analysis", (Holling, 1978, Martin Parry and Timothy Carter, 1998) a method for highlighting and classifying the relationships between key elements of a system. It entails identifying the most relevant variables of the system and entering these into an interaction matrix, which represents the relationships between those variables. If one variable exerts a direct influence another, an entry is made in the corresponding matrix cell.

An interaction matrix representing the relationship between natural resources and agriculture of Mongolia is given in Table 4.5. From the matrix table it can be seen that climate change influences natural zones, water resources, permafrost, snow cover, rangeland, livestock, arable land, pasture water supply, and wild animals. It's total driving power is 11 (row sum). Climate change and rangeland, giving a total dependency of 2 (column sum) influence natural zones.

Table 4.5 An interaction matrix for natural resources and agriculture

	Climate change	Natural zone	Water resources	Permafrost	Snow cover	Rangeland	Livestock	Arable farming	Soil erosion	Pasture water supply	Tourism	Protected area	Wild animals	Infrastructure	Row sum (driving
Climate change		x	x	x	x	x	x	x	x	x			x	x	11
Natural zone			x	x	x	x	x	x	x	x			x		9
Water resources				x	x	x	x	x		x	x		x	x	9
Permafrost			x			x	x	x		x				x	6
Snow cover							x	x		x			x		4
Rangeland	x	x					x								3
Livestock	x					x			x	x					3
Arable farming	x								x						2
Soil erosion	x					x	x	x			x	x			6
Pasture water supply			x			x	x						x		4
Tourism												x	x	x	3
Protected area											x				1
Wild animals						x					x				2
Infrastructure									x		x				2
Column sum (dependency)	4	2	4	3	3	8	8	7	3	6	4	2	6	4	

According to the driving power and dependency on natural resources and economic sectors, the agricultural components can be categorized into four types:

1. relay components, characterized by strong drivers and strongly dependent
2. forcing component, characterized by strong drivers and weakly dependent
3. result component, characterized by weak drivers and strongly dependent
4. autonomous component, characterized by weak drivers and weakly dependent

This categorization can be easily visualized by plotting the row and column totals on a ***driving power-dependency*** graph (Figure 4.15). According to the Cross Impact Assessment, water resources, animal husbandry, and pasture water supply appear to be relay components. Climate change, natural zones, soil erosion, permafrost and snow cover are determined as driving components. These variables have a direct and strong influence on pasture productivity, cropland and other components of ecosystems and infrastructure. Wild animals, tourism, arable land, and pasture productivity appear to be strongly dependent on climate change and the protected areas are an autonomous component.

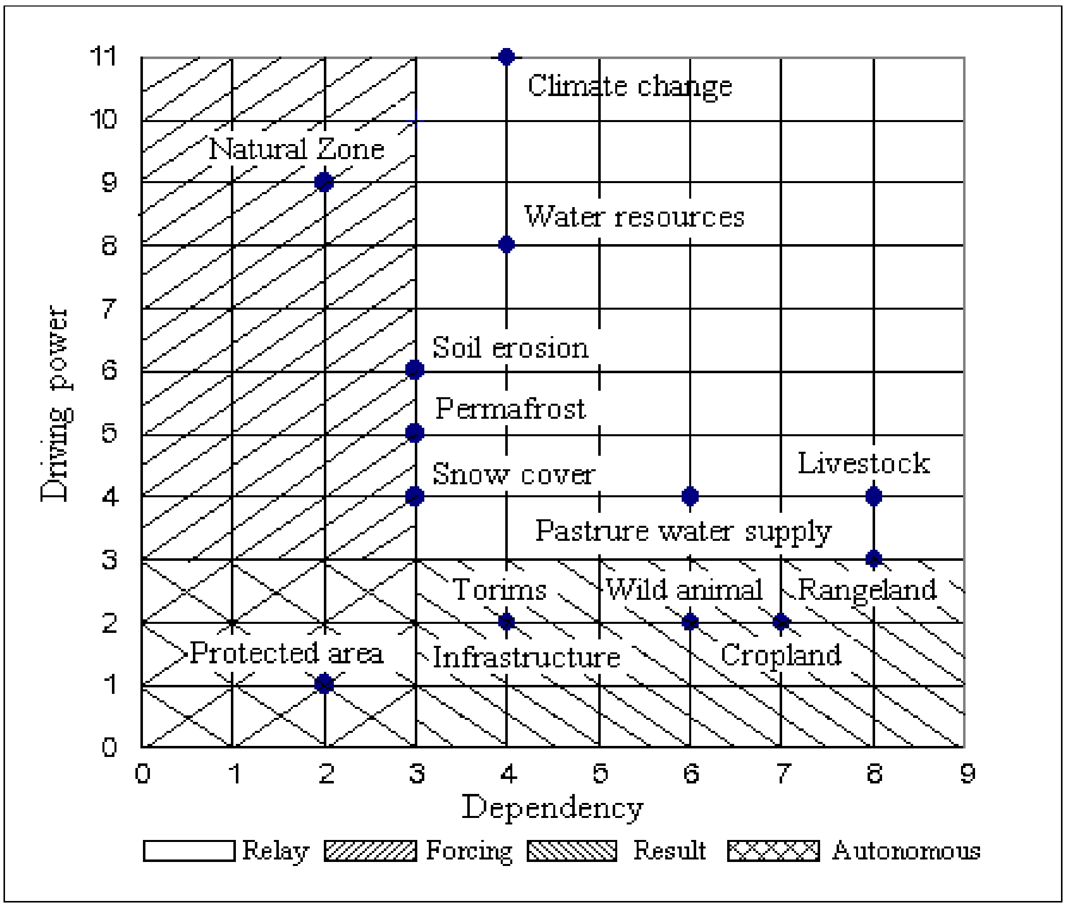


FIGURE 4.15 OUTCOMES OF THE CLIMATE CHANGE IMPACTS STRUCTURAL ANALYSIS

From the water resources impact assessment, it appears that water resources will increase in the first quarter of the 21st century and then will decline. Because temperatures will increase while precipitation rates remain the same, increased river runoff is expected at high altitudes. But even though the quantity of annual river run-off is expected to increase until 2040, the seasonal distribution will remain almost the same. This means that water shortages may still occur during low-water periods. As a result, water resources might decline intensively in the middle of the 21st century. Future increases in temperature and evaporation rates may result in the depletion of the glacier and snow sources that feed the rivers. The decline in water resources is expected to be more pronounced in the Gobi desert and desert-steppe areas where most of the lakes (many of them fed only by in-flowing river) are located. A consequence of river runoff reduction will be the lower water level of lakes in the Lakes basin and—most importantly—the drying-up of the small lakes in the Gobi region.

Agricultural development of this region is more dependent on the availability of water sources. Problems with pasture water supply are already threatening development in the area. Therefore, the expected decline of water resources in the Gobi, desert-steppe and Lakes basin will have serious impacts on moisture recycling (evaporation increase), wetland ecosystems (disappearing small lakes and oasis), land use (lack of irrigation), animal husbandry (pasture overgrazing, expanding desert) and life-style in the rural area.

Exceeding the pasture capacity will reduce its function as a CO_2 sink, increases CH_4 emissions, which both lead to climate change. The National Plan of Action to Combat Desertification in Mongolia (1998) reported that land degradation by overgrazing is already taking place. About 30% of total land is under degradation. Herdsmen are not aware of the problem until the land has actually turned degraded. In sum, climate change impacts on pasture lands can be intensified by unchanged human activities, which have even more pronounced effects on ecosystems.

The animal husbandry sub-sector plays an important role in Mongolia's economy, employing 47.9% of the total population, producing 34.6% of agricultural gross production, and accounting for 30% of the country's export. Animal growth and its productivity greatly depend on pasture land availability. Consequently, pastureland degradation in both size and quality will have significant effects on the national economy.

The recent impact assessment on pasture addressed only the yield and quality of pasture productivity. The pasture grass species have not been considered yet. An estimation of the distribution of grass species under changed climate and natural zone shifts is very important in assessing the pasture capacity.

Changes in natural zones threaten to reduce pasture capacity and distort the conservation of vegetation species. The expansion of the Gobi-desert northwards may cause water resources to decline, temperatures to increase, overgrazing, mismanagement of cropland, and a reduction in vegetative cover. All of these effects will accelerate land degradation, especially in the Gobi and desert-steppe area.

Soil erosion is also a critical driving force. Soil erosion by both wind and water is expected to accelerate primarily through a widening of sandy areas, and secondarily, through the increased intensity of precipitation events. The scarcity of pasture vegetation and desertification will have serious impacts on agriculture. Protected and tourist areas may also be damaged under the changed climate.

Permafrost melting will affect the water and soil moisture balance, and infrastructure. The presence of permafrost plays an indirect role in water circulation, restricting percolation of rain/melt water into the soil and favoring persistence of high soil moisture in the active layer after melting and after rain. In the first half of the 21st century, the permafrost melting may potentially cause the formation of new springs and small karstic lakes, over icing, swamping of pasture and hay lands. All this would result in an increase of flood frequency, reduction of pasture land and forced resettlement of population. Additionally, destruction of permafrost area could have serious effects on infrastructure, particularly on road and bridge constructions, buildings, etc.

In the mid-21st century, if temperature and evaporation have increased, the formed lakes and marshes may dry up due to the melting of the permafrost. In the same period other water resource could shrink as well. Permafrost areas are usually one in the same with those covered by snow cover, and so area water and pasture resources would be expected to doubly decline.

Snow cover plays an important role in soil heat and moisture balance. It also has a significant influence on domestic water use and animal watering during wintertime in the forest-steppe, steppe and Gobi. Therefore, the possible reduction in the number of days with snow cover is a prime concern.

The study of the impacts of climate change on wild animal life is in the initial stages. The location of wild animals strongly depends on natural zones. It is not yet known what will happen to rare and hardly studied mammals such as Khavtgai (*wild bactrian camel*) and the Gobi bear (*ursus arclos*). Changes in food and water resources, climate conditions, population growth, urbanization, and extension sectors such as tourism will have profound effects on the range area and population size of wild animals. To address this complicated issue, additional studies must be carried out. Sensible measures with concrete aims are required to provide for the sustainability of wildlife under a changed climate.

Currently, tourism is not well developed, but it has great opportunities. However, its development will depend, among other factors, on climate change and shifts of natural zones, water resources, soil erosion, use of protected areas, and the location of wild animals.

The protected areas of Mongolia encompass about 18.2 million hectares, including 42 areas that preserve examples of the nation's cultural and ecological heritage. These areas comprise 16.7% of the high mountains, 13.0% of the forest-steppe, 6.8% of the steppe, 13.2% of the desert-steppe, and 50.3% of the desert area. Table 6.5 demonstrates that the conservation of protected areas is relatively insulated from climate effects, in spite of small effects on soil erosion and tourist activities. However, if the distribution of natural zone changes, protected areas will be affected.

To sum up, it can be concluded that the effects of past human activities are large and are expected to increase. According to the results of all sectors, the steppe and desert-steppe are more vulnerable to the small changes of climate variables than other regions. The impacts upon these areas may be that water resources will decline, pastures will degrade, land use will change, animal husbandry will decline, and the economy will decline. Thus, more attention should be paid to conserving and restoring natural resources and to ensuring a balanced management of various human activities in the light of future climate change.

4.6. Adaptation Measures

The IPCC concluded that, although there are substantial uncertainties, global warming could pose important, detrimental effects on agriculture, forestry, natural ecosystems, water resources, human settlements, and coastal protection. The priority aim must be the reduction of uncertainties related to the impacts of climate change so that the necessary adaptation measures can be properly targeted (IPCC, Climate Change 1995).

Based on the impact assessment, response measures to mitigate the adverse effects of climate change have been identified for the natural resources and economic sectors in Mongolia that are the most vulnerable to any changes in climate.

Due to the country's high sensitivity to such climate changes, implementation policies and strategies for adaptation to potential climate change will not only be necessary to meet obligations under the UNFCCC, but will also support national sustainable development activities.

Potential adaptation measures in the most vulnerable sectors are described below.

4.6.1. Rangeland and Livestock

Rangeland and livestock ecosystems are complex, involving numerous interactions among the biotic and abiotic components of the natural system and the human society. Consequently, the effects of a changing climate will have both direct and indirect impacts on different spatial and temporal scales, particularly with respect to forage yield, livestock productivity, and local and national food production capacity.

Adaptation of Mongolia's native pastoral system could take place autonomously, which usually refers to adjustments made within the system. They could also be planned through adjustments external to the system, and initiated or promoted by public policy.

Identified adaptation measures that could be undertaken by the Government are:

(i) Increase public awareness and educate herdsman on the most important climate change impacts and their consequences.

(ii) Develop rangeland and livestock management systems based on pastoral practice and modern technology.

(iii) Restore natural hay making fields and improve forage production systems based on extended rotation methods.

(iv) Use modern pasture water supply systems and solve problems related to the ownership and rental of wells and man-made water sources.

(v) Relieve impacts of harsh winters, severe droughts, and extreme weather conditions by appropriate risk management, particularly by establishing security funds in the form of hay, forage, and cash reserves at national and community levels.

(vi) Strengthen the early warning system within the National Meteorological and Hydrological Services for extreme climate events and weather conditions.

(vii) Develop an insurance system for livestock (especially breeders and selected high productive native animals) and crops with respect to natural disasters.

(viii) Improve the marketing system of livestock and crop products in coordination with long-term weather forecasts and market signals.

(ix) Improve the income tax system in order to regulate the number of livestock and volume of crop production according to the real capacity of pasture and arable land.

(x) Diversify the revenue sources of local people to prevent the possible shock effect of unfavorable weather conditions.

(xi) Improve the health care system both for people and animals, taking into account the expected risk of vector borne disease due to regional warming.

(xii) Plan and implement measures to combat desertification caused by both global processes (such as climate change induced shifts of natural zones) and local activities (such as overgrazing).

4.6.2. Water Supply and Demand

Water plays an important role in the maintenance and restoration of environmental carrying capacities, and therefore must be made a central focus of the total environmental management package. Through water resources management land use and other activities can be guided and controlled.

As per the projections described above, it reasonable to expect that the annual water resources will increase for a certain period. However, the annual distribution of precipitation is expected to remain almost the same. This means that the problem of water shortage in low water periods will persist. One of the most promising strategies to overcome this problem is the introduction of river run-off regulation works. Taking into account the scarcity of natural water resources and their anticipated decrease resulting from climate change, the following adaptation measures can be taken:

Water resources:

(i) Install river water regulation works (for example: erection of cascade basins along the main rivers to regulate runoff and prevent floods).

(ii) Protect the Khuvsgul lake for the production of pure/fresh water.

(iii) Protect the lakes in the Lakes basin because of their sensitivity to global warming, in particular the decrease of permanent snow amounts and glaciers.

(iv) Develop inter-basin transfers.

Residential water supply:

(i) Reduce water losses in distribution pipes
(ii) Introduce water metering
(iii) Introduce water saving technologies such as low-flow toilets and showers, efficient appliances
(iv) Collection of rainwater for garden, toilets, and other applications
(v) Promote water saving by advertisements

Pasture water supply:

(i) Increase public participation in water supply works
(ii) Improve pasture water supply according to the number of animals and pasture capacity
(iii) Reconstruct or rehabilitate wells and proper solution of their ownership problem
(iv) Study the possibility of diverting river runoff from the Arctic Ocean Basin to the southern part of the country i.e. to the dry steppe and semi-desert area

Irrigation:

(i) Introduce water saving technologies in irrigation schemes: drip, micro-spray, night irrigation, etc.
(ii) Introduce new varieties of crops that use less water and are salt-tolerant
(iii) Increase the efficiency of irrigation systems by e.g. rehabilitation
(iv) Erect cascade basins along the main rivers to regulate run-off and prevent floods
(v) Improve sowing areas on irrigated lands
(vi) Introduce water pricing
(vii) Use ground water more efficiently

Water quality:

(i) Improve waste water treatment plants (WWTP)
(ii) Recycle wastewater
(iii) Develop river protection and sanitation zones
(iv) Improve chemical and biological monitoring

Socio-economy issues:

(i) Train people of different ages and social statuses on water saving and sanitation methods
(ii) Increase public awareness to water related issues
(iii) Introduce water cleaning and softening technology
(iv) Introduce policy measures to ensure the equity in access to water
(v) Set out studies to estimate the impacts of hydrological disasters such as flash floods and thunderstorms
(vi) Improve the flood prediction and prevention system

4.6.3. Arable Farming

The vulnerability study indicates that climate change will have significant effects on crop yields in the Central cropland region of Mongolia. Therefore certain adaptation measures should be taken to anticipate these effects. They should be considered on both a national and a farm level.

One of the most important measures is the education of farmers and the general public in order to introduce appropriate farming management, which could prevent possible negative impacts. It is also important to focus agricultural research on the selection and creation of suitable crop varieties for possible options of climate condition. Relevant adaptation measures include:

(i) Improve land cultivation management.
(ii) Conduct studies of new crop varieties that have features such as earlier maturing, higher yields, disease and pest tolerance and drought resistance, etc.
(iii) Set appropriate sowing and planting dates according to expected temperature and precipitation.
(iv) Conduct studies on cultivation of alternative crop species, including winter wheat.
(v) Develop tree stripes in cropland areas to prevent soil erosion and to mitigate droughts.
(vi) Plant perennial and bushy vegetation in abandoned fields in order to conserve soil and mitigate the climate aridity.
(vii) Facilitate the information exchange between farmers at national and international level.
(viii) Improve the infrastructure to facilitate market interactions.
(ix) Solve problems related to land ownership.

4.6.4. Soil Degradation and Desertification

A dry and windy period (May-April) and heavy rain showers characterize the continental climate of Mongolia during the summer (2-5 mm/min), which causes severe surface washing. In addition, human activities such as urbanization, transportation, and overgrazing lead to land degradation and desertification.

The evaluated adaptation measures to prevent the possible impacts of climate change in cropland, field, and pasture land include land management strategies, especially the change of land use patterns to reduce soil loss caused by wind and water erosion. Erosion reductions can be reached in crop fields by cultivating the land along natural contours, planting buffer strips, bushy and woody plants, and by maintaining a constant crop cover. It is very important to maximize the utilization of the soil-protecting crop rotations. Soil erosion and degradation in pasture can be prevented by:

(i) Improving legislative mechanisms for pasture use, focusing on local communities
(ii) Establishing a suitable farming and pasture system that is flexible towards climate variations
(iii) Improving pasture water supply in order to avoid the concentration of animals around certain water sources
(iv) Improving the road network
(v) Restoration of the saxaul forest and other forests and planting woody vegetation in degraded area and area sensitive to soil moisture

4.6.5. Natural Disaster and Vector Borne Diseases

Asia, particularly Central Asia, and especially Mongolia, is one of the areas that is vulnerable to natural disasters. There is a clear indication that the frequency and magnitude of natural disasters increases due to climate change. The 17% drop in spring precipitation over the last 60 years has resulted in an increase in the risk of fires (Natsagdorj, 1999). The magnitude of fire risk probably varies with the intensity of the El Nino/Southern Oscillation (ENSO). The number of fire occurrences and the size of the area affected by fires have also increased significantly during the last few years. Economic damage amounts to several billion Tugricks, while ecological and social impacts have not been estimated yet.

In many Asian countries, including Mongolia, vector borne diseases are a major cause of morbidity and mortality. Rodents, bats and insects are involved in the transmission of infectious diseases. Their populations are known to fluctuate in response to global and local climate conditions. One outstanding example is the broad distribution of Brandt's voles in Mongolia, a phenomenon that could cause serious damage to the pasture carrying capacity.

Food borne trematode infections are a major public health problem in Mongolia and climate change could affect the incidence of infections directly and indirectly.

Response measures to prevent the increased occurrence of natural disasters and vector borne diseases are as follows:

(i) Strengthen the early warning system within the National Meteorological and Hydrological Service with regard to extreme weather events and hydrological disasters

(ii) Undertake full assessment of wild fire-risk zones and increase the public awareness

(iii) Strengthen preventive medicine activities in order to cope with possible vector borne diseases both for humans and domestic animals

4.7 Screening of adaptation measures

Even if the climate does not change as predicted, the adaptation options identified above will have significant benefits. Still, with each option implying its own set of problems and challenges, weighing the costs and benefits of each option in each sector is an important but complicated task for policy and decision. A simplified approach called the *Screening Matrix* was used to examine the adaptation options and evaluate their suitability for implementation. Selected adaptation options were assessed according to six criteria:

- Is this option high priority?
- Is the option in target of opportunity?
- How effective is the option?
- Will the option have benefits even if the climate does not change?
- How expensive will the option be to implement?
- Is there any barrier to implementation?

Adaptation options are qualitatively ranked as high, medium, and low against the criteria to indicate the preference. It should be kept in mind that those options with low costs and low barriers are easier to implement and are preferable to those with high rankings.

Typically, the screening of possibility/preference of a given adaptation option is indicated by a binary answer of *Yes* or *No*. However, the ranking as high, medium, and low was more desirable for policy objectives such as *Provide food security, Maintain social sustainability, Maximize Animal production, Maximize crop production, Combat desertification, Protect environment and water resources, Improve pasture water supply, Improve rural development, Maintain genetic diversity, Maximize export.* These objectives are more general and are summarized from those that have been identified in the policy documents such as *"National Action Programme for Water Resources", "Mongolian Action Plan for 21st Century", "National Action Programme for Mitigation Natural Disasters", "National Action Programme to Improve Health and Working Condition", "National Strategy of Development", "National Action Programme to Combat Desertification"* and others. The screening of these objectives is purely subjective, and is not based on specific integrated or economic models, nor upon certain quantitative analysis of the efficiency of adaptation options.

In general, according to Table 4.6, adaptation options such as (1) change in fertilizer amount, (2) education and increase of awareness of herdsmen, and (3) conservation of natural water resources have high priority, because of their projected high effectiveness and their ease of implementation in terms of cost and other barriers. Population control of animals according to pasture availability and river run-off regulation work appeared to be the most difficult option to implement, implying high costs and other barriers.

As mentioned above this assessment is more subjective. Some of the options also would have to be implemented in advance, before climate change becomes more active. The adaptation strategies that could provide economic, social, technical, and environmental sustainability while minimize uncertainties requires continued study, including a broad and comprehensive research agenda to develop the understanding of the climate system that will be needed for effective decision making.

To adapt to climate change and prevent its adverse effects, possible adaptation measures can be implemented as a part of national sustainable development strategies. Also, it is important to carry out advanced studies on those natural resources whose fates are uncertain, in spite of the fact that they will no doubt play an important role in the socioeconomic development of the country**.**

Table 4.6. Screening matrix for adaptation measures

Sector	Adaptation options	Priority	Target of opportunity	Effectiveness	Other benefits	cost	barrier
Arable land	*changes in planting date*	medium	low	medium	low	low	low
	changes in fertilizer	high	high	high	high	medium	low
	changes in variety	high	high	high	medium	high	medium
	improve irrigation efficiency.	medium	high	high	high	medium	low

	reduce soil erosion	high	high	medium	high	medium	low
Animal Husbandry	*Education and increase of awareness of herdsmen*	high	high	high	high	low	medium
and Range/Pasture land	*define impacts of natural disasters and identify risks associated with global climate change,*	medium	high	medium	medium	medium	low
	Determine an appropriate combination of pasture management and intensive livestock production system	high	medium	high	high	high	medium
	establishment of farming activity of animals for milk and meat supply	medium	high	high	high	high	low
	population control of animals according to pasture availability.	medium	medium	low	low	low	high
Water resources	*Promote river run-off regulation work*	high	high	medium	high	high	high
	Conservation of natural water resources	high	high	high	medium	low	low
	river water transfer from one basin to another	low	medium	low	medium	high	high
	introduction of water saving technology	high	high	high	high	high	low
	Introduction of water softening and purifying equipment	medium	high	high	high	medium	low
Soil Quality	*improving legislative base for pasture use,*	medium	high	medium	medium	low	medium
	proper selection of animals, set proper portion in farming and pastoral system,	medium	medium	high	medium	low	medium
	restoration of saxaul forest and plant woody vegetation.	high	high	high	medium	high	low
	improving road network	high	high	high	high	high	medium

CHAPTER 5 CLIMATE CHANGE RESPONSE POLICY

5.1. Introduction

Article 4.1(a) of the UNFCCC states,

> *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 greenhouse gases not controlled by the Montreal Protocol, and measures to facilitate adequate adaptation to climate change" (UNFCCC, 1992).*

In order to comply with its obligations and commitments under the UNFCCC, Mongolia has developed its National Action Programme on Climate Change. On 19 July 2000, the Mongolian Government approved this programme, which includes the Government's policies and strategies to deal with climate change related concerns and problems.

5.2. Mongolia 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 integrate climate change concerns into other national and sectoral development plans and programmes. The NAPCC is based on pre-feasibility studies on climate change impact and adaptation assessment, GHG) inventories, and GHG mitigation analysis. This Action Programme includes a set of measures, actions and strategies that enable vulnerable sectors to adapt to potential climate change and mitigate GHG emissions. The underlying philosophy of these measures is that they should not adversely affect economic development and current lifestyles.

The implementation strategies in this NAPCC include institutional, legislative, financial, human, education and public awareness, and research programs, as well as coordination with other national and sectoral development plans. Existing barriers to implementation were also identified, as well as possibilities to overcome such barriers. Finally, the programme considered several adaptation measures for animal husbandry and rangeland, arable farming agriculture and water resources.

Research activities will focus on systematic observation and monitoring of the climate system, development of climate scenarios, vulnerability assessment, potential impacts on ecosystems and society, and possible measures to adapt to climate change and mitigate GHG emissions at the national level. A regular update of findings and outputs using the latest scientific knowledge of global climate change problems will be critical. Based on comprehensive studies and analyses, the NAPCC should be revised from time to time in order to facilitate the implementation of Mongolia's policy on climate change.

It is recommended that a considerable amount of capacity building and institutional strengthening take place. Education and public awareness activities should be organized for decision-makers, technical experts, stakeholders, the general public, students, and school children. It will be periodically necessary to wage informational campaigns, distribute informative leaflets and other materials at national, regional and local level, and use the media to inform and educate Mongolia's society. A regular review of the level of public awareness of climate change will be essential to increase public participation in the GHG mitigation activities. Options for informal education in the field of environmental protection include use of mass media (newspapers, television, radio etc.) and organization of conferences and workshops for specialists, the general public and the press.

Successful implementation of NAPCC depends on explicit measure that can meet the requirements of adaptation and mitigation priorities. Therefore there have been identified number of projects that have high priority, high effectiveness, cost-beneficial and relatively easy to implement. Identified projects are summarized in Table 5.1.

Table 5.1 Identified projects for selected adaptation and GHG mitigation measures

	Project title	Brief description	Financial requirements:
	A. Adaptation projects		
1.	Education herdsmen and farmers on sensitive issues of climate change	To understand the reality of the climate change concerns, education and public awareness campaigns for agriculture people should be implemented.	Workshops, information materials and booklets. 0.4 mln US$
2	Converse and restore native rangeland vegetation	At present, the natural grassland is degraded and overgrazed. This tendency will be intensified due to climate change. Therefore, conservation and restoration would be an important task to provide animal husbandry with foods and forage.	Pre-feasibility studies and experiments in selected areas. 1.2 mln US$
3	Development of new agro-technologies for crop planting	It is an actual task to develop a new technology of arable farming suited to climate change.	Development of more suitable technologies in different zones. 0.75 mln US$
4	Establishment and introducing of new crop sowing and planting date	It is necessary to establish new sowing data for spring wheat and potato and introduce in main arable farming areas.	Assessment and experiments 1.5 mln US$
5	Advanced Assessment of changes in Permafrost area and snow cover in Mongolia: Effects and future recommendations	More than half of the country's territory covered by permafrost areas. Snow cover is a water source for animals in winter. So its changes will effect seriously on economy of the country. It is necessary a comprehensive studies and recommendations for future	Advanced assessment of changes in permafrost area and snow cover and prepare recommendations 0.9 mln US$

	Sub Total	agriculture management policy.	**4.75 mln US$**
		B. GHG Mitigation Projects	
1.	Improvement and reconstruction of the small sized boiler houses.	There are should be increasing efficiency of the small capacity hot water boilers. Emission of GHG will reduce 134.0 thousand ton in 5 year.	5 mln US$
2.	Demonstration and introduction of smokeless and high efficiency coal bracketing technology	This project is to provide smokeless coal briquette for households and small industry.	15 mln US$.
3.	Solar and Wind Energy Resources Assessment and Mapping	Mongolia has a rich solar and wind energy resources. But, it is necessary a detailed assessment of the renewable energy resources and make its mapping that covers all the country.	0.6 mln US$
4.	Building Insulation Improvement	Reduce heat losses in buildings and to develop energy efficiency concepts for space heating in buildings	0.5 Mln US$
5.	Carbon emission reduction through Replacement of Incandescent Bulbs with Compact Fluorescent Lamps	Reduces the consumption of electricity for lighting, Decreases electricity demand and evening peak load, while concurrently reducing emissions from power generation, and global and local environmental pollution	12.0 mln US$
6.	Demand Side Management Program for Mongolian industry	Reduces the energy consumption in industry, decreases electricity demand and evening peak load, while concurrently reducing emissions from power generation, reduces global and local environmental pollution	0.5 mln US$
7.	Modification of wet-type cement mills to dry-type mills in Mongolian Cement Industry	convert the production process of Darkhan Cement Plant from current wet to dry process and the second stage of this project is to convert the production process of Hutul Cement Plant from current wet process to the dry process	20.0 mln US$
8	COLLECTION AND TRANSPORTATION OF SOLID WASTE IN THE CAPITAL CITY	The project aimed to establish efficient waste collection and transportation system / network in cities	9.0 mln US$
9	Vehicle fuel efficiency improvement	The objectives are: -to establish standard procedures for rating fuel economy of vehicles; to establish a Vehicle Efficiency Testing Center; and to develop national policies in the implementation of vehicle efficiency standards and labeling.	0.9 mln US$
10	Sustainable energy centre	Management of the sustainable energy fund, implementation of energy efficiency and renewable energy programmes including awareness and training programmes	2.0 mln US$ **65.5 mln**

	SUB TOTAL		**US$**
	GRAND TOTAL		**70.25 mln US$**

5.3. Existing Barriers and Ways to Overcome Them

Each country has its own specific barriers to the implementation of adaptation and mitigation measures, such as limitations in financial and technical resources, human and institutional capacity, its legislative framework, and public support. For instance, in Mongolia the largest obstacle to reducing GHG emissions in the electricity and heat sectors is created by the obsolete techniques and technologies, the low coal quality, and insufficient operational funds. The most widely recognized barriers are considered below.

Institutional: Problems in Mongolia seem more or less recognized on sector levels, and they are being addressed to certain extent. However, there is no coordination of sectoral actions and shared responsibilities are not clearly distinguished between sectors. It is often found that:

- Certain mandates are not identified, or are not clearly allocated to a department;
- There are overlaps in competence, leading to interdepartmental conflicts;
- The management of the sector is therefore far from optimal.

Financial: Because of the difficulties facing Mongolia during this period of economic transition, the Government has failed to resolve financing issues. Although most of the international and domestic investments are allocated in energy supply and production, the problems the sector faces remain significant. In addition, low energy prices and insufficient payments for the use of heat and electricity contribute to serious deficiencies in plant maintenance and the incapacity to keep enough spare parts in reserve.

In regards to the adaptation measures, a lack of financial resources for initial investments stands to limit the implementation of the identified measures.

Technical: Most of the technologies applied in Mongolia’s energy sector are old and are plagued by low efficiency and high energy losses. The heat content of the feedstock coal is low and variable, which leads to combustion problems and poor plant performance. Lack of appropriate technologies and expertise is the most urgent technical problem.

Social: Because consumers generally have low incomes and are not aware of environmental problems related to energy use, energy prices in Mongolia cannot cover full costs. However, it should be possible to increase this awareness. Furthermore, the traditional way of housing may be changed leading to a decrease in energy use.

Legislative: Adequate policies and strategies should be established both at the national and the local level. At the moment, the legal, regulatory and standardization framework are inadequate to effectively implement adaptation and mitigation policies.

In general, the following actions should be undertaken to overcome existing barriers:

(i) Work out national and sectoral policies and strategies, and create an appropriate legislation for control and reduction of GHG emissions;
(ii) Privatize the power supply system;
(iii) Save resources by increasing energy efficiency;
(iv) Improve the management of thermal power plants and the distribution networks;
(v) Establish a suitable pricing system of power supply, which is accommodated to market requirements;
(vi) Introduce clean technologies for power and heat supply;
(vii) Apply environmental laws and standards;
(viii) Participate in multilateral and bilateral initiatives on climate change response actions;
(ix) Use the UNFCCC and Kyoto Protocol mechanisms such as clean development mechanism and technology transfer;
(x) Initiate public awareness campaigns;
(xi) Educate decision/policymakers, national experts, stakeholders and end-users;
(xii) Expand climate change research and studies;
(xiii) Establish an effective organizational structure.

5.4. Legislative Framework

One of the main instruments for the facilitating the implementation of the NAPCC is the legislative framework. The Government of Mongolia has already taken several steps to address environmental and natural resource issues. There is still no law nor regulatory mechanism that addresses climate change related problems. However, some of the existing laws and regulations, especially the environmental protection laws, directly or indirectly relate to emissions of pollutants, including GHG.

One option for the allocation of GHG emission limits among relevant sources and sectors is the introduction of emission permits. The allocation should be based on the inventory of the current emissions of production units and on the assessment of GHG mitigation potential.

Since 1992, the Great Khural (parliament) of Mongolia has passed several laws to support environmental protection. In addition, it passed the State Policy on the Environment in 1997, which forms the legal basis for the protection of the environment and Mongolia's natural resources. The Mongolian Environmental Action Plan was presented in 1995, outlining the country's priorities for environment and resource management. Subsequently, the Mongolian Action Plan 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. In particular, MAP 21 includes some considerations and recommendations related to adaptation to climate change and mitigation of GHG emissions. Finally, the Law on Air was ratified by the Parliament.

These legal instruments should provide a framework for compliance with the goals of the NAPCC. However, in order to implement the adaptation and GHG emission reduction measures, the establishment of special regulations related to climate change response measures—especially GHG mitigation measures—is of critical importance. National strategies to mitigate GHG emissions and adapt to climate change should be reflected in the laws and other legal instruments which regulate the development of relevant economic sectors such as energy, coal mining, agriculture, industry, transport, and infrastructure.

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

5.5. Institutional Framework

The implementation of the NAPCC requires a close coordination of policies for various sectors. Institutional problems in Mongolia seem to be more or less recognized at the sectoral level, and are being addressed to a certain extent. However, there is weak coordination of sectoral actions, and responsibilities are not clearly defined between sectors. Responsibilities for policy formulation and implementation are usually dispersed among several ministries and agencies such as agriculture, energy, local and provincial authorities. Climate change issues should be managed as a unity rather than through a sector-by-sector approach. Such integration does not mean that all responsibilities must be centralized, but that the responsibilities of all essential activities should be made explicit to all institutes and authorities involved. Implementation of the identified measures will also require good coordination among ministries and agencies. Financial assistance and evaluation of achieved results pose other important issues.

The Government has established the inter-disciplinary and inter-sectoral *National Climate Committee (NCC)*, led by the Minister for Nature and the Environment, to coordinate and guide national activities and measures aimed to adapt to climate change. High-level officials such as Deputy Ministers, State Secretaries and Directors of the main Departments of all related ministries and agencies are members of the NCC. The NCC approves the country's climate policies and programmes, evaluates projects, and provides guidance for these activities.

In order to carry out the day to day activities related to implementation of responsibilities and commitments under the UNFCCC and Kyoto Protocol as well as the NCC, and in order to manage activities nationwide and address climate change related problems in various sectors, the *Climate Change Office (CCO*) is established within the National Agency for Meteorology, Hydrology and Environment Monitoring.

The responsible organizations for climate change measures and actions are the Ministry of Nature and Environment (MNE) and Ministry of Infrastructure (MI). The National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM), which is directly under the supervision of the Minister for Nature and the Environment, has been designated by the government as the lead agency charged with climate change programmes and activities. The Agency is responsible for development of policies and strategies, programmes of action, and management and coordination of all activities related to climate change issues in Mongolia. The NAMHEM is responsible also for research on climate change, development of GHG emission inventories, national action programmes and plans, and the National Communications for the Conference of the Parties to the UNFCCC.

The Ministry of Infrastructure (MI) should be responsible for the implementation of GHG mitigation measures, improving the efficiency in the energy sector, and proper operation and maintenance of the station and distribution networks. Mitigation measures must be enacted in power and heat generation, mining, building and construction, and transport sectors. 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, the MI should provide technical and expert support for projects and measures that will address waste utilization, the introduction of renewable energy, and energy savings in the transport sector. The MI also is responsible for the prevention of damage to buildings, roads, bridges, and other constructions by permafrost melting.

The Ministry of Food and Agriculture (MFA) should be responsible for the implementation of measures and projects to mitigate GHG emissions from the industrial sector, and for measures to adapt to climate change in arable farming, animal husbandry, and water resources.

Other government institutions, NGOs, private enterprises, academic and educational institutions should be involved in planning as well as in implementation activities.

Of course, the responsibilities and involvements of specific stakeholder will be different according to the options to be implemented, but participation in various forms will be essential.

Since much of the actual implementation must be carried out at the atomized level of the farmers, herdsmen or communities, it is important that feasible and workable strategies are developed that will influence local habits and traditions. The knowledge and experience of herdsmen and farmers should be incorporated into these strategies in order to achieve optimal results. It is important that national objectives and policies 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 Centres of Meteorology, Hydrology and Environment Monitoring or Local Environmental organizations or the Local Governor's Offices.

5.6. Integration Measures with Other Related Programmes and Plans

The NAPCC 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 degree of integration of 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 the 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 activities.

The passing of new laws or amendment of existing laws—in particular policy or development programmes or plans guiding different economic sectors—should follow national and sectoral strategies and policies related to climate change concerns.

NAPCC will be implemented through the integration of the following existing national and sectoral action programmes, plans and policy documents:

- Concept of National Security of Mongolia, State Great Khural (Parliament) (SGK), 1994.
- National Development Concept of Mongolia, SGK, 1996.
- National Concept of Ecology, SGK, 1997.
- National Plan of Protected Areas, SGK, 1998.
- Mongolian Action Programme for the 21st Century (MAP-21), 1999
- National Environmental Action Plan of Mongolia, GoM 1993.
- National Programme for Natural Disaster Reduction, GoM, 1999.
- Power System Master Plan, ADB, 1996 (It will be updated in 2000)
- National Plan of Action to Combat Desertification in Mongolia, GoM, 1997.
- National Plan of Forestry, Mongolia, GoM, 1998.
- National Plan of Water, Mongolia, GoM, 1998.
- National Plan for Public Ecological Education of Mongolia, GoM, 1997.
- National Plan of Waste Management, Mongolia, GoM, 1999.
- Asia Least-cost Greenhouse Gas Abatement Strategy, Mongolia, ADB/GEF/UNDP, 1998.
- National Plan "100.000 sun's home" of renewable energy in rural area, GoM, 1999.
- Road Master Plan and Feasibility Study, ADB, 1996
- The Police on Promotion and Development of the Industry, GoM, 1998.

- Programme on Promotion of Manufacturing Products for Export, GoM, 1998.
- Programme on Promotion of Small and medium Enterprise, GoM, 1999.
- Renewable Energy Master Plan of Mongolia. Draft 2000.
- Coal Master Plan
- Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia. Draft

5.7. Socio-economic Mechanisms

Social and economic instruments play increasingly important roles in the successful implementation of the NAPCC. At present, there is no existing legal regulation to promote the economic interests of private companies, state owned facilities, and communities in the area of energy and heat use.

Economic instruments could take a limiting (taxes) or promoting (subsidies etc.) approach. Limiting measures include pollution tax, input tax, product tax, export taxes, import tariffs, etc. Promoting measures may include subsidies, soft loans, grants, location incentives, subsidized interest, revolving funds, sectoral funds, ecofunds, greenfunds, tax differentiation or exemption, investment taxes credits, tax relief for environmental equipment or investment, etc.

Mongolia has no experience with pollution or product charges and taxes to limit GHG emissions, and economic instruments to stimulate conservation and efficient utilization of energy, use of new and renewable resources, waste reduction or utilization. Therefore, it is necessary to establish economic mechanisms and instruments to implement the NAPCC, and to introduce an appropriate legal framework.

5.8. Financial Sources

The availability of funding sources is a prerequisite for successful implementation of the adaptation and mitigation strategies and projects identified in the NAPCC. Possible sources of such funding include:

(i) Government funds and resources
(ii) Sustainable Energy Fund that is funded by (a part of) the revenues of the proposed pollution abatement tax
(iii) Local and International Environmental funds
(iv) Private sector investors
(v) Regional and local banking institutions
(vi) Global Environmental Facility (GEF) assistance
(vii) Bilateral and multilateral adaptation and GHG mitigation support
(viii) Clean Development Mechanism initiatives
(ix) The UNFCCC and Kyoto Protocol Implementation Mechanisms such as Transfer of Technology, etc.
(x) International Bank Loans

In the case of Mongolia, foreign financial sources will play a crucial role in the implementation of the NAPCC because the national banking system is weak and Mongolia's private companies have very small financial reserves. Therefore, activities to expand existing cooperation with international financial sources should be undertaken at the national and sectoral level to secure financial and technological support.

CHAPTER 6 RESEARCH AND SYSTEMATIC OBSERVATION

6.1. Introduction

The UNFCCC obligates its Parties to develop and implement a systematic observation and research programme to manage activities and response measures that will mitigate climate change concerns. Effective implementation of the Parties' obligations under the Convention will depend directly on the level of:

- Understanding and knowledge of scientific and technical personnel, as well as policy makers, in the field of climate change.
- Institutional capacity to carry out research and training on climate change issues to satisfy reporting requirements
- Understanding and interpretation of local and regional climate changes and impacts.
- Ability of technical personnel to convey clear and concise information on climate change issues to policy-makers.

Therefore, it is recommended that a considerable emphasis be given to capacity building and institutional strengthening in order to ensure that these qualities and abilities are in place.

6.2. Research

Effective implementation of the climate change adaptation and GHG mitigation measures adopted by the Government or/and various agencies will require a mechanism for continuous research and updates on climate change scenarios and related subjects.

Research activities will be focused on development of climate scenarios at the global and regional level, the potential impacts on ecosystems and society and vulnerability assessment, possible ways and options to adapt to climate change and mitigate the GHG emissions at the national level. In addition, research should lead to regular updates of these findings and outputs using the latest scientific knowledge on global climate change. Based on these findings and analyses, the National Action Programme on Climate Change (NAPCC) should be updated and the implementation of national strategies and policies on climate change should be facilitated.

The National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM) is responsible for research, systematic observation and monitoring of the climate system. However, NAMHEM needs to upgrade and expand its capabilities in order to provide the information needed by the government and related agencies to implement appropriate response measures.

Research and studies related to climate change are performed mainly at the Institute of Meteorology and Hydrology (IMH). The IMH is requested to involve other sectors (energy, industrial, transport and roads, agricultural, animal husbandry, health and welfare, etc.) and academic (botany, biological, geography and permafrost, chemistry, etc.) research institutes and laboratories in pursuit of more comprehensive results and interdisciplinary/intersectoral conclusions. Therefore, Mongolia needs to establish a nationally coordinated research programme on climate change to ensure the improved coordination of activities designed to monitor and analyze climate change.

Climate change research and technology development programmes may include the following:

(i) A systematic climate observation and monitoring programme,

(ii) Climate system and climate change research,

(iii) Research on the effects of climate change on biophysical and socio-economic sectors and vulnerability assessment,

(iv) Studies on the development of response measures to adapt to climate change and to mitigate GHG emissions,

(v) Programmes to develop or/and transfer innovative environmentally sound and energy efficient technologies,

(vi) Database and information management activities.

(vii) Participation in international global and regional environmental research programmes such as the Global Climate Observing System (GCOS), the World Climate Research Programme (WCRP), the Global Atmosphere Watch (GAW), the International Geosphere-Biosphere Programme (IGBP), the Asia-Pacific Network for Global Change Research (APN), the International Hydrological Programme (IHP), etc., and the activities of the Intergovernmental Panel on Climate Change (IPCC).

6.3. Systematic Observation

Climate phenomena have been observed in Mongolia since 1896, but a systematic observation network was not established in the country until 1936. The National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM) and the Institute of Meteorology and Hydrology are the Government bodies responsible for research and systematic observation of climate phenomena in Mongolia.

Atmospheric process over this vast land area, such as the Gobi desert and Tibetan Plateau, play a significant role in the global atmospheric circulation. For example, the dust storms that transport enormous amounts of dust particles east and southeastwards are infamous in the region, and even the world.

The environmental monitoring programme of the NAMHEM is building up a very comprehensive database to support end-users. Recent Meteorological, Hydrological and Environmental observation and monitoring network composition is given in Table 6.1.

Table 6.1. Meteorological, Hydrological and Environmental observation and monitoring stations

Stations	Number
Meteorological	115
Aerological (Upper air)	7
Weather Radar	2
Zoometeorological	5
Agrometeorological	3
Actinometrical (solar radiation)	19
BAPMoN	1
Environmental monitoring Laboratory	22
Agrometeorological stations with limited observation programme	186
Hydrological	123
Environment monitoring laboratory	8

The basic observation network for international exchange of data in Mongolia is composed of 41 synoptic surface stations, 7 upper-air stations, and 1 radar station, spread out over the territory of the country. Among these stations, 28 surface and all upper-air stations are included in the World Weather Watch network. In addition, 4 automatic weather stations are presently in operation. There is one Mongolia-USA collaborative air sampling station at Ulaan Uul in the Gobi-desert area of Mongolia that has been included in the global flask monitoring network since 1992. This station is monitoring background levels of CO_2, CH_4, and CO concentrations in the atmosphere.

When spread out over the vast territory of Mongolia, this systematic observation network is inadequate. Due to limited human, technical, and financial capacities, the existing monitoring stations are incapable of monitoring all the parameters that are needed to carry out relevant climate change studies. There are significant gaps in the datasets. This limits the comprehensive research on climate system dynamics using the GCM scenarios and methodologies suggested by the IPCC and other international research centers, such as Technical Guidelines for Assessing Climate Change Impacts and Adaptation. With the close cooperation of international programmes and initiatives, he National Meteorological Service can improve and upgrade its monitoring capabilities.

CHAPTER 7 EDUCATION, PUBLIC AWARENESS AND INTERNATIONAL ACTIVITY

7.1. Introduction

At present, knowledge and understanding of current climate change and its consequences among the public and even decision-makers is very limited. Therefore, information campaigns, education programs and activities are an important component of Government strategies to address climate change problems. In order to provide an opportunity for public participation in adaptation and GHG mitigation activities, it is important to educate the public with climate change knowledge using the media, inclusion in school programmes, training to different target groups, and distribution of information materials and leaflets.

7.2. Education and Public Awareness

The education and public awareness activities should be targeted to specific target groups:

(a) *Decision makers*: It is necessary to prepare background information, outputs and recommendations from pre-feasibility studies, and provide them to policy makers who support decision making and policy development.

(b) *National technical experts:* The implementation of measures to overcome negative impacts of climate change will require national and international technical experts to conduct studies and carry out analyses. Training of different target groups is an important part of the climate change education program. This can be achieved through participation in local and international training and workshops which will improve the skills of national technical experts and other personnel related to the climate change issues.

(c) *Stakeholders:* Provide personnel of government agencies, NGOs, industries, financial agencies, and academic institutions with information about climate change so as to educate and enhance their participation in solving climate change problems.

(d) *Public:* Organization of regular information campaigns, distribution of informative leaflets and other materials at the local, provincial, and national levels are essential for informing and educating the society. A periodic evaluation of the level of public awareness on climate change can help to gauge participation in the GHG mitigation activities. Options for informal education in the field of environmental protection include using mass media

(newspapers, television and radio programmes, booklets), organizing specialized conferences to emphasize the issue, and holding workshops for the public and the press. There is significant potential reduce energy consumption by altering household practices, and therefore the awareness and motivation of the households becomes all the more critical. End-users should also be encouraged to take initiatives to save energy. Clear explanations of energy policy, the potential for saving energy, and the importance of saving energy are essential. Methods of dispersing information should be adapted to the end-user group.

The issue of adaptation measures and actions will be another important focus of public awareness campaigns. The public should be provided with information about potential impacts of climate change on natural resources and economic sectors, and response measures that will be taken to overcome problems related to water shortages, decreased crop yields and animal husbandry production, melting of permafrost, desertification etc.

(e) Students and school children: Students must be provided with knowledge of the environment and climate change, with optional courses in environmental education, and with special lessons on environmental issues. Activities outside the classrooms in the school programmes are also essential to the implementation of the plan.

Pilot projects, and dissemination of their results, will play an important role in tailoring the message about climate change to the target audience. Therefore, it is recommended that pilot projects on adaptation to climate change and on GHG mitigation actions be initiated. These educational experiments will help to demonstrate the advantages of the adaptation and mitigation measures to the consumers, stakeholders and end-users. Furthermore, materials used for educational and public awareness activities should be continuously developed, and a library/database maintaining materials for distribution, such as educational videos, should be set up to facilitate these activities.

7.2. International Activity and Special Needs

Relatively weak institutional arrangements, significant vulnerability to climate change, and limited capacity to deal with different problems all combine make international cooperation especially necessary to aid Mongolia in its development of response actions to address climate change concerns and implementation of Mongolia National Action Programme on Climate Change. Mongolia's specific needs for international cooperation include:

(i) Support in capacity building, training, research and monitoring,

(ii) Support in vulnerability and adaptation assessment and identification of adaptation measures,

(iii) Assistance in development of GHG mitigation policies and needs for technology transfer,

(iv) Financial and technological assistance in implementation of mitigation and adaptation projects,

(v) Support in climate change education and public awareness activities,

(vi) Assistance to meet national commitment and obligation under the UNFCCC,

(vii) Participation in the global and regional environmental research programmes and activities of the Intergovernmental Panel on Climate Change (IPCC).

Mongolia has consistently demonstrated its strong support of international initiatives in the area of climate change. Mongolia participated in the US Country Studies Programme (USCSP), the regional project on Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS), and the Netherlands Climate Change Studies Assistance Programme (NCCSAP). These projects enabled Mongolia to prepare its GHG Inventory for 1990-1998, to assess the potential effects of climate change on biophysical environment and economic sectors, and to develop GHG mitigation measures. Mongolia also received financial support from the Global Environmental Facility (GEF) to prepare its Initial National Communication (INC) for the Conference of the Parties (COP) to the UNFCCC.

Mitigation and adaptation projects that were identified in the NAPCC will require substantial international support and foreign investments. Therefore, successful implementation of national climate change response measures climate change will depend directly on the availability of financial resources and technical assistance. In order to secure this support from abroad, a close cooperation with the international financial mechanisms, bilateral and multilateral programmes and initiatives will be critical.

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