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# THIRD NATIONAL COMMUNICATION OF MONGOLIA

## Under the United Nations Framework Convention on Climate Change

May 2018

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Under the United Nations Framework Convention on Climate Change

Ulaanbaatar, Mongolia 2018

This **Third National Communication of Mongolia (TNC)** has been prepared in accordance with the UNFCCC Guidelines for National Communications for Non-Annex Countries.
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**Editor–in–chief:** Dr. Batjargal Zamba

**Project Director:** Mr. Batjargal Khandjav

**Director of the ECF:** Mr. Ganbaatar Khurelbaatar

**National Project Team:** Ms. Chuluunkhuu Baatar, Ms. Tegshjargal Bumtsend, Dr. Gerelmaa Shaariibuu, Mr. Zolbayar Purevjav, Ms. Indra Gankhuyag, Ms. Saruul Dolgorsuren, Ms. Sanaa Enkhtaivan, Ms. Davaasambuu Ulzii-Orshikh, Mr. Dorjzodov Nyamsuren

**Leaders of the Thematic Working Groups:**
Dr. Gomboluudev Purevjav
Dr. Dorjpurev Jargal

**Members of Thematic Working Groups:**
Dr. L.Natsagdorj, Dr. G.Davaadorj, Academician Ch.Dorjsuren, Mr. D.Enkhbileg, Ms. B.Gantsetseg, Dr. B.Burmaajav, Professor B.Namkhainyam, Mr. J.Landannorov, Mr. D.Gerelt-Od, Dr. G.Davaa, Dr. B.Bynie, Mrs. B.Erdenetsetseg, Dr. Ya.Jambaljav, Dr. N.Mandakh, Mr. B.Munkhbat, Dr. P.Batimaa, Ms. D.Munkhzaya, Ms. D.Delgermaa

**Individual Consultants**: Dr. D.Dagvadorj, Ms. B.Bolortsetseg, Professor S.Shiirev-Adiya,

# CONTENT

# LIST OF FIGURES

# LIST OF TABLES

# ABBREVIATIONS

| | |
|---|---|
| **AR5** | Assessment Report 5 |
| **AFOLU** | Agriculture, forestry and other land use |
| **AGB** | Above-ground biomass |
| **ALAGAC** | Administration of Land Affairs, Geodesy, and Cartography |
| **AUES** | Altai-Uliastai Energy System |
| **BAU** | Business as usual |
| **BCEF** | Below-ground carbon and expansion factor |
| **BEEP** | Building Energy Efficiency Project |
| **BGB** | Below-ground biomass |
| **BOD** | Biochemical oxygen demand |
| **BRT** | Bus Rapid Transit |
| **BUR** | Biennial update report |
| **CCCO** | Climate Change Coordination Office |
| **CCE** | Climate Change Education |
| **CCPIU** | Climate Change Project Implementing Unit |
| **CES** | Central Energy System |
| **CHP** | Combined Heat and Power Plant |
| **CMIP5** | Coupled Model Inter-comparison Project 5 |
| **COD** | Chemical oxygen demand |
| **CRF** | Common reporting format |
| **CS** | Country-specific |
| **CTCN** | Center for Climate Technology and Network |
| **DOC** | Degradable organic carbon |
| **EC** | Energy Conservation |
| **ECHAM5** | General circulation model (GCM) developed by the Max Planck Institute for Meteorology |
| **EECD** | Energy Efficiency and Conservation Division |
| **EES** | Eastern Energy System |
| **EIC** | Environmental Information Center |
| **ERC** | Energy Regulatory Commission |
| **ESCO** | Energy Service Company |
| **ESD** | Education for Sustainable Development |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FAOSTAT** | FAO statistics |
| **FOD** | First order decay |
| **FOLU** | Forestry and other land use |
| **GCM** | Global Climate Model |
| **GD** | Green Development |

| | |
|---|---|
| **GDP** | Gross Domestic Product |
| **GHG** | Greenhouse Gas |
| **GHG** | Greenhouse Gas Inventory |
| **GIZ** | German international cooperation agency |
| **GWP** | Global warming potential |
| **HadGEM2** | Hadlye Center General circulation model |
| **HFCs** | Hydrofluorocarbons |
| **HOB** | Heat only Boiler |
| **HPP** | Hydro Power Plant |
| **HWP** | Harvested wood products |
| **IEA** | International Energy Agency |
| **INDC** | Intended Nationally Determined Contribution |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IPPU** | Industrial processes and product use |
| **IRIMHE** | Information and Research Institute of Meteorology, Hydrology, and Environment |
| **JCM** | Joint Credit Mechanism |
| **JICA** | Japanese International Cooperation Agency |
| **LEAP** | Long-range Energy Alternatives Planning system |
| **LG** | Liquefied Gas |
| **LPG** | Liquefied Petroleum Gas |
| **LUC** | Land use change |
| **LULUCF** | Land use, land use change, and forestry |
| **M&E** | Monitoring and Evaluation |
| **MAXENT** | Maximum Entropy |
| **MCF** | Methane correction factor |
| **MET** | Ministry of environment and tourism |
| **MRV** | Measurement, reporting, and verification |
| **MSUE** | Mongolian State University of Education |
| **MSW** | Municipal solid waste |
| **NAMA** | Nationally Appropriate Mitigation Action |
| **NAMEM** | National Agency for Meteorology and Environment Monitoring |
| **NCEP** | National Center for Environmental Prediction |
| **NCV** | Net calorific value |
| **NDVI** | Normalized Difference Vegetation Index |
| **NFI** | National forest inventory of Mongolia |
| **NSO** | National Statistical Office |
| **NUM** | National University of Mongolia |
| **PFCs** | Perfluorocarbons |
| **PV** | Photovoltaic |

| | |
|---|---|
| **R&D** | Research and Development |
| **RA** | Reference approach of energy sector |
| **RCP** | Representative concentration pathway |
| **RE** | Renewable Energy |
| **REDD** | Reducing emissions from deforestation and forest degradation |
| **RegCM4** | Regional Climate Model 4 |
| **SA** | Sectoral approach of energy sector |
| **SAR** | Second assessment report of IPCC |
| **SD** | Sustainable Development |
| **SES** | Southern Energy System |
| **SHS** | Solar Home System |
| **SREX** | Special Report on Extremes |
| **SWDS** | Solid waste disposal sites |
| **TAM** | Typical animal mass |
| **TNA** | Technology Needs Assessment |
| **TNC** | Third National Communication |
| **TOW** | Total organically degradable material in wastewater |
| **TTOP** | Top of Temperature Permafrost |
| **UB** | Ulaanbaatar |
| **UNDP** | United Nations Development Programme |
| **UNEP** | United Nations Environmental Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WB** | World Bank |
| **WES** | Western Energy System |
| **WG** | Working group |
| **WHO** | World health organization |

# UNITS

| | |
|---|---|
| **cap** | capita |
| **$CO_2e$** | carbon dioxide equivalents |
| **d.m.** | dry matter |
| **g** | gram |
| **Gcal** | Giga calorie (1 Gcal = 1’000’000’000 Calories) |
| **Gg** | Gigagram (1Gg = 1000t) |
| **Gg** | Gigagram |
| **GWh** | Giga Watt-hour (1 GWh = 1’000’000 kWh) |
| **ha** | hectare |
| **kg** | kilogram |
| **km** | kilometer |
| **kV** | kilovolt |
| **kWh** | kilowatt hour |
| **l** | litre |
| **$m^3$** | a cubic meter |
| **Mt** | million tonnes |
| **MW** | Megawatt (1MW = 1’000’000 watt) |
| **MW** | Megawatt |
| **MWh** | Megawatt hours |
| **t** | tonne |
| **t** | tonnes |
| **Thou. heads** | thousand heads |
| **TJ** | Terajoules |
| **yr** | year |

# GASES

| | |
|---|---|
| **$CO_2$** | Carbon dioxide |
| **$CH_4$** | Methane |
| **$N_2O$** | Nitrous oxide |
| **$SO_2$** | Sulphur oxide |
| **$NO_x$** | Nitrogen oxides |
| **CO** | Carbon monoxide |
| **NMVOCs** | Non-methane voltaic organic compounds |
| **HFCs** | Hydrofluorocarbons |
| **PFCs** | Perfluorocarbons |

# FOREWORD

Climate change is the global challenge with severe environmental, social and economic implications. Losses and damages occurred around the world due to climate change-induced disastrous events have been undeniably devastating. The world nations commonly have acknowledged that the impacts of climate change and urgency to take response measures which are clearly indicated by an approval of the historical Paris Climate Agreement at the UNFCCC COP 21 in 2015. Upon an operationalization of the Green Climate Fund (GCF) in 2013 and approval of the Paris Agreement in 2015, the momentum has built and awareness has risen to accelerate the implementation through active and efficient collaboration across government, business, non-governmental and, international organizations and citizens to achieve the climate and development objectives.

In Mongolia, not only natural resources but also key socioeconomic sectors, like agriculture are adversely affected by altering climate condition. The frequency and magnitude of natural hazards including harsh winter (dzud), drought, snow and dust storms and flash floods are increasing and thereby climate change has tremendous impacts on traditional livelihoods. Observed data at meteorological stations in Mongolia have shown that an annual mean air temperature increased by 2. 24°C between 1940-2015; the warmest 10 years in the past 76 years occurred in the last decade; winter precipitation has increased and further projected to increase while an annual precipitation decreased by 7% over the past 76 years, resulting in a higher aridity index. In addition to the drying landscape, changes in water availability are expected to continue. Furthermore, the rural-urban migration has increased due to the socio-economic conditions, environmental degradation, and dzud, causing burden on the urban centres which are not prepared to provide basic social services and livelihood opportunities for those migrants. Rural and urban livelihood alike is very much affected by and vulnerable to climate change impacts.

The Government of Mongolia has adopted national and sectoral strategies and policies which address climate change adaptation and mitigation issues such as National Action Plan on Climate Change (2011-2021), the Green

Development Policy (2014-2030), the Intended Nationally Determined Contributions under the Paris Agreement (2015-2030), the State Policy on Renewable Energy (2015-2030), and Mongolia's Sustainable Development Vision 2030. In terms of the national policy implementation, through the international and bilateral cooperation, solid demonstration projects implemented and initiatives are in place based on successful international cooperation mechanisms like Green Climate Fund, Adaptation Fund, GEF and as well as bilateral cooperation arrangements with Japan, Germany and other partner countries.

Further, the Government of Mongolia is striving to achieve collective impact in climate change and integrate the collaboration among various stakeholders in adopting sustainable natural resources management, developing climate resilient infrastructure, building capacities and mobilizing funds towards the low carbon and climate resilient development.

The Third National Communication of Mongolia under the UNFCCC has brought together the findings of the latest climate change studies in Mongolia to raise awareness of decision-makers, private sector and general public on the status of current and future climate change and its environmental, social and economic implications, as well needs and gaps in term of capacity, technology and finance so that appropriate response measures can be planned and implemented.

On behalf of the Government of Mongolia and myself, I would like to thank UN Environment and the Global Environment Facility for the technical and financial assistance provided in preparing this report. Special acknowledgments and thanks must be given to the Mongolian team of national experts and as well as key ministries, agencies, stakeholders, research institutions and non-governmental organizations for their contributions and efforts in preparing this valuable report. I firmly believe this report will serve as a useful information resource for the domestic and international communities and will be utilized as the basis for the national and sectoral policy development, and international cooperation.

TSERENBAT Namsrai
Member of the Parliament
Minister of Environment and Tourism

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Great efforts were made by more than 40 national experts from various sectors to collect data and conduct climate change studies, relevant assessments, GHG inventory and future scenario development. Thus, a special credit goes to the thematic working groups led by Dr. Gomboluudev Purevjav and Dr. Dorjpurev Jargal. Moreover, a special recognition goes to those organizations have been involved and dedicated their time to the TNC development process by providing valuable data, information, feedback and technical advice: National Statistics Office (NSO), National Agency Meteorology and Environmental Monitoring (NAMEM), the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Ministry of Energy (MoE), Ministry of Food, Agriculture and Light Industry (MoFALI), Ministry of Construction and Urban Development (MoCUD), Ministry of Road and Transport Development (MoRTD), Ministry of Mining and Heavy Industry (MoMHI), Administration of Land Affairs, Geodesy and Cartography (ALAGC), Municipality of Ulaanbaatar city, Energy Regulatory Commission (ERC), Forest Research and Development Center (FRDC), Water Supply and Sewerage Authority (WSSA) and other stakeholders.

The development of TNC has involved not only the national experts and agencies but also experts from international organisations, who provided valuable technical assistance and support. The special thanks are extended to Nairobi Office of United Nations Environmental Programme (UN Environment), the Global Support Programme (GSP), United Nations Programme for Reducing Emissions from Deforestation and Degradation of forests in developing countries (UN-REDD), and GIZ Project for "REDD+ National Forest Inventory".

Special thanks also go to the Ministry of Environment and Tourism and Climate Change Project Implementing Unit (CCPIU) of Environment and Climate Fund (ECF) which mobilized a dedicated team of national experts and the scientific advisor to ensure the quality and effectiveness of works. This team of hardworking experts has successfully managed the whole process in a timely manner, completed the national GHG inventory in accordance with IPCC 2006 guidelines, and compiled the report.

Throughout the entire process of TNC development, the most of involved experts and government officials were able to learn from each other, gain new technical skills, which made the cooperation more effective. Without the collaboration and dedication of the team members and all relevant stakeholders, this report would not have succeeded.

We wish to express a great appreciation for everyone and best wishes for fruitful cooperation in the future.

**Editor-in-chief**

# EXECUTIVE SUMMARY

## 1. National circumstances

***Geography:*** Mongolia is located in north-east Asia and bounded between 41°35'-52°06'N latitudes and 87°47-119°57'E longitudes. The country territory is occupied 1564.1 thousand. sq. km, which extends 2392 km from west to north and 1259 km from north to south. Mongolia borders with the Russian Federation to the north and Republic of China to the south and the total length of the national border is 8252.7 km.

***Climate:*** The climate of Mongolia is harsh and continental due to its very unique geographical location in the center of the Eurasian continent such as high elevation above sea level, surrounded by high mountains and highly remote location from the sea. Therefore, main features of Mongolian climate are characterized by high seasonality with very distinct four seasons, high amplitude of temperature and low precipitation. Latitudinal and altitudinal spatial distribution could be clearly distinguished in any geographical distribution of climate variables. The annual mean air temperature is about -4°C in the Altai, Khangai, Khentii and Khuvsgul mountains ranges, -6-8°C in the depressions between mountains ranges, also along the valley of big rivers, 2°C in the steppe-desert region and 6°C in the southern part even exceeds. The annual precipitation exceeds 400 mm at high mountain belts, while 300-400 mm in the Khangai, Khuvsgul and Khentii mountains and also in the Khalkh river basin in the Eastern region, 250-300 mm in Mongol Altai and forest-steppe, 150-250 mm in steppe and 50-150 mm in Gobi and desert region. In the south-inner side of Altai Mountain, annual precipitation ranges even less than 55 mm. About 85% of total precipitation falls from April to September and among them, 50-60% falls only in July and August.

***Land use:*** According to the land use classification (integrated land fund/ resource), land cover of Mongolia is classified into following classes: 73.5% of the country is considered for agricultural land use (0.9% of which for crop production, 1.5% for hayfield and 96.2% to be pasture); 0.46% is occupied by urban area; 9.6% is forest including bush and shrub; 0.4% is to be water bodies and remaining 1.7% belongs to unused land. However, depending on definition and classification terms, the percentage of forest cover appears to be different in some sources. For example, the forest cover of Mongolia is to be 11.89% in forestry source while according to land use classification, forest cover percentage is 9.14% of the country (ALAMGC, 2015). By 2014, the total area of the national protected area national protected area reached 27.2 million ha and it occupies 17.4% of Mongolian territory. The economy of Mongolia and food security of population directly depends on the agricultural sector and many other sectors of the economy such as mining mainly based on land resource. Therefore, soil erosion, desertification and any other forms of land degradation are key important problems of Mongolia that require urgent solutions.

*Water resource and glaciers:* According to the research findings, the surface water resource of Mongolia composed mainly from lake water which is about 500 $km^3$ and another 19.4 $km^3$ accumulates in glaciers. An average river runoff is estimated to be 34.6 $km^3$/year. River runoff 30.6 $km^3$ forms within Mongolian territory and remaining 4 $km^3$ of river runoff forms in neighboring countries and flows through Mongolian territory, and the reachable groundwater resource is estimated to be 10.8 $km^3$. In 2010, water use rate was 326.3 million $m^3$/year and it is expected to increase up to 478.2 million $m^3$/year in 2021 according to the low use scenario. In mid scenario, water use increase rate will be 26.8% and will be doubled in high scenario compare to this low use scenario.

*Forest resource:* According to forest report of 2016, Mongolian forest resource is estimated by 18454.6 thou.ha, 17911.1 thou.ha (97%) of them corresponds to the forested area and 543.5 thou. ha (3%) in the forest zone. About 68.6% of forest area (12280.0 thou.ha) is covered by forest. From them, 11500.4 thou.ha is occupied by natural trees, 777.5 thou.ha by shrubs and bushes, 2.1 thou.ha by planted forest and 31.5% (5631.1 thou.ha) area has not yet covered by forest. The ratio between forested areas and the total area of territory as expressed by percent is called forest richness, which is estimated by 7.9 percent (CFRD, 2016). Mongolian forest resource consisted of more than 140 species of trees and shrubs. Among them, 62.5% is occupied by larch, 10.4% by birch, 5.4% by cedar, about 4.2% by pine, 1.4% by willow, 0.3% by aspen, 0.2% by spruce, 0.1% by poplar, 0.03% by elm, 0.01% by fir as respectively. In 2014, the National Forest Inventory was conducted with the support of German Development Cooperation Agency (GIZ). Results show that coniferous and deciduous forest coverage in the northern part of Mongolia is 9.1 million of ha, growing stock volume 1036 million of $m^3$, growing stock volume per hectare is 114 $m^3$/ha. Aboveground dry biomass is 60.3 tonnes/ha, its carbon pool-30.7 tonnes C/ha, belowground biomasses 18.3 tonnes/ha, its carbon pool is 9.3 tonnes C/ha.

*Biological resource:* Nowadays, there are 18300 species of vertebrates, invertebrates, and plants registered in Mongolia as biodiversity. At present, 39 orders, 112 families, 683 genus and 3127 species are registered in Mongolian plant kingdom. Among the officially registered species, 153 species are native and 458 of them endemic. Moreover, 1574 species of algae, 1030 species of lichen and 470 species of mushroom have been registered. From the plant kingdom, 195 species are introduced in Mongolian Red Book as critically endangered and near threatened. In case of the animal kingdom, 138 species of mammals, 476 species of birds, 16 species of reptile, 6 species of Amphibia, 74 species of fishes and about 13000 species of insects are registered in Mongolian harsh ecological condition. Since 1998, another 52 new bird species registered. According to the law on fauna, 28 species of mammals belonging to extremely rare and another 76 of animal species to be a rare animal list by the Government resolution under No. 07 from 2012. Due to danger to living environment of animals, about 11% of mammals near threatened, 3% are vulnerable or extinct risk in the wild, the number of bird species reduced by 4%. Also, the assessment stated that 11% of critically extinct species of plants already extinct, 26% under near threatened, 37% at high risk of extinct in the wild and about 15% may become rare.

*Government structure:* The governance of Mongolia is parliamentary and composed of Government and local government units and politically unitary state. In terms of administrative delineation and units, Mongolia consists of 21 aimags (provinces) 329 soums (villages) and 1560 bags. As for the capital city of Ulaanbaatar, consists of 9 districts and 132 khoroos. In the constitution of Mongolia states that administrative and territorial management to be implemented by corporate management of local self-governance and the state control. Therefore, administrative and territorial units have a special organization, which is called "Citizen Representative Khural" for local management similar to the public council. The decentralization process is still in progress since 1990s.

*Population:* Population growth rate of Mongolia was highest in Asian continent reaching 2.1-2.5% before 1990s. At the end of 2015, the total population of Mongolia has reached 3057.8 thousand (NSO, 2015). Birth rate per 1000 people increased in 2006-2009 and reached 25.7 in 2009 and then observed slight decrease up to 23.1 in 2010 and increased 25.1 in 2011 again. Since 2012, the birth rate has a continuous increasing trend and in 2015, the birth rate of Mongolia reached 28.0 per 1000 people. An average life expectancy of the country in 2015 is 69.9 year. An average life expectancy according to gender diversity, for women is 75.84 years and for men is 66.02 years. By the end of 2015, 68 percent of Mongolian population lives in cities and towns.

*Macroeconomy:* Besides natural barriers such as harsh and arid climate, landlocked geographical location, Mongolia is trying to overcome different obstacles and problems related to the transition from a planned economy to a market economy. Although having to reach yet at planned targets and results in each area, the government organizes several complex measures related to privatization, liberalization on trade and investment and integrated exchange rate and going ahead keeping the general orientation of country's development.

Due to a rapid growth in the mining sector from 2008 -2012, macroeconomic indicators are much improved and economic growth reached 17.5% in 2011. This growth was one of the highest in the world, however, depending on several internal and external factors, could not keep this performance and economic growth of the country is slowed down to 12.3% in 2012 and 11.6% in 2013 and 7.9% in 2014 and 2.3% in 2015. The main reason for such decline was price decrease of Mongolia's few export products such as coal, iron ore, copper, and other mining products in the world markets.

Animal husbandry is still occupied an important role in country's economy, employment and export earnings. About 12.8% of GDP of the country compounds by the agricultural sector and 77.5% of it created by animal husbandry (livestock) by 2015. 35.0% of country's total workforce belongs to the agricultural sector and 7.0% of export of the country comes from this sector (NSO, 2014). Although over 20 percent of the animals are lost during severe dzud of 2009-2010, the sector has been revived back again. By the end of 2015, the number of livestock reached a historical record level of 56 million of heads. However, due to the over exceeding livestock density and as well as climate change the pasture degradation has become the critical issue in Mongolia.

In the past, arable farming did not have an important role in Mongolian agricultural sector. However, since the 1960s, cultivation campaign of prairie land has begun and the new agriculture sector has formed. Cultivated and planted lands significantly increased from previous years and by 2015, 390.7 thou. ha of area cultivated for crops and 12.8 ha for potatoes and 7.7 thou. ha of vegetables were planted in 2015 (NSO, 2014). Thus, Mongolian arable farming sector is almost fully meet domestic demand by grain and potato crops and nearly provide more than half of the vegetable needs. Unfortunately, under continental dry climate condition with frequent droughts, a variation of harvest is high and unstable.

*Energy resource and energy production:* The coal is the main resource for Mongolia for energy and heat production. However, environmental pollution issues, especially burning raw coal and use for different purposes are becoming very serious problems of the society. Besides the ineffective use of coal, air pollution has become an extremely critical issue for cities especially for the capital city of Ulaanbaatar due to use of coal in individual houses (Ger Districts) and thermal power plants for heating and energy production. Renewable energy resources of Mongolia are estimated as abundant. Yet still have not fully utilized the renewables due to finance and other challenges. However, it is notable to mention that with the financial mechanisms are in a place such as Joint Credit Mechanism (JCM), Green Climate Fund (GCF) and multilateral financial channels, several private sector-led renewable energy projects are implemented in Mongolia including 50 MW wind farm under CDM, two individual 10 MW solar power plants under JCM, 10 MW solar plant under GCF and 50 MW wind farm funded by multilateral financial agencies.

***Legal Framework:*** Mongolia has joined the United Nations Framework Convention on Climate Change (UNFCCC) in 1993, the Kyoto Protocol in 1999 and the Paris Agreement on Climate Change in 2016. Therefore, these documents are international legislative bases and statement to follow on climate change policies and strategies. Although there is no special law on climate change in Mongolia, there are some other laws which reflect the concept and support climate change-related measures and activities. In another word, the climate change issues have yet precisely and completely reflected in related laws and development programmes of Mongolia. However, to some extent, the general principle and concept of policy and legal framework on climate change are considered in Mongolia. For example, these legislative documents: the Law on Air, Law on Energy, Law on Forest, Green Development Policy, Sustainable Development Vision 2030, National Programme on Climate Change and Mongolia's Intended National Contribution, are all reflected mitigation and adaptation needs and appropriate measures.

## 2. National Greenhouse Gas Inventory

The main sources of GHG emissions have been divided into the following sectors: Energy (CRF 1), Industrial Processes and Product Use (IPPU, CRF 2), Agriculture (CRF 3), Land use, Land use change and Forestry (LULUCF, CRF 4) and Waste (CRF 5).

Total GHG emissions in Mongolia in 2014 were 34,482.73 Gg $CO_2$e (excluding LULUCF). This represented 57.09% increase from the 1990 level of 21,950.73 Gg $CO_2$e and 5.49% increase from the 2013 level with 32,687.27 Gg $CO_2$e. Net GHG emissions in 2014 were 10,030.80 Gg $CO_2$e (including LULUCF).

This represented 1,034.44% increase from the 1990 level of -1,073.46 Gg $CO_2$e and 23.23% increase from the 2013 level with 8,139.60 Gg $CO_2$e.

In general, emission and removal from each sector increased in 2014 comparing to the base year and differences are showed in the Table by percentage changes and absolute values of each GHG inventory sectors.

Table 1.1 Mongolia's GHG emissions/removals by sectors in 1990 and 2014

| Sector | Emissions and Removals, (Gg $CO_2$e) | | Change from 1990 (Gg $CO_2$e) | Change from 1990 (%) |
|---|---|---|---|---|
| | 1990 | 2014 | | |
| Energy | 11,091.14 | 17,267.79 | 6,176.64 | 55.69 |
| IPPU | 218.66 | 328.06 | 109.39 | 50.03 |
| Agriculture | 10,585.30 | 16,726.98 | 6,141.68 | 58.02 |
| Waste | 55.62 | 159.91 | 104.29 | 187.49 |
| Total (excluding LULUCF) | 21,950.73 | 34,482.73 | 12,532.00 | 57.09 |
| LULUCF | -23,024.18 | -24,451.93 | -1,427.75 | 6.20 |
| Net total (including LULUCF) | -1,073.46 | 10,030.80 | 11,104.26 | 1,034.44 |

GHG emissions in 2014 from the energy sector were 17,267.79 Gg $CO_2$e accounting for 50.08% of total national emissions. The second highest sharing of the total emission was from the Agriculture sector with 16,726.98 Gg $CO_2$e accounting for 48.51%. Emissions from IPPU and Waste sector contributed 328.1 Gg $CO_2$e (0.95%) and 159.91 Gg $CO_2$e (0.46%) respectively to the national total in 2014.

Comparing to 1990, sectoral emission increase for the Energy sector were 55.69%, for the IPPU sector were 50.03%, for the Agriculture sector were 58.02%, for the Waste sector 187.49% and removal for the LULUCF sector were 6.2% in 2014.

Two main sources of the total emission were Energy and Agriculture sector for all years of the inventory. However, the percentage share of emission sources was varied year by year depending on economic and climatic factors such as demand increase in the energy sector and natural disaster occurrence in the agriculture sector.

## 3. Present climate change and future projections

*Present climate change:* Near-surface temperature and its annual mean over Mongolia have increased by 2.24°C between 1940-2015 periods according to

48 meteorological stations, which are evenly distributed in the territory. Warming intensity is higher in a mountainous region and less in the steppe and Gobi region. The warmest 10 years in last 76 years occurred since 2000.

In Mongolia, 85% of total precipitation falls in the warm season and only 3% even less precipitated as snow in winter. There was no significant change in annual precipitation during last 76 years, only small 7% decrease is detected. However, winter snow is getting to increase. Since 1940, it was increased by 22% and also 40% since 1961. It indicates that winter snow is suddenly increased due to high-intensity global warming.

According to trends of some extreme climate indices, frost days are decreased by nearly 15 days, while summer days are increased by 19 days in last 45 years, 1971-2015. Monthly maximum of daily maximum temperature is increased by 2.6°C, while the monthly minimum is increased by 0.3°C. Also, warm spell duration indicator is increased by 13 days.

Since 1940, drought condition has been increased; especially consecutive drought years are continued since 2000. Among them, 2000, 2002 and 2015 are mostly affected to socio-economy in the country. If there is a severe drought in summer and harsh condition next winter, the mass number of livestock loss occurs as usual. Therefore, dzud is evaluated by a combination of summer and winter condition (Natsagdorj, 2001). The study shows increasing of dzud intensity in Mongolia since 1990s. Among them, dzud in 1999-2000, 2001-2002 and 2009-2010 are most severe and consequently, damage and loss were relatively higher compared to other years.

*Future climate change:* Future projection of winter, summer and annual mean of temperature and precipitation over Mongolia are estimated by ensemble mean of 10 GCMs from 2016 to 2100 under high (RCP8.5), mid (RCP6.0) and low (RCP2.6) GHG emission scenarios. Generally, temperature change directly depends on the intensity of GHG emission. However, winter temperature change slightly low and inter-annual variability is higher than compared to summer temperature change. The intensity of temperature changes is similar for all RCP's scenarios until the first half of this century and then it gives different results while increasing year to year. In near future 2016-2035, the seasonal temperature change will range only 2.0-2.3°C, but it will be expected as 2.4-6.3°C depending on each RCP scenarios in far future 2081-2100. For precipitation change, winter snow is expecting to increase and summer rainfall has no significant change, there is only slightly increasing less than 10% for all scenarios. Winter snow will be increased by 10.1-14.0% depending on each scenario in near future and by 15.5-50.2% in far future as respectively.

## 4. Climate change impact, vulnerability, and adaptation assessment

*Current changes in surface water:* The annual total river flow since 1978 varies, gradually increasing and reaches its maximum value of 78.4 $km^3$ in 1993. Long lasting low flow period steadily continues since 1996 and reaches its minimum of 16.7 $km^3$ in 2002. 22.7 $km^3$ of annual, total river flow was formed in 2015, which is lower than its long-term mean by 11.9 $km^3$.

There were 4296 lakes, covering total water surface area of 15514.7 sq.km, acquired from a topographic map scaled as 1:100000, compiled, based on air photos taken in the 1940s. The lake area data, retrieved from LANDSAT ETM, TM and L8 satellite images show that there were 3464 lakes with a total surface area of 14312.6 sq.km in 2015. Accordantly, total lake area reduced by 7.8% or 1201.9 sq.km and 832 lakes were dried out in 2015, in comparisons with data of 1940s.

Detailed comparisons of areas of individual glacier massifs derived from different sources of data show that areas of glacier massifs tend to be overestimated with topographic map compiled in 1940s. The total glacier area, distributed in 42 mountain massifs, derived from a topographic map, scaled as 1:100000, was 535.0 sq.km in 1940$^{th}$. Glacier areas, retrieved from LANDSAT satellite data, were 389 sq.km in 2011. Accordantly, glacier areas retreated by 13.75 in 2000-2011 periods. Totally glaciers retreated by 29.9 in last 70 years. Glacier retreat and shrinkage intensified after 1990s and most intensive ablation occurred in last 10 years (Davaa G, 2015).

*Future climate change impact on water:* An average water temperature, projected by RegCM4-ECHAM5 model output results will increase by 0.7-1.5°C and 3.2°C in periods of 2016-2035, 2046-2065 and 2080-2099 in the AOB and by 1.5°C, 1.6°C, and 3.3°C in the POB and by 0.8°C, 1.6°C and 3.1°C in the AIDB in comparisons with a water temperature of the 1986-2005 period. The projected average water temperature by RegCM4-HadGEM2 is expected even higher than that projected by RegCM4-ECHAM5 model.

An annual mean precipitation, projected by RegCM4-ECHAM5 is expected to increase in 2016-2035, 2046-2065 and 2080-2099 periods by 0.01 mm, 30.6 mm, 53.7 mm in the AOB, by 0.01 mm, 20.6 mm, 32.9 mm in the POB and by 0.02 mm, 19.9 mm, 41.4 mm in the AIDB, respectively comparisons with the annual mean precipitation observed in 1986-2005 period. An annual mean precipitation, projected by RegCM4-HadGEM2 model results is higher than that projected by the RegCM4-ECHAM5.

An annual mean (Apr-Oct) evaporation from open surface of water, projected by RegCM4-ECHAM5 is expected to drastically increase in

2016-2035, 2046-2065 and 2080-2099 periods by 143.5 mm, 162.3 mm, 221.6 mm in the AOB, by 164.7 mm, 364.5 mm, 370.2 mm in the POB and by 106.8 mm, 96.1 mm, 150.2 mm in the AIDB, respectively comparisons with the annual mean evaporation from open surface of water, observed in 1986-2005 period. The evaporation, projected by RegCM4-HadGEM2 model results is less than that projected by the RegCM4-ECHAM5.

An annual mean runoff depth, projected by RegCM4-ECHAM5 is expected to increase in 2016-2035, 2046-2065 and 2080-2099 periods by 0.0 mm, 8.9 mm, 15.6 mm in the AOB, by 0.0 mm, 4.0 mm, 6.2 mm in the POB and by 0.0 mm, 2.1 mm, 4.3 mm in the AIDB, respectively comparisons with the annual mean runoff depth, observed in 1986-2005 period. The runoff, projected by RegCM4-HadGEM2 model results is less than that projected by the RegCM4-ECHAM5.

According to the river basin specific projections on water balance elements, almost no changes in precipitation and accordantly no changes in runoff are expected in the period of 2016-2035. However, the annual mean (Apr-Oct) evaporation from the open surface of water and evapotranspiration are expected to drastically increase that will lead to an imbalance of water, drying effect will be prevailing in river basins.

*Change of forest cover:* Recently, the forest cover of Mongolia is significantly changing due to the combined effect of climate change and human influences. Direct causes of such changes are logging, frequent forest fire, epidemics of insects and mining activities etc. Among the mentioned factors affecting on forest resource, logging, animal grazing, and mining activities are considered as local human-related activities. According to forest inventory, forest area of Mongolia was 13.1 million of ha in 1999 while forest area is estimated to be 12.3 million ha in 2015. It reduced by 806.0 thou.ha or by 6.6% (approximately by 50.4 thou.ha or 0.41% in every year). As for last 5 years (2010-2015), forest area has reduced by 759.0 thou.ha or 6.2% (reduction rate is 47.5 thou.ha or 0.39 percent per year). Statistics of 1999-2015 show that 11.1 million $m^3$ of wood logged in country scale (which is equivalent to 3.3 million ha of forest), every year on average 206 thou.ha of area forest area destroyed by a forest fire and harmful insects propagated in 571 thou.ha area (total area is 9.1 million of ha) during this period.

The area affected by forest fire is increased by 650.8 thou.ha or 38.1% (annually 130.0 thou.ha or 7.6% in a year) in 2010-2015 and are disrupted by harmful insects also increased by 76.0 thou.ha or 127.0% (increase of destroyed forest area due to harmful insects by 15.2 thou.ha or 25.5%) in same period and all these indicate intensifying of forest degradation.

The studies have shown that a number of forest fire occurrences and size of fire affected area has a close correlation with spring dryness (drought-summer condition) index where correlation coefficient reached 0.62.

*Future impact on the forest ecosystem:* There is a high probability of shrinkage of forest area in the low land area while in high mountains observe shifting up of the upper boundary of forest boundary due to the melting of permafrost, increase of heat accumulation with increasing of phenology period and intensifying of the photosynthesis process.

The statistical correlation study under RCP4.5 scenario indicates that occurrence of forest fire will be increased by 34-51 cases for periods of the beginning of the century (2016-2035), mid of century (2046-2065) and at the end of century (2081-2100). Also, study results show that area of forest affected wildfire and harmful insects expected to increase in given periods by 175-403 thou.ha and 450-872 thou.ha, as respectively. Under the RCP8.5 scenario, this trend will be 2-9 times greater than baseline and intensity of changes much exceeds previous scenarios.

The potential distribution change due to climate change for all species is compared to current distribution. In average the spatial distribution will decrease by up to 4% for RegCM4-ECHAM5 and up to 6% for RegCM4-HadGEM2 climate change projections during this century. Only Pinus sylvestris will increase by 4% near future and Betula platyphylla and Pinus sylvestris by 2% in far future with projection RegCM4-HadGEM2.

*Permafrost distribution in Mongolia:* Northern and high mountainous regions of Mongolia have continuous and discontinuous permafrost, while sporadic and isolated permafrost distributes in the foothills and slopes of Altai, Khangai, Khuvsgul and Khentii mountain ranges, as well as along small river valleys and in depressions (Jambaljav Ya, 2016). As a reference to the latest permafrost map by the scientist Ya. Jambaljav et al., the permafrost occupies about 29.3% of the country's area from isolated to a continuous distribution in Mongolia. Using the mean annual ground temperature (MAGT) at the bottom of a seasonal thawing (at the top of the permafrost) and / or the mean annual ground temperature at the bottom of a seasonally frozen layer (where there is no permafrost), the country's area was divided by continuous (MAGT <-2°C), discontinuous (-2°C <MAGT <-1° C), sporadic (-1°C <MAGT <0°C), isolated (from 0°C <MAGT <± 1°C) and seasonal frozen ground (+ 1°C <MAGT), respectively.

The permafrost temperature has been increased by 0.04-0.29°C for every ten years. The temperature of permafrost in all boreholes involved in some studies show increasing trend by 0.15-0.22°C in every 10 years, while the temperature of the borehole located in the bank of Monguush dry bed in the Darkhad depression has increased by 0.29°C in every decade.

*Future impact on permafrost:* Future change and impact of permafrost change have been estimated by TTOP (Temperature on Top Of Permafrost) model. Inputs of the model are an annual mean temperature selected from outputs of future climate change models such as RegCM4-HadGEM2, RegCM4-ECHAM5 and snow cover and vegetation cover, and soil thermal characteristics.

Distribution of permafrost took 28.01% or 0.44 million of $km^2$ of the total territory of Mongolia during the period of 1986-2005, while permafrost area expected to cover 22.88% or 0.36 million $km^2$, 10.88% or 0.17 million $km^2$, and 1.48% or 0.02 million $km^2$ of area of the territory of Mongolia, respectively in 2016-2035, 2046-2065, and 2080-2099 as indicated by RegCM4-HadGEM2 modeling results.

The model output of RegCM4-ECHAM5 shows that permafrost degradation will take place in 4.61% of the total area within a period of 2016-2035 and about more than 50% of them will be regions with the continuous type of permafrost.

Overall, results according to the two models conclude that permafrost area of Mongolia is expected to reduce by 16.46-18.31% in 2016-2035 and such reduction of permafrost regions will be continued in 2046-2065 and 2080-2099 by 33-61.23% and 74-94.7%, respectively.

*Changes observed in the pasture:* About 82% of the territory of Mongolia is considered as natural pastureland as main source livestock grazing as well as only largest grassland ecosystem in the world which conserves unique native landscape. However, it is clearly indicated that process of degradation of soil and pasture is intensifying in Mongolia based on satellite images and ground measured observation due to negative human influences and climate change impacts. According to the results of the assessment of desertification and land degradation situation on 2015 done by specific factors of trends and changes of the Desertification Atlas of Mongolia (DAM, 2013), 76.8% of Mongolian territory has been affected by desertification and land degradation.

The assessment of the state and capacity of pasture has concluded that about half of Mongolian pasture area still have yet lost essential characteristics as pasture ecosystem if succeed to change present improper utilization practice and from then within 10 years Mongolian pasture can recover or improve the situation.

Key reasons for pasture degradation are excessive overgrazing, which is caused by exceeding of pasture capacity due to the vast number of livestock and increasing intensity of droughts and dryness.

*Soil fertility:* Ecosystem models are used for the estimation of the content of soil and pasture and their future changes. According to the recent analysis which applied outputs of regional climate change model uses NCEP analysis data, 1986-2005 (P.Gomboluudev, 2016), the highest contents of organic carbon and organic nitrogen are observed in the upper layer of soil or at depth of 0-20 cm or 4550 g/m$^2$ and 410 g/m$^2$, as respectively. In high mountain regions, the content of organic carbon of in the soils is 2180 g/m$^2$ and 2660 g/m$^2$ in the steppe region, while the lowest content of organic carbon, 1330 g/m$^2$ in the soils is observed in desert steppe regions. As for nitrogen content, it is similar to carbon content or higher values in the soils of high mountain area (410 g/m$^2$) and it varies from 220 to 75 g/m$^2$ in the steppe and desert regions. In case of model outputs, aboveground biomass varies around 20-30 g/m$^2$ while belowground biomass is 480-1460 g/m$^2$ which are 22-45 times greater than the aboveground biomass. The amount of aboveground biomass is around 30 g/m$^2$ and the below-ground biomass is 1100-1460 g/m$^2$ in the forest-steppe and steppe region. These values also somehow express soil fertility of the region.

*Impact on soil fertility and pasture yield:* The future state of soil and pasture of Mongolia was estimated by Century model using outputs of future climate change projection data by REGCM4-ECHAM5 and RegCM4-HadGEM2 models. The state of pasture is projected in following three future periods as 2030 (2016-2035), 2065 (2050-2065) and 2080 (2081-2100) under a moderate scenario of stress on pasture use. Estimated results show that aboveground biomass is expected to reduce, especially more intensive reduction in 2080.

Modeling results demonstrated that under the high-stress condition on pasture use, all characteristics of pasture are expected to decrease which limits growing, yielding capability of plants and further weakens root systems. All mentioned situation cause soil and pasture degradation and intensified conditions for further desertification. More intensive reduction of soil and plant productivity is related to excessive overgrazing of pasture land, wherein the forest-steppe and steppe regions.

*Pasture fatality caused by rodents.* Recently, an areal propagation of some harmful insects and rodents has clearly observed with the increase of the occurrence of drought and climate change intensity. For example, propagation of Brandt's vole (gerbil) and grasshopper have been occurring in steppe region and caused huge damage to the pasture during the drought of 2000-2002. Moreover, propagation of this harmful insects spread in arable farming land causes significant loss of harvest, crop yield and vegetable during these years. For the assessment of future impacts under climate change, grasshopper distribution is estimated by REGCM4-ECHAM5 and RegCM4-HadGEM2 model outputs. The assessment shows that high propagation of Barabensis grasshopper can be reduced slightly at the beginning of the century and further tendency propagation of grasshopper is expected to increase with climate change intensity.

According to MaxEnt model simulation, Barabensis grasshopper is distributed in 4,473 thou.ha over Mongolia. This area of distribution is extending to change with slight decrease by 1.4% in 2016-2035, increase by 5.2% 2046-2065 and by 4.6% in 2081-2100 according to RegCM4-ECHAM5 model output.

*Impact on biodiversity:* An impact assessment has estimated a size of relic area and distribution area in total of 12 species of mammals, birds, and insects of Mongolia using baseline data of 1986-2005 and outputs of climate models of RegCM4-HadGEM2 and RegCM4-ECHAM5 for particular future periods of 2016-2035; 2046-2065 and 2080-2100.

An average relic area of the baseline of 1986-2005 and model outputs of 12 species was 119543±15222 km$^2$ (n=12). At the same time, an average of model outputs for three mentioned periods (24 changes of two different models) have been decreased by 97102±11108 (n=24), 97908±10415 (n=24) and 298777±11974 km$^2$ in 2016-2035, 2046-2065 and 2080-2100, respectively. In case distribution area, a mean of 12 species was 525551±69303 km$^2$ (n=12) and an average of projected distribution area by models for three mentioned future periods (24 changes of two different models) will be decreased by 417591±40535 km$^2$ (n=24), 415417±40809 km$^2$ (n=24) and 430803±43547 km$^2$, 2016-2035, 2046-2065 and 2080-2100, respectively.

Biodiversity of Mongolia, namely within some selected animal species, their mean values change and projected reduction for relic and distribution area are consistent with regional climate model results. It can be concluded that overall impact assessment has a certain confidence.

*Impacts on wheat yield:* The future wheat harvest pattern has been estimated by DSSAT v4.6 model which based on the outputs of regional climate models by RegCM4-HadGEM2 and RegCM4-ECHAM5 under the RCP8.5 scenario. Changes in wheat yield are estimated by comparing wheat yield in baseline climate calculated by the models with an average yield of wheat estimated for 2020, 2050 and 2080 time slices under the emission scenarios. According to the model analysis, wheat yield changes estimated by DSSAT v4.6 model, which projected by two mentioned regional climate models, is expected to decrease by 9%, 18% and 37% under RCP8.5 emission scenarios according to the ensemble mean of models in 2020, 2050 and 2080, respectively.

*Impact on animal husbandry:* The number of livestock was quite stable between 20-25 million during the old socialist period since 1940s of the last century. Then since mid-1990s, after privatization of livestock sector, it sharply has increased and reached to 61.5 million at the end of 2016, which previously had never been achieved. The traditional structure of livestock herds was significantly broken in the last 20 years. Nowadays (in 2016) goat population accounts for 41.6% of the total livestock herds. It is clear that goat population increased due to demand of cashmere market, which makes up a significant portion of herder’s income. At the same time, the number of the cattle herd which grazes pasture with tall grass due to biological specific characteristics, accounts for 9.7% of the total livestock during the period of 1960-1990, while its percentage is reduced till 6.6% after dzuds of 1999-2000. The winter season is becoming harsher because of increase of winter precipitation in the form of snow and frequency and intensity of dzud have much increased due to the above mentioned two factors, and consequently and negatively impacted to animal husbandry.

According to the future climate change projections, the intensity of drought and harsh winter (dzud) is expected to increase in Mongolia. The percentage of possible animal losses in near future under moderate GHG emissions scenario, RCP4.5 is estimated by relationship of future intensity of drought, wintering, and dzud indexes, and animal loss which is based on the results of 10 global climate models (ensemble mean) which provide the best simulation of the past climate of Mongolia. The estimation shows that about 5.5% of the livestock which counted at the beginning of a year, will be lost in mid of this century and this percentage will reach to 7.6% at the end of this century. Thus, livestock loss is expected to increase by about 50% in the mid of this century compared to the present situation and loss will be doubled by end of the century compared to the present loss rate. A significant increase of livestock losses certainly will affect negatively on the reproduction of livestock which directly relates to the livelihood of herders and food supply to the population.

Due to climate change, plant productivity and yields much weakened in last twenty years in most parts of Mongolia. Especially in the central part of the country as well as in western part of the eastern region, the plant productivity has decreased by 5-13% in 1961-1990. In return, it has affected unfavorably on livestock grazing and further influences on live weight of animals. The live weight of a mature Mongolian Cow generally has a tendency to decrease from 1980 to 2015. Measurement results are shown that fluctuations of live-weight of animals are increased significantly in recent years. It seems to be a live-weight decreasing of winter-spring is higher than a live-weight decreasing of summer-autumn. Also, increasing of live weight fluctuation is indicating that increasing of herd's vulnerability due to its environmental change. The meat and wool yields of animals also have a decreasing trend in connection with a summer-autumn decrease of live weight of cattle. Similar trends also to appear in sheep and goat's measurements cases.

Impacts of climate change on distribution and propagation of livestock disease is not much studied and only outlined the very general way on a global scale. It appears that climate change can influence the ecology or environment and in the way of animal disease infection. Detailed research evidence and data on animal disease are very limited in Mongolian case.

The pasture water supply is a critical issue for improvement of pasture use. A warming of the water temperature due to future climate warming would provide an improvement of ecosystem productivity and positively impact on livestock water supply in the cool and high mountain regions of the country. However, increasing trend of evaporation predicts entirely dry conditions for Mongolia. Therefore, water resource is expected to be one of the crucial challenges for Mongolia. Consequently, it will likely affect the water supply of pasture to a certain degree.

*Impacts on natural disasters:* About 10 different types of natural disasters occur in our country, which causes significant damage to the socio-economy of the country. Most of them are originated from atmospheric phenomena. If natural disasters are ranked according to the risk of socio-economic, drought, dzud, forest and steppe fires, snow storms, floods and extreme cold are considered to be major disastrous events in the country. Some statistics registered since 1989, show that about 49 extreme and disastrous events related to the atmospheric phenomena occur in Mongolia in every year. Considering their occurrence in 2 decades of last 20 years, it shows that around 30 extreme and disastrous events were observed in the first decade, while these statistics have increased by 2 times in the second decade.

Among the disastrous and extreme events, which occur in Mongolia, strong winds, flash floods, thunderstorms, and squall are appeared to be the most frequent disasters and take 22.4%, 22.4% and 15% of the total disasters, respectively. In total, 308 people have killed due to extreme and disastrous events in a period of 2004-2015 and 40.0% of them caused by strong wind storms, 24.0%, and 16% are due to flash floods and lightning, as accordingly. The frequency of heavy rain and flash flooding, squall winds, hail, and lightning is increased sharply in Mongolia and cases which lead to danger and damages have been increased by 2 times in last 20 years.

Percentage of damage caused by disasters in the gross domestic product reached 7.5 – 11.5% during the years of 2000 and 2001, where country's economy was weak. In 2010, when almost 23% of the total livestock has been lost due to dzud, the percentage of damage caused by natural disasters took 6.22% of the GDP (from a percentage of GDP of the previous year).

It is estimated that frequency of disastrous events related to the atmospheric phenomenon is expected to increase by almost 23-60% by the middle of this century in any climate change scenario. The assessment of future projection for drought and dzud have been done by estimating index, which represents summer and winter conditions defined by monthly air temperature and precipitation data used in the assessment of future climate change of Mongolia (Gomboluudev P, 2014) by Global Climate Models. Drought frequency is expected to increase by 5-15% under moderate scenarios of GHG and by 5-15% under high emission scenario. Relatively intensive increase (15%) is to be observed in the southern part of the country by 2020 and 2050 under average scenarios of GHG and in the central part of the country by 2080. In case of high emission scenarios of GHG, about 15% increase is to be observed in 2020 level in western and eastern parts of the country. Furthermore, increases are to be observed until 20-25% and 30-45% in 2050 and 2080, respectively.

The frequency of dzud is expected to increase by 5-20% under moderate scenario and in case of high emission scenario; the increase will be around 5-40%. Relatively intensive increase (15%) is expected to occur in south-east and northern parts of the country at the end of this century or at the level of 2080 under moderate scenarios, while 40-45% increase is expected to occur in the north of Mongolia.

*Impacts on public health:* Climate change-related heat waves, air pollution, flooding, drought, water shortages and pollution and impacts of climate on agriculture are likely to affect the health of our country's population in direct and indirect ways. Due to mentioned impacts of climate change, may spread out of cardiovascular and respiratory diseases, including asthma, diarrhea, and malnutrition, transmitting infectious diseases and other infectious diseases may increase among the population, especially among children. Even potentially may increase emerging and re-emerging infectious diseases.

In the last 34 years of climate warming, respiratory disease is may decrease while cardiovascular has increased. Increasing of cardiovascular diseases is possible to increase the frequency of heat waves. The frequency of heat wave has a direct correlation with the mean air temperature of the summer season (Natsagdorj L, 2008). There is some evidence of an increase of infection of tick-borne encephalitis caused by forest ticks. According to survey and data of the National Center for zoonotic disease, 7 people died due to above-mentioned infection in 2005-2015. According to this relationship, there is a high probability of morbidity of tick-borne diseases are caused by forest tick under climate warming. The estimation done by above relationship shows that number of victims of tick-borne encephalitis expected to increase by 80% by mid of this century and even may increase up to 2 times at the end of the century.

*Integrated vulnerability and risk assessment of climate change:* The quantitative assessment of climate change for the basic natural components of the ecosystem such as water resources, forests, permafrost, wildlife, pasture-soil and natural disasters and key socio-economic sectors such as arable farming, animal husbandry, and human health have been done using results and outputs of the global and regional climate change dynamic models. The quantitative impacts of the mentioned components and sectors appear in different dimensions and units. Therefore, it is certainly needed to integrate results of impacts by the different sectors and carry out vulnerability and risk assessment of climate change. For this purposes, indices were determined, which express the current and future risks. Parameters of the particular sectors which most closely related to climate change are selected as indicators for the assessment. These indicators are determined at provinces and regional levels and converted into one dimension using normalization method of the UN's human development index (HDI, UNDP, 2006). Finally, the current average value of the normalized indicator is considered a vulnerability index, while future mean values are to be considered as risk index.

In this assessment, quantitative impact assessment results of different sectors in a period of 2046-2065 have been used, which is based on climate change projection downscaled by the regional climate model RegCM4-ECHAM5 and

RegCM4-HadGEM2. As results indicated the current vulnerable and risk indexes for all environmental and socio-economic sectors will be increased in Mongolia. In general, in the current situation of sectors belongs to the "vulnerable" classes and it is expected to become "much risky" class during the 2046-2065 period. Concerning situation at the regional level, depending on their specific condition it is to be different from regions to regions and climate change vulnerability and risk index is averaged within the region by aimags as well. According to climate change projection, the vulnerability and risk index will be increased in all regions and aimags of Mongolia.

## 5. Climate Change Adaptation Policy and Strategy

Climate change has become a challenging problem over the recent decade that needs to be dealt with immediately due to its detrimental effects. Since the 1990s, there have been several scientific assessments conducted on climate change; this further allows the formulation of long-term policy on adaptation to climate change. Due to geographical location and topography features, climate change will be much more severe in Mongolia in near future. Adaptation and mitigation strategies to a certain extent are being reflected in the government policies such as the "Green Development Policy" which deals with the coordination of environment and economic activity. However, there are certain measures to be taken that will overcome barriers which include dealing with at the institutional and structural level, investment and funding levels, and at the social level.

The most of economic activities in our country will be dependent on natural resources such as pasture, animal husbandry, agriculture and water resources. Due to the shift of geographical transition zone which is the basis for agricultural lands, pasture availability and crop development of arable farming will be changed and even in some cases crop yield can be improved to some extent in some regions. However, most agricultural producers are needed to make substantial investments in order to adapt to the climate change and potentially may face significant losses. And change will affect to increase competition for water resources in regions with scarce water scarcity and impacts on the well-being of the community. Therefore, the government adaptation strategies should focus on the following key issues. *Animal husbandry:* expansion of production of clean products and providing sustainable food security for citizens and creating a livestock sector which overcomes risks and is adapted to climate change to produce a raw material for light and food industries. *Arable farming:* in ensuring domestic needs in farm-based food and animal feed through mitigation of risks related to potential negative impacts and full beneficial use of the positive impacts of climate change. *Water resources:* reducing the risks of water resources that are related to climate change, protection of water quality and resources, ensuring sustainable water supply to the population, industry and agriculture and prevention of flood hazards. *Forest resources:* build and strengthen the capacity of the forest sector to adapt to climate change by reducing the negative consequences of climate change and most effectively using the positive of climate change impacts of climate change. *Public Health:* improve and strengthen the health systems capabilities in accordance with the protection of human health against adverse impacts of climate change and adaption to climate change.

To ensure economic, social, technical and environmental sustainability, to eliminate uncertainty and to develop future strategies for adaptation, requires long-term research activities. Comprehensive and detailed scientific analysis and research play an important role in understanding and cognition of a complex nature of the climate system in order to provide support for decision-making on climate change.

## 6. Policies and Measures to Mitigate GHG Emissions

Mongolia's primary source of energy is coal; it is estimated that there are 173 billion tonnes of coal. Coal-fired thermal power plants accounted for a total of 96.1% of the total electricity supply in 2015; a total of 5541.74 GWh of electricity. There are quite numbers of regulations in place aimed at reducing GHG emissions by increasing renewable energy and improving energy efficiency. Such as Mongolia's 2030 Sustainable Development in energy supply related goals include: the share of power demand supplied by domestic power generation sources will be 100% by 2030, the share of renewable energy sources in total installed power capacity for domestic supply will be 30% by 2030, the use of nuclear energy for electricity and heat generation for the period 2025-2030. Mongolia's Renewable Energy Law was approved in 2007 and renovated in 2015. Its purpose is to regulate the generation and delivery of power from renewable energy resources and to encourage the development of privately financed power projects by setting up the legal framework that will allow electricity from Renewable energy to be bought. One of the main factors which are contributing to energy usage is heat loss in buildings. Green Development Policy aims to decrease heat loss by 40% by 2030 by insulation improvements for existing buildings and the implementation of new energy-efficient standards for new buildings. The Energy Conservation (EC) Law of Mongolia was approved by the Parliament on 26 November 2015. The EC Law mandates large energy consumers to undergo an energy audit and to report annually its energy consumption as well as its plans and activities to reduce their energy consumption. Furthermore, the EC law could promote ESCO activities to overcome the barriers to the implementation of Energy Efficient Projects in Mongolia.

Energy efficient motors are expected to be introduced as motor systems consume 70% of the total electricity, this will significantly save electricity; with a potential of 20% reduction in electricity consumption. GHG emissions from industries are increasing due to the development of mining and quarrying. Measures are being taken such as the introduction to dry-processing technology to produce cement in order to decrease GHG emissions. One of the main ways to decrease emissions is to limit the increase in the total number of livestock by exporting meat and meat products and to limit the increase rate of livestock production. In terms of waste, to increase the amount of recycled waste.

## 7. GHG Emission Projections

GHG emissions from Power and heat plants are calculated by using the LEAP model; a tool that simulates a scenario-based energy-environment model. LEAP model includes sectors such as buildings, industry, transport, and agriculture. The total energy demand from all sectors is expected to increase by 2.7 times in 2030. The energy sector accounts for 52% of the total GHG emissions. The second largest source is agriculture sector accounting for 37%. Lastly, industrial and waster sector accounts for 11% of the total GHG emissions. If mitigation strategies such as the usage of hydropower power plants, wind parks, and large-scale solar PV's are implemented by 2030, the total GHG emission is expected to decrease from 37,308.00 Gg $CO_2$e to 33,431.00 Gg $CO_2$e. The state policy for energy sector aims to decrease energy wastage to 7.8% by 2030; which is a 5.9% decrease compared to 2014. Energy waste will be decreased through the installation of efficient lighting and demand-side management at designated energy consumers. One of the main GHG emission sectors is the agricultural sector. The reduction of livestock population by increasing livestock export is a major mitigation strategy.

## 8. Technology Needs Assessment

Due to geographical location, the effects of climate change are intensified in Mongolia. Adaptation of technology is divided into 3 sectors; hardware, software and orgware technologies. From the vulnerability and impact assessment, a list of adaptation technologies has been made. To assess the specific types of adaptation technologies, the rate of reducing climate change, positive effect on the economy, environmental and social sectors and investment benefits have been prioritized. In the arable farming sector, due to the intensity of drought, overheating and evaporation, a growth rate of wheat will decrease by 9-37%. To counteract this, 13 technologies have been introduced such as agro-forests, early warning systems, and insurance and information technology to ensure the sustainability of crops. In terms of the livestock sector, the reduction of pasture yields and changes to the plant composition from climate change caused a loss of 5.5% and is expected to increase to 7.6% by the end of the century. The introduction of adaptation technologies such as fodder production, water supply, and pasture and livestock management will help to improve the immunity to overcome the effects of climate change. Similarly, in other sectors such as the water resource, forest resource, some biological diversity, public health and natural disasters, the introduction of adaptation technologies is expected to decrease the effects of climate change. However, there are still barriers and obstacles which could be faced during the scale-up and implementation stages. Reasons such as lack of finance, lack of policy and decision making, lack of human resource capacity and the lack of research studies.

Laws such as the "Law on Technology Transfer (1998)" promote the introduction of technologies which minimizes or reduces GHG emissions and waste related to pollution. The energy sector is the biggest contributor to GHG emissions; with non-renewable resources taking up the majority. Unfortunately, utilization of the sources is not used at an efficient level. Creating an optimal structure of sources for energy system will increase the efficiency of electricity production and reduce GHG emissions. The implementation of advanced technologies in energy production, increasing renewable electricity capacity by up to 30%, reducing electricity transmissions losses are the suggested options to be introduced in the near-future. Implementation of projects such as increasing the share of renewable energy in the total energy generation by up to 30%, and the introduction of small hydro-power plants, wind power generators, (PV) Solar Systems and Geothermal Heat pumps will greatly affect the efficiency of the integrated energy system in a positive manner. In terms of heating systems, it is divided into 3 different types of systems: district heating systems, medium-capacity heating systems and small-capacity heating systems, and low-pressure hot water boilers. Reducing the number of small capacity and low-pressure boilers and instead focusing on the development of the district heating system will increase the efficiency of heat transfer and most importantly, reduce GHG emissions. Coal accounts for 96% of the total fuel utilization, although it is cheap and plentiful, its detrimental effects on the environment are unavoidable. The introduction of coal combustion technology (CFB) and coal-bed methane utilization for hot-water heating boilers will significantly reduce air pollution and GHG emissions. The introduction of thermal insulation technology will be one of the main factors in reducing the consumption of electricity, thus saving energy which ultimately reduces GHG emissions. Introducing new technologies such as dry cement production technology will decrease GHG emission by twice, so the introduction of other technologies that increases efficiency should be promoted. In terms of the livestock sector, technologies related to grassland protection such as the implementation of sustainable grassland management will decrease the effects of pasture degradation. In Mongolia, waste is managed poorly; mostly waste-disposal open dumps are present. Instead of this, the introduction of technologies related which generates energy from methane production from solid waste treatment or by burning the wastes is a more efficient way to manage waste and further establishes a more sustainable and balanced future.

## 9. Constraints and gaps, and related financial, technical and capacity needs

Mongolia, like many other developing countries, has specific barriers to the implementation of adaptation and mitigation measures such as financial and technical resources, human and institutional capacity, and public support. The biggest problems facing the electricity and heat production sectors in reducing GHG emissions are the use of obsolete techniques and technologies, the low coal quality, and insufficient funds.

The implementation of mitigation measures requires a high level of technical capacity and effective coordination across different sectoral agencies, which are currently a challenge for Mongolia. Most of the technologies applied in Mongolia's energy sector are still out of date and have a 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. A lack of appropriate technologies and know-how is the most urgent technical problem.

Other key financial, technical and capacity barriers include a lack of support by financial institutions for renewable energy investments (particularly hydro-power plants); lacks domestic technological and technical resources for clean fuel production; and Carbon capture and Storage-CCS plant.

Moreover, reporting of National Communications including GHG inventory and BUR is financed by GEF enabling activities through UNEP. In other words, there was no substantial government financing (except in-kind contribution) for these reporting requirements because of the economic difficulties in Mongolia, as the country is undergoing a transition period and the Government fails to resolve financing issues as required national circumstances and needs.

## 10. Other relevant information

*Climate change research studies:* Climate change research studies in Mongolia significantly improved over 20 years such as dynamic downscaling of global climate model results into on a regional scale using dynamic models, assessment of interaction between atmosphere and land cover, defining climate change risks in various socio-economic and natural components, technology needs assessments for adaptation, development of adaptation policies and strategies to climate change and assessment of pale-climate using tree ring growth and geological sediments. A considerable amount of works have been done on assessing impacts of climate extreme condition such as drought and dzud on pastoral livestock, as well as quite a few studies have carried out on climate change impacts and consequences. Up to now, Mongolia uses greenhouse gas emission standard factor which recommended by the methodology of Intergovernmental expert group on Climate Change (IPCC) and has been done for the first time some amendments (Namkhainyam B et al., 2013) in the pastoral livestock sector within Government project of Mongolia in 2012-2013.

*Climate observation networks:* At present days, 135 meteorological stations are operating in Mongolia and carrying out permanent observation in accordance with the standard programme of the World Meteorological Organizations (WMO). Another 180 meteorological posts which only conducting observation during the daytime. Since 1993, began to install Automatic Weather Stations (AWS) in the meteorological observation network and today the network consists of 90-95 of AWSs and some of them combined with human observation and AWS. Furthermore, there are quite many monitoring stations and posts operate throughout Mongolia including 8 solar radiation stations, 11 stations for radiation and radiation balance, greenhouse gas monitoring station at Ulaan-Uul site ("Red Mountain") of Erdene soum of Dornogovi aimag. There are also meteorological stations and posts in the agricultural regions of Mongolia for observation of phenology phases, heights, density, thickness, damage rates, causes and harvest of wheat, potatoes, and vegetables. At present, 132 hydrological stations are measuring the daily water level, discharge, water temperature and also ice thickness and phenomenon. Permafrost and glacier studies and monitoring as well are conducted in Mongolia.

*Cooperation on climate change:* The Ministry of Environment and Tourism (MET) is the main central government body responsible for coordination climate change issues at the national level. However, there are gaps in terms of institutional arrangement and human capacity with the only few numbers of staff within the MET for the policy development, implementation, monitoring and capacity building and etc. Despite the limited capacity, the government of Mongolia has been actively engaged in the international, bilateral and national level of climate policy dialogues and we have achieved quite important milestones in the past. Under the Japan-Mongolian Joint-Credit Mechanism (JCM), two 10MW solar plant, and under the multilateral financial cooperation two 50 MW wind parks are established. It is also notable that XacBank, as accredited by the Green Climate Fund (GCF), has approved two mitigation projects which further promotes the private sector investment and while supporting the local businesses. Together with the technical support of international experts, in 2014 the National Forest Inventory and in 2016 the National GHG Inventory was conducted in accordance with the international guidelines and standards. In the future, the Government of Mongolia seeks to enrich the collaboration and cooperation even more in areas of research, advanced technologies and innovative interventions to tackle climate change.

*Integrating Climate Change Actions into Development Policies and Plans:* The effects of Climate Change are expected to become increasingly more severe in the future. These negative impacts will severely affect socioeconomic sectors, local communities, herders, and farmers. So it is crucial that the challenges and risks of climate change are assessed in order to integrate adaptation and mitigation actions. However, most policies and plans that are being set are failing to take climate change effects into account. In order for adaptation and mitigation strategies to be included in policies the following processes must take place: understanding the risks associated with climate change, integrating climate change adaptation and mitigation at national, sectoral, activity level plans and lastly, at local levels. There are policies such as the Sustainable Development Vision 2030 which takes ideas of integration of climate change considerations into account to the National Development Goals. In order to avoid maladaptation risks and to introduce new opportunities, it is important that climate lens is applied to its sectorial strategies and policies. Adaptation actions will be implemented in environmental sectors. Mitigation measures will be implemented in sectors related to energy and industry as these are the sectors which are most responsible for GHG emissions.

*Information, knowledge sharing, and networking:* The information on climate change is mostly shared through MET and its agencies such as the NAMEM, IRIMHE, and EIC. In the future, it is important that there is a National online platform that promotes and spreads awareness of important information on climate change mitigation and adaptation to the public.

*Raising climate change education and public awareness:* Climate Change is a global issue, so it is important that all countries and people know the effects of climate change and also a more general knowledge about this issue. By allowing public access to important information and data on environmental decisions and policies, it is more likely that the issues will be addressed as an internationally acclaimed problem. Furthermore, the addition of legislation and laws on promoting education and knowledge on climate change and ecology will contribute towards the implementation of policies and plans related to the mitigation and adaptation of climate change. Also, it is crucial that from a young age, children and young adults will understand the importance of a sustainable future. To promote this, in Mongolia, a Sustainable Development Education is being included in the general secondary school curriculum. In addition to this, information on Climate Change Education is being spread on TV, radio, magazines and books and online. It is essential that the public is well informed about the issues of climate change for any policies and laws to be implemented effectively.

# Chapter 1

## THE COUNTRY PROFILE

# 1. The country profile

## 1.1. Geographical location

Mongolia is located in north-east Asia and bounded between 41°35′-52°06′N latitudes and 87°47-119°57′E longitudes. The country territory is occupied 1564.1 thou. sq. km which extends 2,392 km from west to north and 1,259 km from north to south. Mongolia borders with the Russian Federation to the north and Republic of China to the south and the total length of the national border is 8,252.7 km. The mean elevation is 1,580 m above sea level and the highest point is Khuiten mountain with an elevation of 4,374 meters in Western Mongolia (the highest peak of Mongolia Altai mountain range), while the lowest point is Khokh lake depression with an altitude of 532 m (Eastern steppe). Mongolia is ranked in terms of territory size at 7th among Asian counties and 17th place in the world. Mongolia is one of the biggest continental inland countries (Figure 1.1).

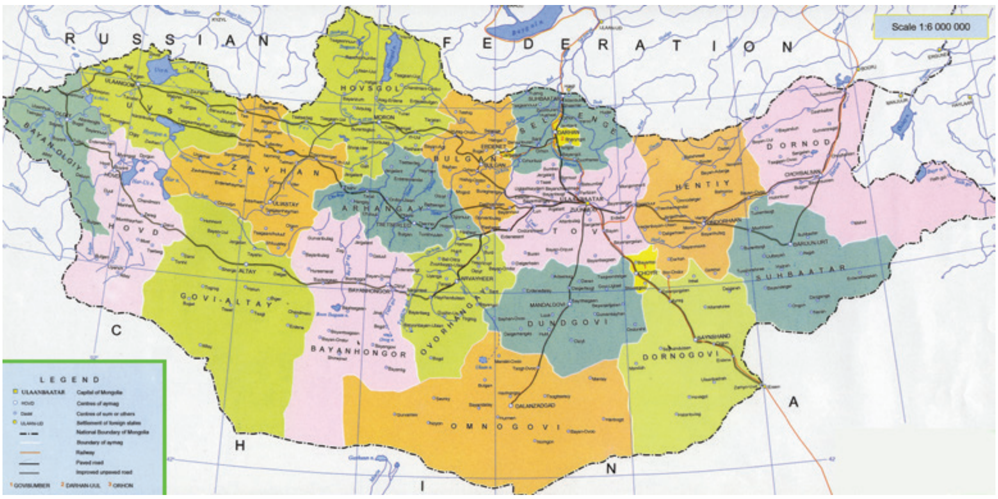


Figure 1.1 Geographical location of Mongolia

Mongolia is surrounded by high mountain ranges and it blocks advection of cold air mass from the north and warm air mass from the west and south-west direction, moreover, moisture flux transportation from Pacific and the Indian Ocean is limited due to this specific location. The territory of Mongolia divides into four distinct natural zones such as forest-steppe, steppe, desert-steppe, and desert. There are High Mountain and forest-steppe zone western and central part, while steppe region in the eastern and Gobi desert (Mongolian Gobi) in the southern part of the country as dominantly.

## 1.2. Natural resource

*Climate.* The climate of Mongolia is harsh and continental due to its very unique geographical location in the center of the Eurasian continent such as highly elevated above sea level, surrounded by high mountains and highly remote location from the sea. Therefore, main features of Mongolian climate are characterized by high seasonality with very distinct four seasons, high amplitude of temperature and low precipitation. Latitudinal and altitudinal spatial distribution could be clearly distinguished in any geographical distribution of climate variables.

The annual mean air temperature is about -4˚C in the Altai, Khangai, Khentii and Khuvsgul mountains ranges, -6-8˚C in the depressions between mountains ranges, also along the valley of big rivers, 2˚C in the steppe-desert region and 6˚C in the southern part even exceeds. Warmest point is Ekhiingol where the annual mean air temperature is 8.5˚C (Figure 1.2).

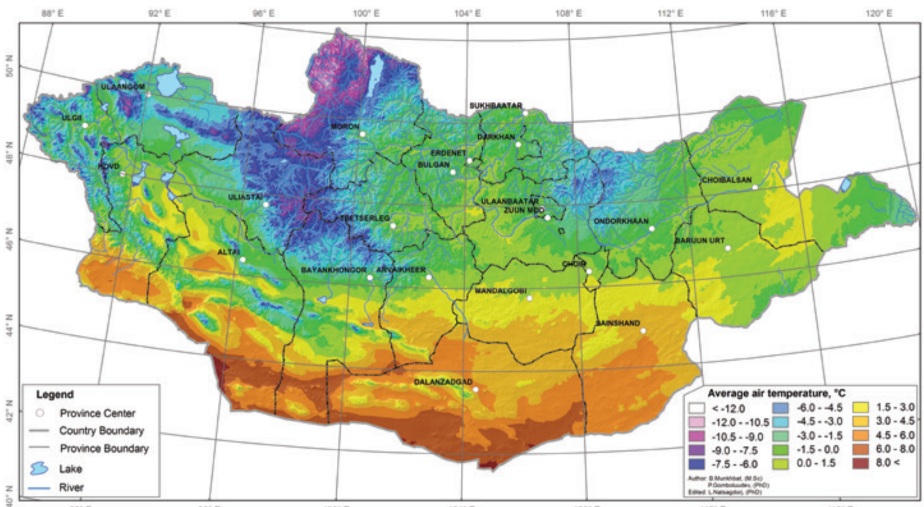


Figure 1.2 Spatial distribution of annual mean temperature, 1961-1990 (Munkhbat, 2014)

The monthly mean temperature of coldest month, January is about -30-34˚C in the valleys of Altai, Khangai, Khuvsgul and Khentii mountains, -20-25°C in the steppe region and -15-20˚C in the Gobi and desert (Figure 1.3).

Since 1936, when systematic instrumental observation of weather began, the absolute minimum air temperature was -55.3˚C (it was recorded at Zuungovi soum in Uvs aimag at 31st December of 1976). In case of the capital city of Ulaanbaatar, absolute minimum air temperature reached -49.0˚C (in December of 1954).

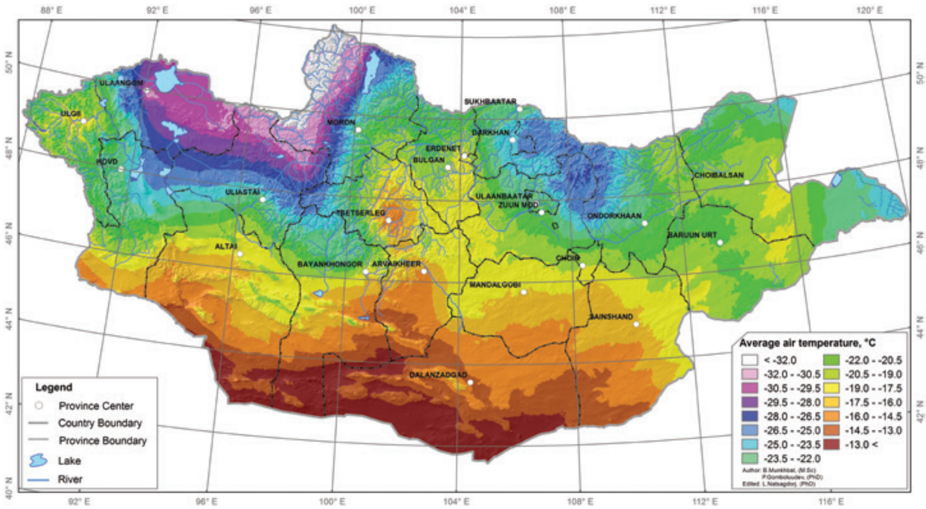


Figure 1.3 Spatial distribution of monthly mean temperature, January 1961-1990 (Munkhbat, 2014)

The warmest month is July and its mean temperature is slightly cooler than 15˚C in Altai, Khangai, Khuvsgul and Khentii mountain ranges, 15-20°C in the Great Lake depressions and valleys between Altai, Khangai and Khuvsgul mountains and also Orkhon-Selenge river basins and 20-25˚C in eastern steppe and southern Gobi and desert regions (Figure 1.4). An absolute maximum air temperature is 44.0˚C recorded in Darkhan city on 24th July of 1999.

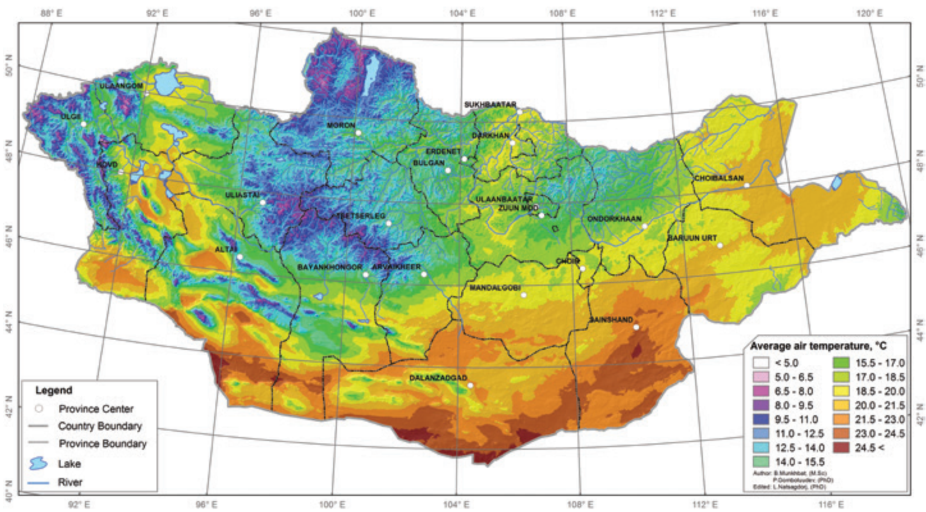


Figure 1.4 Spatial distribution of monthly mean temperature, July (Munkhbat, 2014)

Generally, the thermal heat resource is sufficient during plant growing season in Mongolia. However, there is a high risk of occurrence of frost in the mountain region. Mongolia is located in the arid and semi-arid region; therefore the amount of precipitation generally is low. The annual precipitation exceeds 400 mm at high mountain belts, while 300-400 mm in the Khangai, Khuvsgul and Khentii mountains and also in the Khalkh river basin in the Eastern region, 250-300 mm in Mongol Altai and forest-steppe, 150-250 mm in steppe and 50-150 mm in Gobi and desert region. In the south-inner side of Altai Mountain, annual precipitation ranges even less than 55 mm.

Spatial distribution of precipitation in Mongolia is very specific due to the vast area, land composition, roughness and geographical peculiarity. Typically, precipitation decreases from north to south and from east to west; however, surface roughness has much impact on the spatial distribution of precipitation (Figure 1.5).

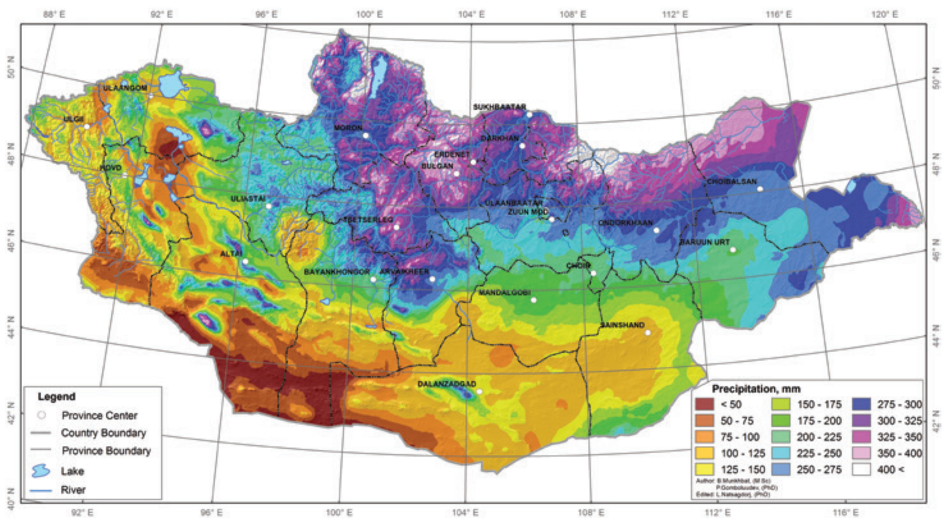


Figure 1.5 Spatial distribution of annual precipitation, 1961-1990 (Munkhbat, 2014)

About 85% of total precipitation falls from April to September and among them, 50-60% falls only in July and August. Winter precipitation, snow amount is very low. Precipitation amount during the cold season is about 30 mm in the mountain area while 10 mm in the Gobi region and it is even less than 10 mm. Duration of forming snow cover is about 150 days in the mountain regions such as Khangai, Khentii, and Khuvsgul where winter precipitation is 30 mm (from November to March) and around 100-150 days in the steppe and forest-steppe, 50-100 days in the Great Lake depression and Eastern steppe, and less than 50 days in Gobi and desert zone. The average snow cover depth is not much, about 5 cm in mountains, reaches its maximum up to 30 cm and 2-5 cm in the steppe region and its maximum depth may reach 15-20 cm.

Generally, precipitation amount is low; however, its intensity is high. Since systematic, instrumental observation from 1940s, highest daily maximum rainfall was observed in the Dalanzadgad where daily maximum rainfall reached 138 mm ($5^{th}$ of August, 1956). Hourly rain recorded up to 40-65 mm ever less than 1 hour.

In terms of sunshine duration in Mongolia, there are less cloud and high number of days with clear sky, which ranges about 230-260 days during the year. Total sunshine duration is about 2,600-3,300 hours per year. Therefore, solar energy resource is relatively high.

Mongolian steppe and desert-steppe regions are very windy. Annual average wind speed in the mentioned regions is in 4-6 m/s. Average wind speed is 1-2 m/s in the Altai, Khangai, Khuvsgul and Khentii mountains, and 2-3 m/s in the valleys of mountains and in other areas. Mostly, west, northwest and northerly winds dominate, but the wind depends very much on local orography and landscape, and mountain-valley breeze wind often could be occurred.

A number of days with sandstorm is about 10 days during the year in the mountain areas such as Altai, Khangai, Khuvsgul, and Khentii, 50 days in the Great lake depression, especially exceeds 90 days in Gobi of Altai Mountain and around Mongol Els area (Chung Y.S. et al., 2004) (Figure 1.6).

Around 61% of dust storm occurs in March during spring, while 7% occurs in summer. A dust storm is relatively less in the autumn and winter seasons. Mongolian dust storms are one of the main sources of “yellow dust” in East Asia.

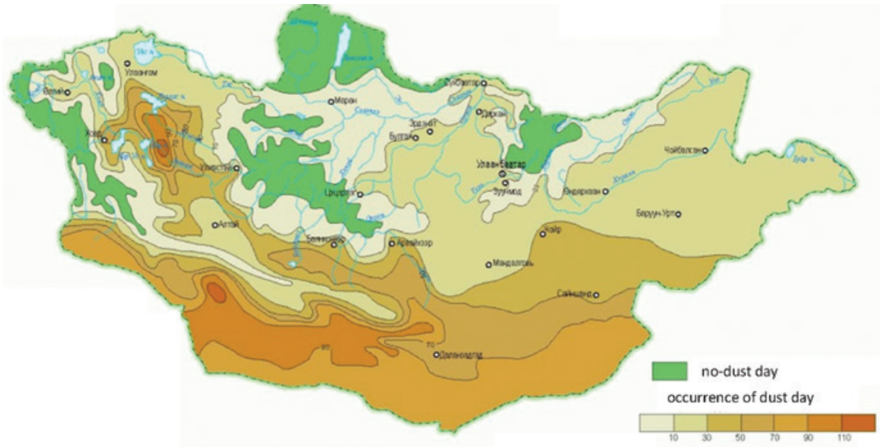


Figure 1.6 Spatial distribution of dust storm frequency, 1960-2008

***Land use.*** According to the land use classification (integrated land fund/ resource), land cover of Mongolia is classified into the following classes following classes. Where 73.5% of the country is considered for agricultural land use (0.9% of which for crop production, 1.5% for hayfield and 96.2% to be pasture); 0.46% is occupied by urban area; 9.6% is forest including bush and shrub; 0.4% is to be water bodies and remaining 1.7% belongs to unused land. However, depending on definition and classification terms, the percentage of forest cover appears to be different in some sources. For example, the forest cover of Mongolia is to be 11.89% in forestry source while according to land use classification, forest cover percentage is 9.14% of the country (ALAMGC, 2015).

A relatively large area of the country belongs to the classification of land for special needs (where lands ensuring national defense and security, natural reserve, national protected area, lands under road and communication networks). By 2014, the total area of the national protected area is reached 27.2 million of ha and it occupies 17.4% of Mongolian territory.

The economy of Mongolia and food security of population directly depends on the agricultural sector and many other sectors of the economy such as mining mainly based on land resource. Therefore, soil erosion, desertification and any other forms of land degradation are key important problems of Mongolia, which which require for urgent solutions for urgent solutions. Recently, land degradation continuously increased from year to years in the country. Mining pit, damp, wastewater, traffic of heavy mining machinery related (road damage and dust) to the open mining operation and activities are much contributing to increased land degradation and environmental pollution in the country.

***Water resource and glaciers.*** The surface water resource of Mongolia composed mainly from lake water (Tserensodnom J. et al., 1996) which is about 500 km$^3$ and another 19.4 km$^3$ accumulates in glaciers (Davaa G. et al., 2012). An average river runoff is estimated to be 34.6 km$^3$/year. River runoff 30.6 km$^3$ forms within Mongolian territory and remaining 4 km$^3$ of river runoff forms in neighboring countries and flows through Mongolian territory (Myagmarjav B and Davaa G., 1999). Reachable groundwater resource is estimated to be 10.8 km$^3$ (Jadambaa N., 2009).

In 2010, the water use rate was 326.3 million m$^3$/year and it is expected to increase up to 478.2 million m$^3$/year in 2021 according to the low use scenario. In mid scenario, water use increase rate will be 26.8% and will be doubled in high scenario compare to this low use scenario (Table 1.1).

Table 1.1 Projection of water use rate in Mongolia

| Water users and sectors | | Water use amount, millions m$^3$/year | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | | | 2021 | | |
| Scenarios | | low | mid | high | low | mid | high |
| Drinking water and household | Urban | 66.4 | 70.9 | 78.6 | 67.2 | 72.9 | 81.8 |
| | Rural | 4.1 | 4.0 | 4.0 | 5.9 | 6.0 | 6.0 |
| Social amenities | Social service | 4.8 | 5.6 | 7.6 | 6.3 | 8.7 | 17.2 |
| | Household service | 5.7 | 5.9 | 6.8 | 6.0 | 6.5 | 8.5 |
| Industry, construction and construction material production | Light and Food industry | 4.4 | 5.1 | 6.6 | 5.6 | 7.6 | 13.5 |
| | Heavy industry | 1.6 | 1.8 | 2.3 | 2.0 | 2.7 | 4.7 |
| | Energy | 1.6 | 2.0 | 2.4 | 2.1 | 3.2 | 4.5 |
| | Mining | 37.8 | 44.7 | 54.3 | 43.9 | 63.5 | 97.3 |
| | Construction and construction material production | 51.9 | 81.1 | 102.0 | 61.1 | 111.1 | 186.1 |
| Agriculture | Animal husbandry | 90.2 | 94.9 | 109.4 | 103.1 | 108.6 | 117.3 |
| | Irrigated agriculture | 125.0 | 169.8 | 203.2 | 165.5 | 260.8 | 360.0 |
| Others | Tourism | 1.2 | 1.4 | 1.6 | 2.7 | 3.4 | 4.0 |
| | Green facilities | 2.5 | 2.6 | 2.6 | 2.7 | 2.9 | 3.0 |
| | Road, railway and transportation | 3.2 | 3.6 | 4.1 | 4.1 | 4.5 | 5.0 |
| Country's total water use millions m$^3$/year | | 400.6 | 493.4 | 585.6 | 478.2 | 662.4 | 908.9 |

*Source: Development of IWRM Planning of Mongolia, Volume III, Ulaanbaatar, 2012*

***Forest resource.*** Mongolian forest grows on the southern edge of the cold temperate region of northern hemisphere under harsh continental climate condition. Therefore, its productivity is low; the growth rate is slow and very vulnerable to climate change, drought, wildfire harmful insects, and tree diseases. Besides such natural factors, the forest is also vulnerable to the human impacts; therefore, natural recovery capability of the forest is extremely weak.

All type of tree species, shrubs, and saxaul which grow in Mongolian territory and including planted forest is defined as forest resource of Mongolia. According to forest report of 2016, Mongolian forest resource is estimated by 18,454.6 thou.ha, 17,911.1 thou.ha (97%) of them corresponds to the forested area and 543.5 thou.ha (3%) in the forest zone. About 68.6% of forest area (12,280.0 thou.ha) is covered by forest. From them 11,500.4 thou.ha is occupied by natural trees, 777.5 thou.ha by shrubs and bushes 2.1 thou.ha by planted forest and 31.5% (5631.1 thou.ha) area have not yet covered by forest (Figure 1.7). The ratio between forested areas and the total area of territory as expressed by percent is called forest richness, which is estimated by 7.9% (CFRD, 2016).

79.3% (9,739.4 thou.ha) of forested area of Mongolian forest resource is covered by coniferous and deciduous forest, 14.4% covered (1,763.14 thou. ha) by saxaul (*Haloxylon ammodendron*) and 6.3% (777.5 thou.ha) covered by shrubs respectively.

In the area uncovered by forest, open forest (sparse forest) is about 3,495.3thou.ha (62.1%), the complete burned forest is 1708.4 thou.ha (30.3%), logging area is 106.1thou.ha (1.9%), to be forested area is 174.0 thou.ha (3.1%) and forest area suffered by harmful insects and diseases are 135.8thou.ha (2.4%) as accordingly.

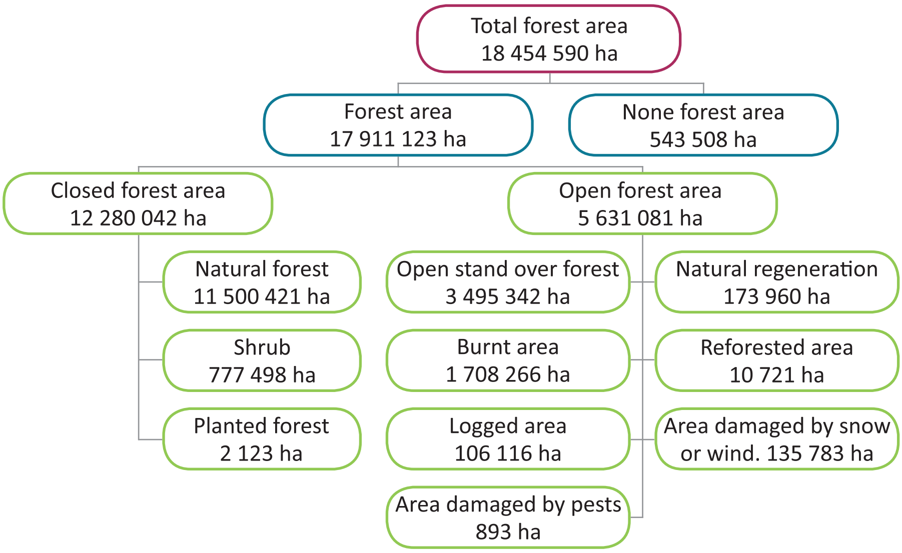


Figure 1.7 Area of forest cover and forest resource (Forest Research and Development Center, 2016)

Mongolian forest resource consists of more than 140 species of trees and shrubs. Among them, 62.5% is occupied by larch, 10.4% by birch, 5.4% by cedar, about 4.2% by pine, 1.4% by willow, 0.3% by aspen, 0.2% by spruce, 0.1% by poplar, 0.03% by elm, 0.01% by fir as respectively. In Gobi and desert region, the saxaul is occupied by 15.3% and 0.06% by certain species of bushes. So, about 85.6% of the total forest area or namely the northern part of the country is covered by coniferous and deciduous forests. In the southern part, mainly grow saxaul and certain species bushes which occupy 15.4%.

Forest resource of Mongolia is estimated by 1 billion 243.4 thousands of cubic meter of wood. Its 78.6% takes larch, 9.3% is Siberian stone pine, 6.1% is birch, 5.0 % is Scots pine, 0.28% is willow, 0.23% is aspen, 0.18% is poplar, 0.05% is aspen, 0.02% is Siberian fir, 0.01% is Siberian elm, 0.002% is Desert poplar and finally 0.14% is saxaul. Land protection zone is occupied by 82.9% and land use zone is by 17.1% in Mongolian forest resource area.

In 2012, Mongolia involved in REDD+ programme on the reduction of carbon emission caused by forest degradation of the UN. Moreover, in 2014, The German International Cooperation Agency's (GIZ) project named "Biodiversity and Adaptation of Key Forest Ecosystems to Climate change II" in cooperation with REDD+ National Forest Inventory" was carried out multipurpose national forest inventory of Mongolia. Results show that coniferous and deciduous forest coverage in the northern part of Mongolia is 9.1 million of ha, growing stock volume 1,036 million of $m^3$, growing stock volume per hectare is 114 $m^3$/ha. Aboveground dry biomass is 60.3 tonnes/ha, its carbon pool 30.7 tonnes C/ha, belowground biomasses 18.3 tonnes/ha, its carbon pool is 9.3 tonnes C/ha; stock volume dead standing trees is 18.7, biomass-6.2 tonnes/ha, carbon pool is 3.1 tonnes C/ha, belowground biomass of dead standing trees is 2.1 tonnes/ha, its carbon pool is 1.1 tonnes C/ha; stock volume of stumps is 2.0 $m^3$/ha, and its biomass is 0.5 tonnes/ha, related carbon pools 0.2 tonnes C/ha, root biomass is 1.1 tonnes/ha and its carbon is 0.5 tonnes C/ha; stock volume of fallen trees is 25.8 $m^3$/ha with biomass of 5.9 tonnes/ha and its carbon pools 3.0 tonnes C/ha (MET, 2016).

***Biological resource.*** Nowadays, there are 18,300 species of vertebrates, invertebrates, and plants registered in Mongolia as biodiversity. Although a number of species in terms of classification of species seemed to be relatively well enough registered, information on their natural resource, numbers are very much limited. Mainly, endangered and hunting value mammals and birds, also some plant species are more studied and information about them more available.

At present days, 39 orders, 112 families, 683 genus and 3,127 species are registered in Mongolian plant kingdom. Among the officially registered species, 153 species are native and 458 of them endemic. Moreover, 1,574 species of algae, 1,030 species of lichen and 470 species of mushroom have been registered. From the plant kingdom, 195 species are introduced in Mongolian Red Book as critically endangered and near threatened. Recently, distribution and resource atlas of 80 species of profitable plant of Mongolia are published.

In case of the animal kingdom, 138 species of mammals, 476 species of birds, 16 species of reptile, 6 species of Amphibia, 74 species of fishes and about 13,000 species of insects are registered in Mongolian harsh ecological condition (Table 1.2). Since 1998, another 52 new bird species registered. According to the law on fauna, 28 species of mammals belonging to extremely rare and another 76 of animal species to be a rare animal list by the Government resolution under No 07 from 2012. Due to danger to living environment of animals, about 11% of mammals near threatened, 3% is vulnerable or extinct risk in the wild, a number of bird species reduced by 4%. Also, the assessment stated that 11% of critically extinct species of plants already extinct, 26% under near threatened, 37% at high risk of extinct in the wild and about 15% may become rare.

Table 1.2 Species composition of the animal kingdom

| Composition of classification | Number of animal species | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | By 1998 | | | | By 2014 | | | |
| | Orsers | families | geniusec | species | orsers | families | geniusec | species |
| Insects | | 2 | 100 | 13,000 | | 2 | 100 | 13,000 |
| Fishes | | 11 | 36 | 75 | | 11 | 36 | 74 |
| Amphibia | 2 | 4 | | 6 | 2 | 4 | | 6 |
| Reptile | 2 | 7 | 15 | 22 | 2 | 6 | 15 | 22 |
| Birds | 17 | 56 | 193 | 434 | 17 | 60 | 203 | 486 |
| Mammals | 8 | 22 | 73 | 138 | 8 | 22 | 73 | 138 |

Government's regulatory and administration body is responsible for conducting inventory assessment studies on animal numbers and heads every 4-8 years. Results of the inventory and assessment study show that animal numbers decreased by 70-50% compare to 1970-1980 level. However, animal numbers (heads) are slightly increased by 20-40% since 1990-2000 situation level. According to last 4 years statistics, moose count 16,400, wild boar 35,000, roe deer 30,000, musk deer 6,600 and deer number is around 18,000-22,000 (by the year, 2010). As for Mongolian gazelle is estimated to be 3-6 millions of heads, goitered gazelle 12,000, wild Asian ass 14,000, wild mountain sheep 18,000, Siberian ibex 25,000 (by the 2009 ), and wild camel 800-1,200, reindeer 140-200 (at 2012 level) and sable's number is around 3,400-3,600 (to date of the year 2013 ) etc.

## 1.3. Socio-economic profile

***Government structure.*** The governance of Mongolia is parliamentary and composed of Government and local government units and politically unitary state. In terms of administrative delineation and units, Mongolia consists of 21 aimags (provinces) 329 soums (villages) and 1,560 bags. As for the capital city of Ulaanbaatar, it consists of 9 districts and 132 khoroos.

The constitution of Mongolia states that administrative and territorial management to be implemented by corporate management of local self-governance and the state control. Therefore, administrative and territorial units have a special organization, which is called "Citizen Representative Khural" for local management similar to the public council. Recently, the decentralization process is still continuing since 1990s.

In terms of the climate change governance, the Ministry of Environment and Tourism is the main body responsible at the national level. However, due to the complexity of the issue itself, the robust coordination mechanism is necessary to be established at the national level to ensure the effective implementation of climate change policies and measures.

***Population.*** Population growth rate of Mongolia was highest in Asian continent reaching 2.1-2.5% before 1990s. At the end of 2015, the total population of Mongolia has reached 3,057.8 thousand (NSO, 2015).

A birth rate per 1,000 citizens have been increased in 2006-2009 and reached 25.7 in 2009 and then observed slight decrease up to 23.1 in 2010 and increased 25.1 in 2011 again. Since 2012, the birth rate has continuous increasing trend and in 2015, the birth rate of Mongolia reached 28.0 per 1,000 persons. Average life expectancy of the country in 2015 is 69.9 year. An average life expectancy according to gender diversity, for women is 75.84 years and for men is 66.02 years.

Due to intensive development and industrialization in last 40 years, urbanization very rapidly increases in Mongolia. By the end of 2015, 68 percent of Mongolian population lives in cities and towns. Another reason for such increase of urban population is mechanical movement (migration) of people to cities, especially to the capital city of Ulaanbaatar. Nowadays, the population of Ulaanbaatar city reached 1,396.3 thousand people due to population growth, a related increase in demand and consumption, natural resource exploitation and usage range also have increased respectively. Exploitation and usage rate of some renewable natural resources such as surface and groundwater resource, forest and pasture already exceed acceptable level in some regions and if continue such tendency, such situation may cover the entire country. Thus, complex planning of measures on protection of the natural resource and its rational use and their implementation is urgently required.

***Macroeconomy.*** Besides natural barriers such as harsh and arid climate, landlocked geographical location, Mongolia is trying to overcome different obstacles and problems related to the transition from a planned economy to a market economy. Although having to reach yet at planned targets and results in each area, the government organizes several complex measures related to privatization, liberalization on trade and investment and integrated exchange rate and going ahead keeping the general orientation of country's development.

At the beginning of the transition or during the period of 1990-1993, serious declines in the key economic indicators occurred and the economy significantly regressed from pre-transition levels. But since 1994 gradually has recovered by forcing through the stages of boom and bust. Due to a rapid growth in the mining sector from 2008 -2012, macroeconomic indicators are much improved and economic growth has reached 17.5% in 2011. This growth was one of the tops of the world, however, depending on several internal and external factors, could not keep this performance and economic growth of the country is slowed down to 12.3% in 2012 and 11.6% in 2013 and 7.9% in 2014 and 2.3% in 2015.

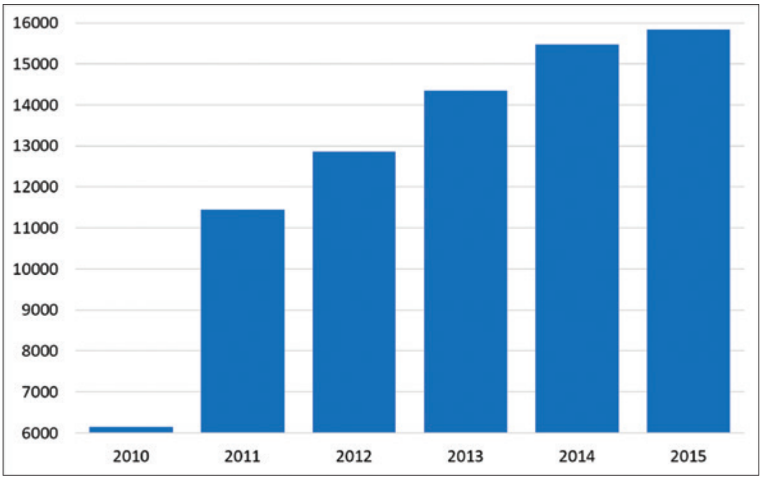


Figure 1.8 The gross domestic product, comparative prices of 2010, by billion tugrugs, (source: NSO)

The main reason for such decline was decline in the prices of Mongolia's export products such as coal, iron ore, copper, and other mining products in the world markets. Figure 1.8 is shown the annual amount of GDP for 2010-2015 with comparative prices of 2010. It shows that our economy much expands and nearly doubled in the past 6 years.

***Agriculture and Food security.*** Although Mongolia fully provides its own needs of a citizen in meat, milk, and potatoes by domestic production, there is some gap between urban and rural population's consumption. For instance, mean consumption of urban people 1.5 times less than rural people and in case of milk production, urban people consumption 3.9 times less than rural people. On the other hand, rural people consume vegetable and potatoes 2 times less compare to urban people and egg is 9.5 times less than urban citizens (NPFS, 2009). Meat and flour production dominate in the food of Mongolian people and still consume the very small amount of fruits and vegetable which are main vitamin source for a human being. In the structure of the product consumer of one family in the country, flour takes 27-38%

in an urban area while 40-53% in rural areas which is indicating flour as one of the important consumers after the meat.

***Animal husbandry.*** Animal husbandry is still occupied an important role in country's economy, employment and export earnings. About 12.8% of GDP of the country compounds by the agricultural sector and 77.5% of it created by animal husbandry (livestock) by 2015. Country's 35.0% of the total workforce belongs to the agricultural sector and 7.0% of export of the country comes from this sector (NSO, 2014). Although over 20 percent of the animals are lost during severe dzud of 2009-2010, the sector has been revived back again. By the end of 2015, the number of livestock reached a historical record level of 56 million of heads (Figure 1.9).

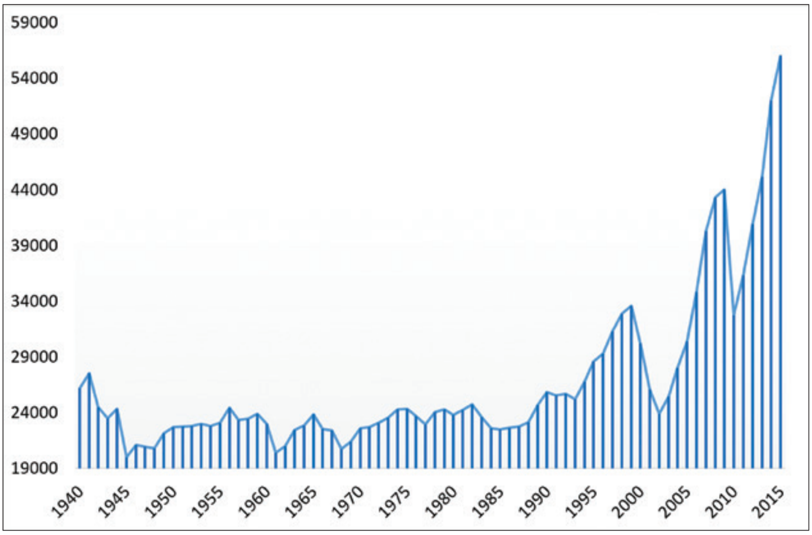


Figure 1.9 Number of livestock dynamic, thou.heads

Concerning location or breeding of herds, 70.4% of total camels in the Gobi region, and 61.8% of horse in the steppe and forest-steppe, 64.9% of the cattle in the forest-steppe and high mountain regions, 74.7% of the sheep in the steppe, forest-steppe and high mountain zones and 57.4% of goats in the steppe and in the Gobi Desert are allocated. As for the percentage of different herds in the total livestock numbers, 5.9% of them are horses, 6.7% is cattle herd, 44.6% is sheep, 42.1% is goats and 0.7% is camels (Figure 1.10).

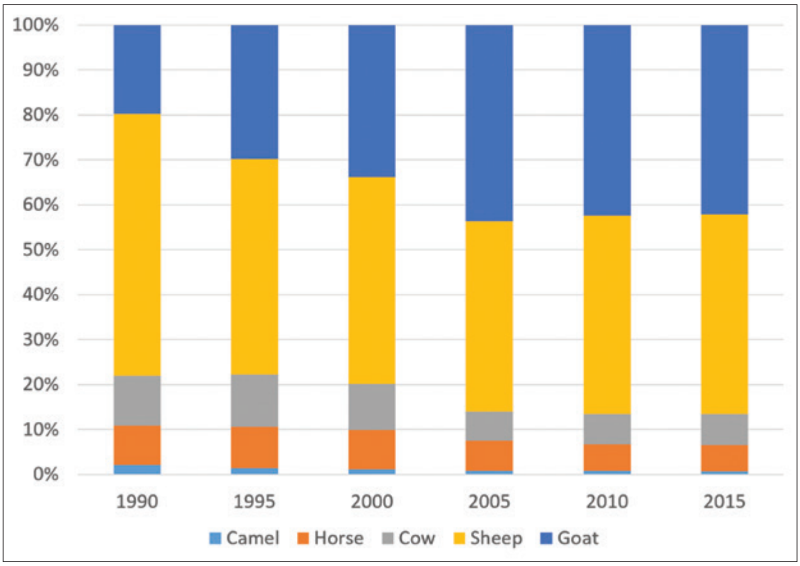


Figure 1.10 Ratio of different livestock herds, in percent

***Arable farming.*** Previously, the arable farming did not take an important and key role in Mongolian agricultural sector. However since the 1960s or the beginning of the cultivation campaign of prairie land (Wilderness campaign), the new agriculture sector is formed. The size of cultivated land has greatly expanded until 1990 and turnover fields had reached 1.3 million hectares. Since 1990, due to economic crises, cultivation area reduced as the cultivation of prairie land stopped, and only potatoes, vegetables, fodder crops were planted in a smaller area.

However, because the government launched the campaign "Third Campaign for Reclamation" in 2008 as result of the implementation of agriculture support policies, the agricultural sector recovered again. Cultivated and planted lands are significantly increased from previous years and by 2015, 390.7 thou.ha of area cultivated for crops and 12.8 thous.ha for potatoes and 7.7 thou.ha of vegetables were planted in 2015 (NSO, 2014).

Thus, Mongolian arable farming sector almost fully meets the domestic demand by grain and potato crops and nearly provides more than half of the vegetable needs. In 2000-2002, Mongolia met only about 30% of the domestic flour demand. But after the Third campaign and as a result of several measures taken by the government, the volume of imports of flour is reduced from year to year and by 2013-2015 level, an already became able to produce 90% of domestic needs in flour (Figure 1.11).

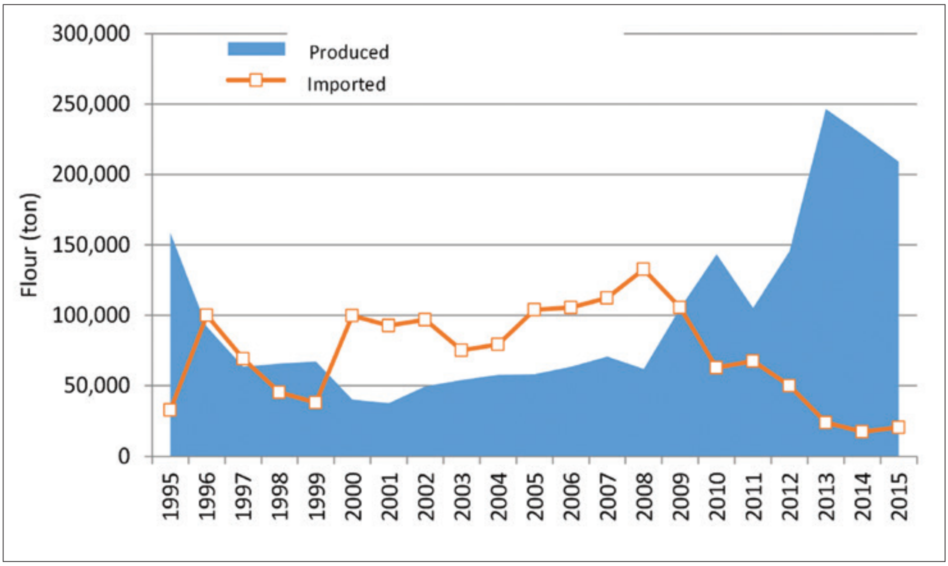


Figure 1.11 Total wheat production amount and import rate of flour

The total crop yield reached 518.7 thou.tonnes in 2014, among them 489.4 thou.tonnes of grain was harvested and this was highest since 1991. This means, we do not only meet the domestic demand but also able to become an exporter of wheat. Moreover, harvest from 1 hectares unit area reached an average yield of 16.9 centners in 2014 and this performance result was recognized highly in our case where there is limited experience on irrigated agriculture cultivation and it actually broke the record of the last 55 years experiences (NSO, 2015).

However, under the continental dry climate condition with frequent droughts, a variation of harvest is high and unstable. For example, at the beginning of summer of 2015 (from 20$^{th}$ of June till 10$^{th}$ of July, 2015) the yield has dropped to 5.6 centners/ha.

***Energy resource and energy production.*** Energy production sector of Mongolia is divided into two different systems. At first, the Central Integrated Energy system supplies the majority of the country's need. Secondly, diesel oil stations for energy production are installed in remote areas. There are five power plants in Mongolia which use coal for energy production and in 18 province centers, isolated energy systems operate for the local network. 80% of total powers generated come from coal. Coals from mines within the country are delivered by railway to the power stations and 65% of all exploited coals in the country are used only for energy production (Figure 1.12).

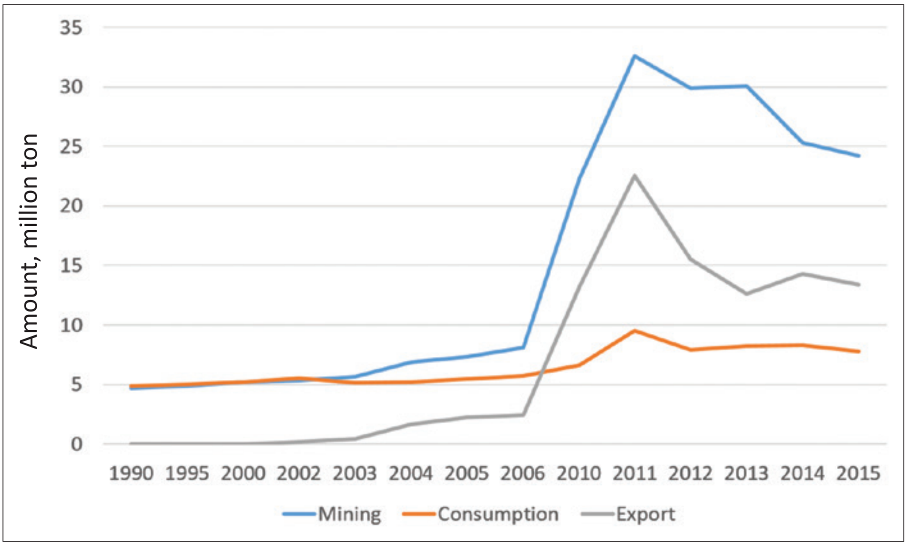


Figure 1.12 Coal exploitation rates of Mongolia and its use, millions of tonne

During the production stage, 49% of total generated energy from the power plant is lost and another 11% is lost during transmission and dissemination. Heat loss is about 40% and mainly due to the poor condition of dissemination line and networks. Thus only about 25% of total produced energy by coal is consumed for heating and power supply purposes. In terms of percentage, 70% of energy production and 90% heat production is produced by coal, however, the efficiency of energy production is very low (Figure 1.13).

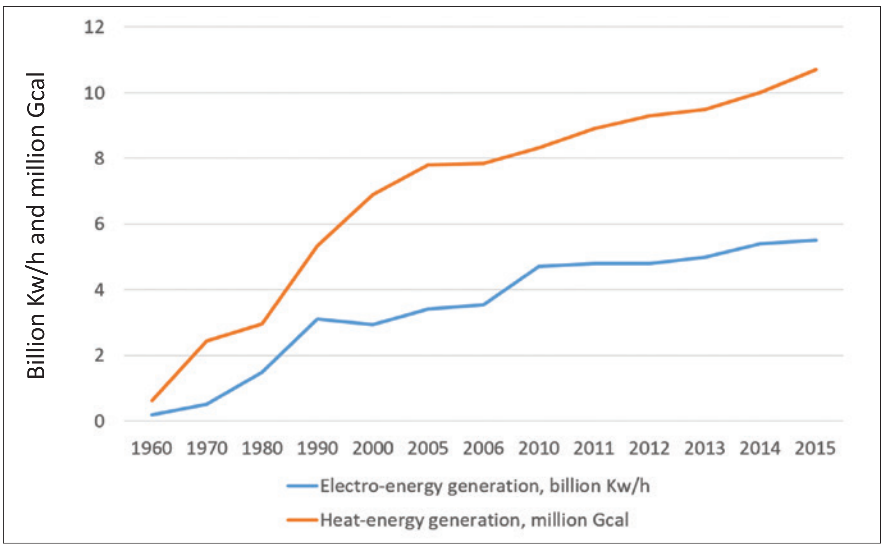


Figure 1.13 Energy and heat generation of Mongolia

Coal is the main resource for Mongolia for energy and heat production. However, environmental pollution issues, especially burning raw coal and using it for different purposes have become very serious problems for the Mongolian society. Besides the ineffective use of coal, air pollution becomes an extremely critical issue for cities especially for the capital city of Ulaanbaatar due to use of coal in individual houses (ger districts) and thermal power plants for heating and energy production. For example, the stable temperature inverse forms during winter season in the Ulaanbaatar city area and such phenomena causes air mass dispersion block along the Ulaanbaatar city and smoke and pollution from ordinary stoves of families, heat production facilities, steam boilers of different companies and 3 big power plants of city create an extremely serious situation in terms of air pollution and air quality. Reports and statements of WHO indicate that in terms of air pollution Ulaanbaatar city is considered one of highest in the world.

Renewable energy resource of Mongolia is estimated to be abundant. But still have not experienced the use of this resource as effectively. At present, there are five medium and small-sized hydropower stations are in operation in Western Mongolia and four of them operate only during summer season. When we consider about hydropower power capacity of Mongolia, careful consideration of river runoff and climate change impacts and some environmental impact issues is necessary.

In Mongolian condition, there is a great opportunity to provide energy need of nomadic families by small-sized solar batteries and wind propellers, particularly in the Gobi region. In the Altai, Khangai, Khentii Mountains 43 geothermal points were identified but have not yet developed infrastructure for application of such power sources. Mongolian first wind park in Salkhit doest not only contributes to the reduction of carbon emission but also increases energy production of Mongolia likely by 5% in near future.

A wise government policy, its clear planning, and optimum management on energy-related issues and effective cooperation with investors from the private sector are crucially important in the utilization of the renewable energy resource of the country. On the positive note, the first-ever 10MW solar plant has operationalized in Darkhan aimag under the Japan-Mongolian Joint Credit Mechanism (JCM), and the second 10MW solar plant as well established by the private sector under the JCM. Additionally, GCF funded 10MW solar plant is under the implementation by the nationally accredited entity, XacBank.

A promotional system which supports effective use and consumption of energy is weak in Mongolia and energy consumption for the unit product is high and 1.5 times higher than the developed countries. Heat loss of buildings, apartments, and construction reaches 30% and commercial energy consumption per capita of the country is also high compared to the regional developing countries. Such high cost is due to cold, harsh climate condition of Mongolia and also a high rate of energy losses.

***Legal framework.*** The United Nations Framework Convention on Climate Change (UNFCCC) entered into force in 1994, Kyoto protocol towards it's implementing into force in 2005 and finally the Paris Agreement approved on 15 December 2015, are the key legal bases and main direction of policy and strategy on measures of coping with climate change, mitigation of negative impacts and adaptation to climate change. Mongolia has joined the United Nations Framework Convention on Climate Change (UNFCCC) in 1993, the Kyoto Protocol in 1999 and the Paris Agreement on Climate Change in 2016. Addition to the climate change convention, Mongolia has joined and ratified many international environmental conventions and agreements, related to the environment at the international level such as "Convention to Combat Desertification", "the Convention on Biodiversity" of the United Nations and as well as "the Vienna Convention" on ozone layer protection. Therefore, these documents are international legislative bases and statements to follow on climate change policies and strategies.

Although there is no special law on climate change in Mongolia, there are some other laws which reflect the idea of the problem and support climate change-related measures and activities. In other words, the climate change issues have yet precisely and completely reflected in related laws and development programmes of Mongolia. However, to some extent, the general principle and concept of policy and legal framework on climate change are considered in Mongolia. For example in "Law on Air" updated in 2012, reflected important basics such as create a policy and legal framework on climate change, ensure the implementation of the UNFCCC and carry out the GHG inventory.

**Box 1.1:** from "Law on Air"

***Article 24.*** *Mitigation impacts of climate change and adaptation to climate change*

*24.2. National greenhouse gas emission and sink inventory are organized by a designated office according to approved methodology and guideline adopted by the COP.*

*24.3. The permissible level of emission from the source during the entity activities approve in cooperation with other relevant state government administration bodies.*

The National Action Program on Climate Change (NAPCC) is the key government policy document oriented to measures and actions. The first edition of the programme has been approved by the State Great Khural (Parliament) in 2000 and the updated second edition was approved in 2011. The objectives, strategic goals, and implementation stages, timing and expected outcomes and indicators of the programme have been developed strongly consistent with the national development strategies and policies of the country. The program is scheduled in two-phase from 2011 to 2021 under 96 measures within 5 strategic goals.

Furthermore, in 2014 Green Development Policy approved by the Parliament aims at incorporating development pathways inconsistent with climate change. In addition, Mongolia's Sustainable Development Vision-2030 approved in 2016 by the Parliament has envisaged Mongolia to be one of the leading Middle-Income Countries that has eradicated poverty in all its forms and preserves the ecological balance while continuing to build strong and stable governance systems.

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# Chapter 2

## NATIONAL GREENHOUSE GAS INVENTORY

## 2. National greenhouse gas inventory

In this chapter included Mongolia's greenhouse gas (GHG) emissions from anthropogenic sources and removals by sinks. The main GHG emissions are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), fluorinated gases (HFCs, PFCs), and sulfur hexafluoride ($SF_6$) as well as indirect gases carbon monoxide (CO), nitrous oxides ($NO_x$) and sulfur dioxide ($SO_2$). This chapter also summarizes the annual GHG emissions and removals for the period 1990-2014 and trend analyses.

The GHG emissions have been estimated from energy, industrial processes and product use (IPPU), agriculture, land use, land use change and forestry (AFOLU/LULUCF) and waste sectors according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

Although Mongolia is a developing country and not obliged to apply the IPCC 2006, there was a necessity to shift to the newest methodology in order to improve the quality of GHG inventory and to enhance the capacity building and GHG inventory system in Mongolia. Another reason for using the IPCC 2006 is that the guidelines include updated methods and improved default values.

Net emissions have been presented in carbon dioxide equivalents ($CO_2$e) using the 100-year global warming potentials (GWPs)[1] from the 1995 IPCC Second Assessment Report (SAR). In general Tier 1 IPCC method was applied. However, there were selected categories such as fuel combustion, fugitive emissions from solid fuels, LULUCF for which Tier 2 method was used.

Mongolia's GHG inventory has been prepared using data from a combination of sources from national and international institutions. The main source of activity data is the official statistics of Mongolia. According to the recommendation of IPCC 2006, it's preferred to use data from national statistics. In cases where the required data was not available, the data from international sources such as International Energy Agency (IEA), United Nations Food and Agriculture Organization (FAO), World Bank (WB) and certain assumptions were used.

### 2.1. Greenhouse gas inventory in 2014

Total GHG emissions of Mongolia in 2014 were 34,482.73 Gg $CO_2$e (excluding LULUCF). This represents a 57.09% increase from the 1990 level of 21,950.73 Gg $CO_2$e and 5.49% increase from the 2013 level with 32,687.27 Gg $CO_2$e.

*1 The source of GWPs used is the IPCC Second Assessment Report (SAR). The GWPs of direct GHGs are: 1=$CO_2$, 21=$CH_4$, 310=$N_2O$, HFC-134a=1300, HFC-152a=140, HFC-143a=3800. GWPs for indirect GHGs are not available. However, they were reported but are not included in the inventory total.*

Net GHG emissions in 2014 were 10,030.80 Gg $CO_2e$ (including LULUCF). This represents a 1,034.44% increase from the 1990 level of -1,073.46 Gg $CO_2e$ and 23.23% increase from the 2013 level with 8,139.60 Gg $CO_2e$ (Figure 2.1 and Table 2.1).

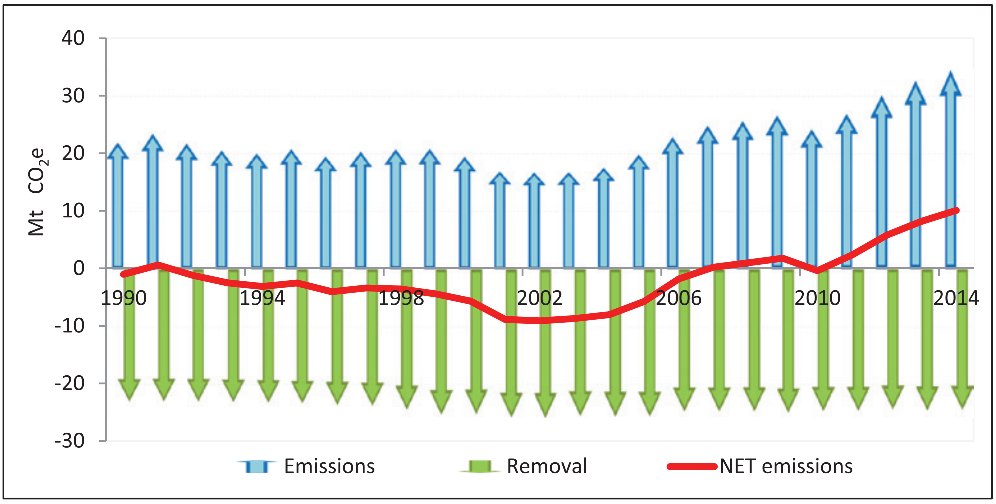



Figure 2.1 Mongolia's total and net GHG emissions and removals, 1990-2014 (Mt $CO_2e$)

In general, emissions and removals from each sector increased in 2014 compared to the base year and differences are shown in Table 2.1 by percentages and absolute values of each GHG inventory sectors.

Table 2.1 Mongolia's GHG emissions/removals by sectors in 1990 and 2014

| Sector | Emissions and Removals, (Gg $CO_2e$) | | Change from 1990 (Gg $CO_2e$) | Change from 1990 (%) |
|---|---|---|---|---|
| | 1990 | 2014 | | |
| Energy | 11,091.14 | 17,267.79 | 6,176.64 | 55.69 |
| IPPU | 218.66 | 328.06 | 109.39 | 50.03 |
| Agriculture | 10,585.30 | 16,726.98 | 6,141.68 | 58.02 |
| Waste | 55.62 | 159.91 | 104.29 | 187.49 |
| Total (excluding LULUCF) | 21,950.73 | 34,482.73 | 12,532.00 | 57.09 |
| LULUCF | -23,024.18 | -24,451.93 | -1,427.75 | 6.20 |
| Net total (including LULUCF) | -1,073.46 | 10,030.80 | 11,104.26 | 1,034.44 |

GHG emissions in 2014 from the energy sector were 17,267.79 Gg $CO_2e$ accounting for 50.08% of total national emissions. The agriculture sector with 16,726.98 Gg $CO_2e$ accounts for 48.51% of the national total. Emissions from IPPU and Waste sectors contributed 328.1 Gg $CO_2e$ (0.95%) and 159.91 Gg $CO_2e$ (0.46%) respectively to the national total in 2014 (Figure 2.2).

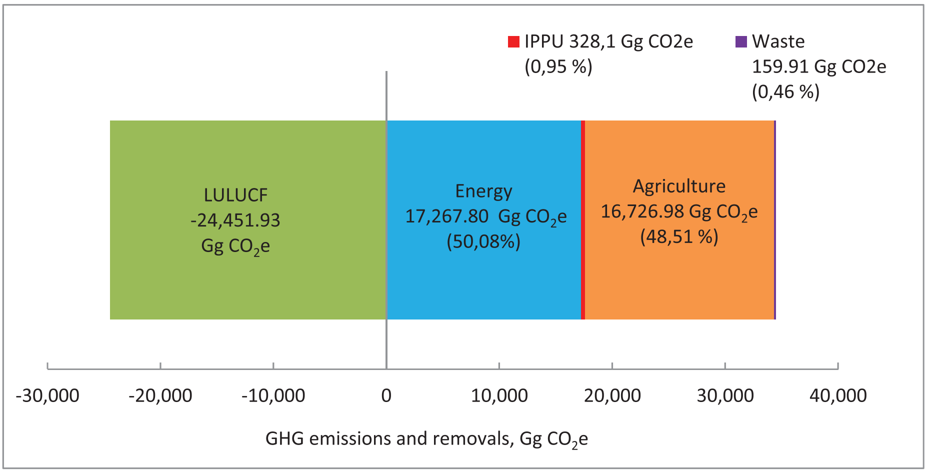



Figure 2.2 The composition of Mongolian GHG emissions by sectors in 2014

The aggregated GHG emissions and removals by sectors between 1990 and 2014 are shown in Table 2.2 including national total emissions with and without LULUCF. Comparing to 1990, emissions increase for the energy sector was 55.69%, for the IPPU sector was 50.03%, for the agriculture sector was 58.02%, for the waste sector was 187.49% and removal for the LULUCF sector was 6.2% in 2014 (see Table 2.2).

In 2014 the energy sector emission decreased by -2.78%, the IPPU sector emission increased by 37.72%, the agriculture sector emission increased by 15.05%, the waste sector emission increased by 7.93% and the LULUCF sector emission decreased by -0.39% compared to 2013.

Table 2.2 The aggregated GHG emissions and removals by sectors, Gg $CO_2e$

| Year | Energy | IPPU | Agriculture | Waste | LULUCF | Total (incl. LULUCF) | Total (Excl. LULUCF) |
|---|---|---|---|---|---|---|---|
| 1990 | 11,091.14 | 218.66 | 10,585.30 | 55.62 | -23,024.18 | -1,073.46 | 21,950.73 |
| 1991 | 12,879.99 | 144.23 | 10,407.34 | 56.18 | -22,950.70 | 537.04 | 23,487.74 |
| 1992 | 11,225.37 | 107.57 | 10,348.57 | 54.96 | -22,992.04 | -1,255.57 | 21,736.47 |
| 1993 | 10,407.61 | 70.15 | 10,021.88 | 53.66 | -23,099.45 | -2,546.15 | 20,553.30 |
| 1994 | 9,093.72 | 83.71 | 10,807.34 | 54.00 | -23,212.78 | -3,174.01 | 20,038.77 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1995 | 8,920.66 | 82.81 | 11,719.79 | 55.71 | -23,364.15 | -2,585.18 | 20,778.97 |
| 1996 | 7,290.90 | 82.26 | 12,067.63 | 56.56 | -23,596.88 | -4,099.54 | 19,497.35 |
| 1997 | 7,094.52 | 86.95 | 13,093.45 | 58.27 | -23,762.22 | -3,429.03 | 20,333.19 |
| 1998 | 7,204.28 | 84.09 | 13,423.70 | 58.58 | -24,407.44 | -3,636.79 | 20,770.65 |
| 1999 | 7,174.94 | 78.41 | 13,525.34 | 62.71 | -25,328.82 | -4,487.43 | 20,841.39 |
| 2000 | 7,528.89 | 63.95 | 11,790.52 | 66.04 | -25,188.38 | -5,738.98 | 19,449.40 |
| 2001 | 7,547.49 | 50.39 | 9,224.50 | 68.45 | -25,828.96 | -8,938.13 | 16,890.83 |
| 2002 | 8,068.76 | 92.03 | 8,485.01 | 74.16 | -25,884.36 | -9,164.41 | 16,719.95 |
| 2003 | 7,967.05 | 96.97 | 8,646.21 | 76.52 | -25,547.44 | -8,760.70 | 16,786.74 |
| 2004 | 8,125.47 | 83.47 | 9,265.37 | 79.03 | -25,639.68 | -8,086.33 | 17,553.35 |
| 2005 | 9,738.30 | 140.46 | 9,881.33 | 83.33 | -25,658.09 | -5,814.68 | 19,843.41 |
| 2006 | 11,503.25 | 139.99 | 11,133.62 | 87.74 | -24,750.19 | -1,885.59 | 22,864.60 |
| 2007 | 11,930.76 | 155.73 | 12,729.74 | 92.25 | -24,757.59 | 150.90 | 24,908.49 |
| 2008 | 11,919.81 | 182.27 | 13,451.41 | 97.65 | -24,716.09 | 935.05 | 25,651.14 |
| 2009 | 12,491.36 | 157.57 | 13,909.39 | 103.10 | -24,950.95 | 1,710.48 | 26,661.42 |
| 2010 | 13,227.35 | 251.63 | 10,635.70 | 108.26 | -24,670.87 | -447.93 | 24,222.94 |
| 2011 | 14,823.77 | 256.05 | 11,723.02 | 122.14 | -24,636.33 | 2,288.64 | 26,924.97 |
| 2012 | 16,357.95 | 300.64 | 13,308.67 | 137.79 | -24,377.05 | 5,728.00 | 30,105.05 |
| 2013 | 17,762.11 | 238.21 | 14,538.79 | 148.17 | -24,547.66 | 8,139.60 | 32,687.27 |
| 2014 | 17,267.79 | 328.06 | 16,726.98 | 159.91 | -24,451.93 | 10,030.80 | 34,482.73 |

*Note: Totals of columns not consistent due to rounding.*

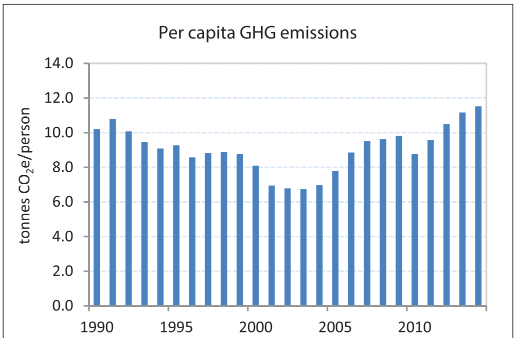
The energy and agriculture sectors are the major sources of emissions for entire time series. However, the percentage of national total varied depending on economic and climatic factors such as demand increase in the energy sector and natural disaster occurrence in the agriculture sector.

While Mongolia's total GHG emissions excluding LULUCF is comparatively low, the per capita rate of GHG emissions is relatively high compared to other developing countries. The reason for that is Mongolia has a cold continental climate and therefore the heating season lasts almost 7 months. The main source for heating and cooking in Mongolia is the fossil fuel and because of the low fuel and energy efficiency, the per capita emissions are high. From Table 2.3 and Figure 2.3 can be seen the major indicators of total GHG emissions of Mongolia for the period 1990-2014.

Table 2.3 Major indicators of total GHG emissions (excl. LULUCF) for the period 1990-2014

| Indicators | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|
| Total emissions (excl.LULUCF) | Gg $CO_2e$ | 21,950.73 | 20,778.97 | 19,449.40 | 19,843.41 | 24,222.94 | 34,482.73 |
| Population | thousand persons | 2,153.47 | 2,243.00 | 2,403.11 | 2,551.08 | 2,760.97 | 2,995.95 |
| Per capita GHG emissions | tonnes $CO_2e$/person | 10.19 | 9.26 | 8.09 | 7.78 | 8.77 | 11.51 |
| GDP* | billion 2010 US $ using exchange rate | 3.85 | 3.35 | 3.84 | 5.25 | 7.19 | 11.41 |
| Per GDP GHG emissions | kg$CO_2e$/US $ | 5.70 | 6.20 | 5.06 | 3.78 | 3.37 | 3.02 |

** IEA Statistics, https://www.iea.org/statistics/statisticssearch/report/?country=MONGOLIA&product=indicators&year*



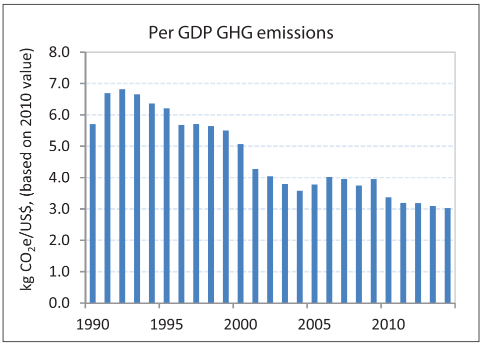




Figure 2.3 Major indicators of total GHG emissions (excl. LULUCF) for the period 1990-2014

Below Figure 2.4 shows that contribution of sectors to Mongolia's total emissions for the period 1990-2014.

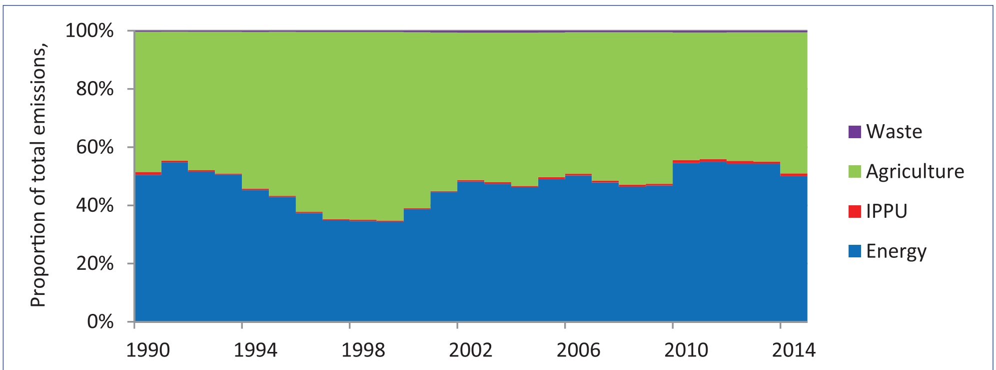



Figure 2.4 The contribution of sectors to Mongolia's total emissions for the period 1990-2014

## 2.2. Description and interpretation of emission trends sectors/ categories

### 2.2.1. Energy

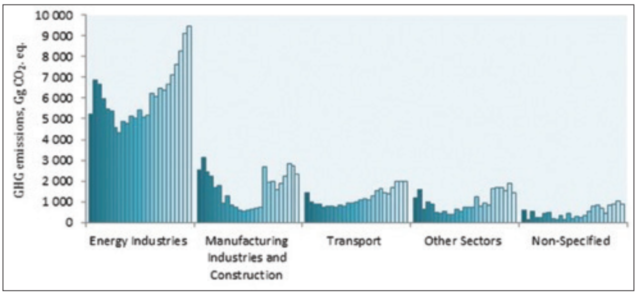



Figure 2.5 Trends in the energy sector by categories, 1990-2014

The energy sector is the most significant source of the GHG emissions with 50.08% share of the national total emissions in 2014. The GHG emissions fluctuate in the latest years mainly due to economic trend, the energy supply structure and climate conditions. Total emissions in the energy sector in 2014 increased by 55.69% compared to the base year 1990. A large part of emissions in energy sector comes from energy industries (electricity generation, electricity, and heat production in CHPs) source category (54.87%). The emissions from energy industries increased by 3.81% compared to 2013. One of the factors influencing the GHG emissions from energy industries source category is the increasing energy demand. To reduce the GHG emissions from this source category the energy efficiency of electricity and heat production should be improved (see Figure 2.5).

### 2.2.2. Agriculture

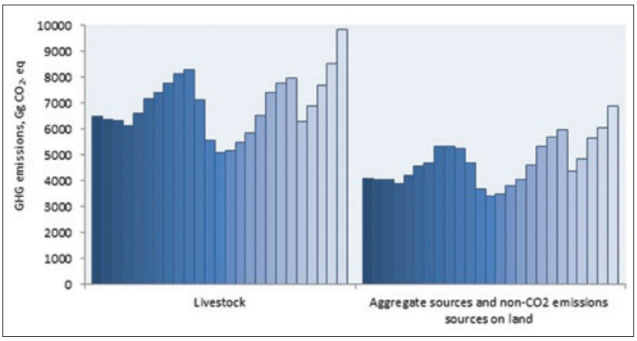



Figure 2.6 Trends in the agriculture sector by categories, 1990-2014

In 2014, the agriculture sector accounted for 48.51% (16.726.97 Gg $CO_2e$) of total national direct GHG emissions (without LULUCF), is the second major source of GHG emissions after the energy sector in the country. Total emissions in the agriculture sector in 2014 increased by 58.02% compared to the base year 1990; in particular, due to increasing the number of domestic livestock which increased 25.8 million in 1990 to 51.9 million in 2014 (see Figure 2.6). Emission reduction between 1999-2002 and 2009-2010 caused by livestock loss during the winter disaster.

### 2.2.3. Industrial processes and product use (IPPU)

The Industrial Processes and Product Use (IPPU) sector contributes 0.95% of the total GHG emissions in 2014. The total GHG emissions of IPPU sector in 2014 increased by 50.03% compared to the base year 1990. The emission fluctuations in IPPU sectors are linked with the economic situation of the country. The GHG emissions increased in 2014 by 37.72% compared to 2013. The main contributor to the total emissions from IPPU sector is the mineral industry (cement and lime production) and it represents 68.86% of emissions. The cement and lime are the important ingredients for the building materials production. The building material industry is growing in parallel with the population and the economy (see Figure 2.7).

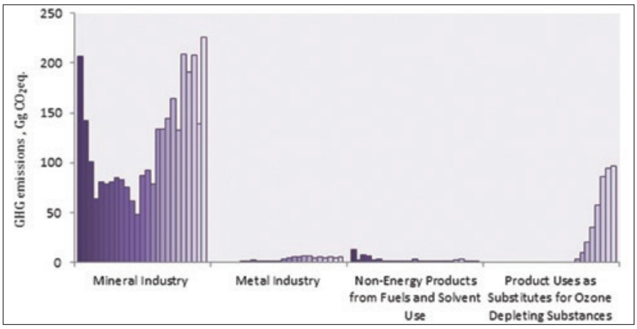



Figure 2.7 Trends in the IPPU sector by categories, 1990-2014

### 2.2.4. Waste

The waste sector is the insignificant source of the GHG emissions contributes only 0.46% to national total. However, GHG emissions have increased continuously year after year in relation to the population growth, especially in urban areas. Total aggregated emissions from the Waste sector have increased by 104.29 Gg $CO_2e$ (187.49%) from the 1990 level of 55.62 Gg $CO_2e$. The total $CO_2$ equivalent emissions from waste sector in 2014 increased 7.93% compared to 2013 (Figure 2.8).

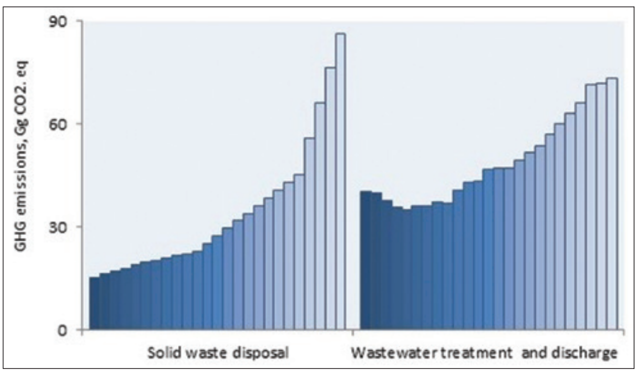



Figure 2.8 Trends in the waste sector by categories, 1990-2014

### 2.2.5. Land use, land use change, and forestry

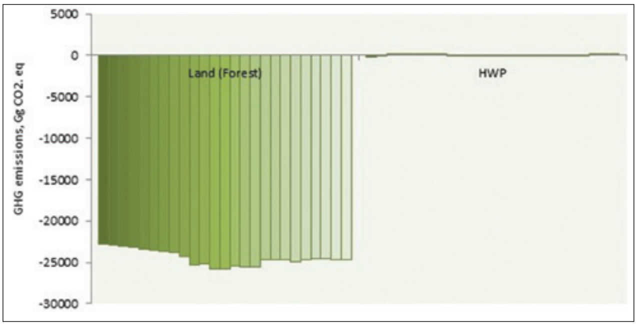



Figure 2.9 Trends in the LULUCF sector by categories, 1990-2014

LULUCF is a net sink in Mongolia accounted approximately 50% of net removal of the country's direct GHG emission. Total removals were -24,451.93 GgCO2e in 2014 and -23,024.18 GgCO2e in the base year. This increase (6.2%) in 2014 is due to forest area expansion in recent years. According to the country's land report forest area has increased from 15,660.48 thou. ha in 1990 to 16,864.77 thou. ha in 2014. Availability of data for LULUCF inventory is still lacking. It should be noted that only forest land remaining forest land category is reported under Land category for this submission (Figure 2.9).

## 2.3. Description and interpretation of emission trends by gases

### 2.3.1. Carbon dioxide ($CO_2$)

The most important GHG in Mongolia is carbon dioxide ($CO_2$) (without LULUCF) accounting 46.41% of the national total in 2014. The emissions from all sectors (excl. LULUCF) increased by 46.46% from 10,927.61 in 1990 to 16,004.13 Gg $CO_2$e in 2014 mainly due to higher emissions from the energy sector.

The main source of $CO_2$ emissions in Mongolia is the fossil fuel combustion. Within the fuel combustion category, the energy industries are the most important sub-source with the growth of 81.92% from 5,178.13 Gg in 1990 to 9,420.14 Gg in 2014. The second contributor to $CO_2$ emissions is the manufacturing industries and construction source category with the decline of 8.65% from 2,519.05 Gg in 1990 to 2,301.20 Gg in 2014.

### 2.3.2. Methane ($CH_4$)

$CH_4$ emissions increased from 6,872.62 to 11,341.60 Gg $CO_2$e with a growth of 65.03% from 1990 to 2014. The main sources of $CH_4$ emissions in Mongolia are the enteric fermentation in the agriculture sector, the fugitive emissions from coal mining and handling, and solid waste disposal on land (landfills) contributes 32.89% to national total GHG emissions in 2014.

### 2.3.3. Nitrous oxide ($N_2O$)

$N_2O$ emissions increased from 4,150.49 to 7,040.58 Gg $CO_2e$ for the period 1990-2014, which is 69.63% increase over the years. The main sources are: direct $N_2O$ emissions from managed soils; indirect $N_2O$ emissions from managed soils; energy industries; manufacturing industries and construction; transport and residential sectors, and domestic wastewater treatment and discharge contributes 20.42% to national total in 2014.

### 2.3.4. Hydrofluorocarbons (HFCs)

The activity data for the estimation of HFCs emissions were available only from 2012 to 2014. Therefore the emissions have been estimated only for last few years. Since the HFCs emissions are directly related to the consumption of applications which include fluorinated substitutes, the emissions increase with the growing consumption of applications. For the emissions estimation from HFCs was used Tier 1 method of IPCC 2006 which is using the default emission factors. The Tier 1 method then back-calculates the development of banks of a refrigerant from the current reporting year to the year of its introduction. The year of introduction for HFC-134a (mobile air conditioning) was 2007. Thus the emissions results from the estimation showed for the period 2007-2014 and increased remarkably from 3.17 to 96.43Gg $CO_2e$ due to the growth of imported refrigeration and air conditioning equipment contribute the remaining 0.28% in 2014.

The trend of $CO_2$, $CH_4$, $N_2O$ and HFCs emissions are presented in Figure 2.10, 2.11 and Table 2.4.

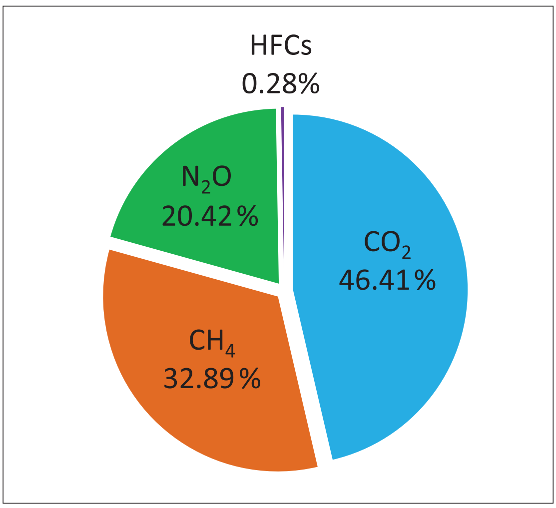



Figure 2.10 The share of gases in 2014

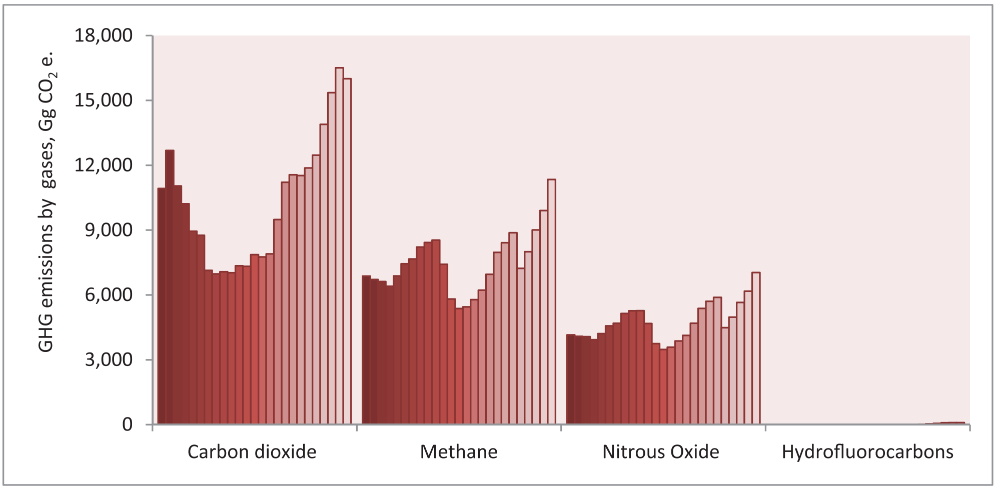



Figure 2.11 The trend of $CO_2$, $CH_4$, $N_2O$ and HFCs emissions for the period 1990-2014

Table 2.4 Mongolia's total GHG emissions by gases in 1990 and 2014

| Direct GHGs | Emissions, (Gg $CO_2$e) | | Change from 1990 (Gg $CO_2$e) | Change from 1990 (%) |
|---|---|---|---|---|
| | 1990 | 2014 | | |
| $CO_2$ | 10,927.61 | 16,004.13 | 5,076.51 | 46.46 |
| $CH_4$ | 6,872.62 | 11,341.6 | 4,468.98 | 65.03 |
| $N_2O$ | 4,150.49 | 7,040.58 | 2,890.09 | 69.63 |
| HFCs | NA | 96.43 | NA | NA |
| Total | 21,950.73 | 34,482.73 | 12,532.00 | 57.09 |

*Note: Total emissions exclude net removals from the LULUCF sector. The percent change for hydrofluorocarbons is not applicable (NA) because the emissions estimation of hydrofluorocarbons was not conducted for 1990.*

### 2.3.5. Description and interpretation of emission trends for indirect GHGs

This chapter summarizes the trends for nitrogen oxides ($NO_x$) and carbon monoxide (CO). The following table shows the indirect gas emissions from mainly the biomass burning in the forest land category for the years 1990 and 2014 (Table 2.5).

Table 2.5 Mongolia's total emissions by indirect gases for the years 1990 and 2014

| Indirect GHG emissions | Emissions, (Gg $CO_2$e) | | Change from 1990 (Gg $CO_2$e) | Change from 1990 (%) |
|---|---|---|---|---|
| | 1990 | 2014 | | |
| $NO_x$ | 1.78 | 0.04 | -1.74 | -97.75 |
| CO | 63.63 | 1.54 | -62.9 | -97.58 |

### 2.3.5.1. Nitrogen oxides ($NO_x$)

The $NO_x$ emissions caused by biomass burning in forest land decreased from 1.78 to 0.04 Gg $CO_2$e, during the period from 1990 to 2014. The level of $NO_x$ emissions of 2014 was -97.75% below the level of 1990.

### 2.3.5.2. Carbon monoxide (CO)

The main source of CO emissions is burning biomass in forest land. The CO emissions decreased from 63.63 Gg in 1990 to 1.54 Gg in 2014 which are resulted from the biomass burning in the forest land. In 2014 the CO emissions were -97.58% below the level of 1990.

## 2.4. The trend of GHG emissions by sources (1990–2014)

### 2.4.1. Energy

The energy sector of GHG inventory (GHGI) in Mongolia covers two main source categories, namely fuel combustion (CRF 1.A) and fugitive emissions (CRF 1.B). Within the fuel combustion source category were estimated emissions from energy industries (electricity generation, combined heat and power generation), manufacturing industries and construction (in aggregated manner), transport (civil aviation, road transportation, railways), other sectors (commercial/institutional, residential, agriculture/forestry), non-specified (stationary combustion) and fugitive emissions (coal mining and handling, oil production).

This sector is the main contributor to overall GHG emissions (excluding LULUCF) with its share of 50.08% and 17,267.79 Gg of $CO_2$ equivalents ($CO_2$e) in 2014. The Figure 2.12 below shows the share of each sector in the total GHG emissions excluding LULUCF from the year 2014.

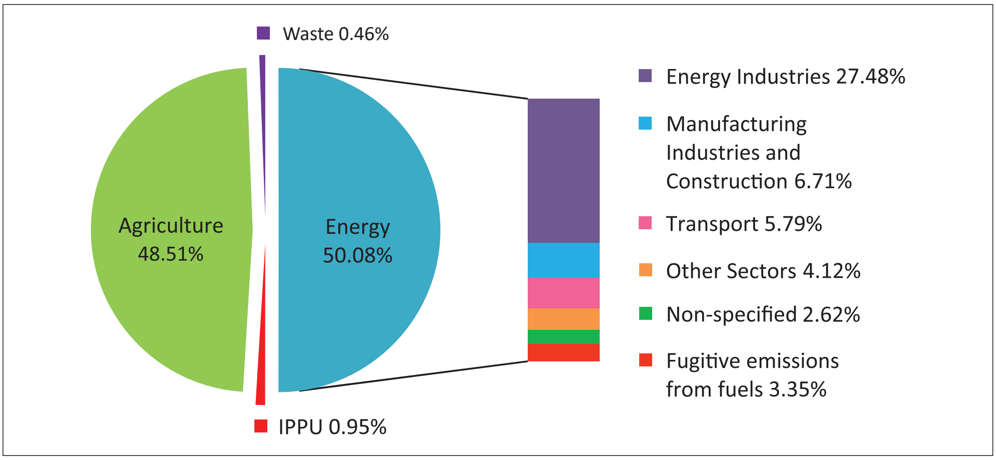



Figure 2.12: The share of each sector in total GHG emissions of Mongolia (excl. LULUCF), 2014

Within the energy sector, energy industry contributes the most percentage to the GHG emissions and next two contributors are manufacturing industries and construction, and transport sectors each with 54.87%, 13.40%, and 11.57% (see Table 2.6). The share of energy industries is relatively constant, e.g. from 46.97% in 1990 increased up to 68.09% in 2000 and slightly decreased to 54.87% in 2014. The share of manufacturing industries and construction source category is decreased from 22.86% in 1990 to 7.59% in 2000 and gradually increased up to 13.40% in 2014. This change is linked to the consequences of the transition from the planned to the market economy in the late 90's. In addition to fuel combustion, also pollution from small sources of residential heating systems and fugitive methane emissions from solid fuel transmission/transport/distribution contribute significantly to total GHG emissions. The emissions from energy sector have been increased by 55.69% from 11,091.1 Gg $CO_2$e in 1990 to 17,267.8 Gg $CO_2$e in 2014.

Table 2.6 GHG emissions from the energy sector by source categories, Gg $CO_2$e

| Categories | Emissions | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|
| Energy Industries | Gg | 5,209.46 | 5,374.38 | 5,126.45 | 6,201.15 | 7,110.12 | 9,474.70 |
| | % | 46.97 | 60.25 | 68.09 | 63.68 | 53.75 | 54.87 |
| Manufacturing Industries and Construction | Gg | 2,535.38 | 1,792.04 | 571.47 | 716.30 | 1,888.93 | 2,313.48 |
| | % | 22.86 | 20.09 | 7.59 | 7.36 | 14.28 | 13.40 |
| Transport | Gg | 1,439.66 | 771.75 | 935.12 | 1,108.73 | 1,400.58 | 1,997.25 |
| | % | 12.98 | 8.65 | 12.42 | 11.38 | 10.59 | 11.57 |
| Other Sectors* | Gg | 1,164.36 | 468.85 | 646.36 | 1,221.03 | 1,690.48 | 1,422.37 |
| | % | 10.50 | 5.25 | 8.58 | 12.54 | 12.78 | 8.24 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Non-specified | Gg | 611.38 | 421.83 | 148.07 | 333.48 | 456.93 | 903.37 |
| | % | 5.51 | 4.73 | 1.97 | 3.42 | 3.45 | 5.23 |
| Fugitive emissions from fuels (coal, oil) | Gg | 130.91 | 91.80 | 101.42 | 157.60 | 680.31 | 1,156.62 |
| | % | 1.18 | 1.03 | 1.35 | 1.62 | 5.14 | 6.70 |
| Energy Total | Gg | 11,091.14 | 8,920.66 | 7,528.89 | 9,738.30 | 13,227.35 | 17,267.79 |
| | % | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

** Other sectors include Commercial/Institutional, Residential and Agriculture/Forestry/Fishing source categories.*

The inventory of emissions from fuel combustion includes direct GHG emissions such as $CO_2$, $CH_4$, $N_2O$ and indirect such as $NO_x$, CO, NMVOCs, and $SO_2$ emissions as well, while fugitive emissions from coal and oil production are $CO_2$ and $CH_4$.

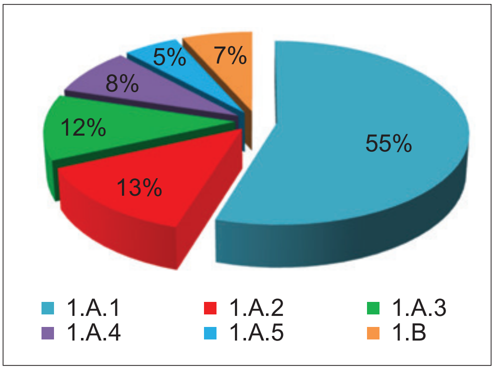



Figure 2.13 The share of aggregated GHG emissions by categories within energy sector in 2014

| SECTOR 1: ENERGY – CATEGORIES, 2014 | Gg $CO_2e$ |
|---|---|
| 1. ENERGY TOTAL | 17,267.79 |
| 1.A.1 Energy Industries | 9,474.70 |
| 1.A.2 Manufacturing Industries and Construction | 2,313.48 |
| 1.A.3 Transport | 1,997.25 |
| 1.A.4 Other Sectors | 1,422.37 |
| 1.A.5 Non-specified | 903.37 |
| 1.B Fugitive emissions from fuels | 1,156.62 |

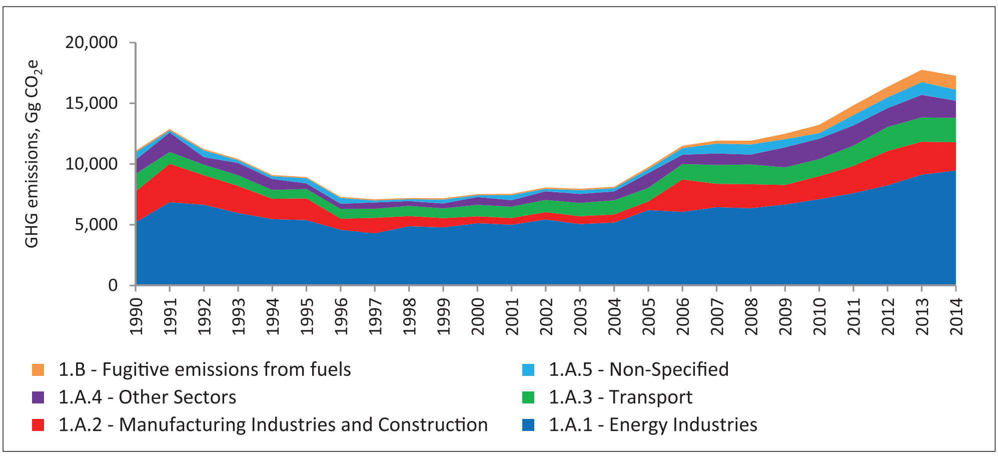



Figure 2.14 Trend in aggregated emissions by source categories within the energy sector for the period 1990-2014 (in Gg $CO_2e$)

As shown in Figure 2.14, the share of energy industries (mostly electricity and heat production) in total fuel combustion source category (CRF 1.A) is the highest, namely 54.87%, within the energy sector followed by manufacturing industries and construction with 13.40%, and other sectors where included commercial/Institutional, residential, agriculture and forestry categories with 8.24%. The residential category within the other sectors (CRF 1.A.4) has the highest share with 83.59% and followed by agriculture/forestry 14.09% and commercial/institutional 2.32% categories in the year of 2014. The road transportation represents 83.84% and it is the most important key source with one of the highest shares of emissions within the transport category. The second important source is the railway with 14.12% and the civil aviation source category, from which is the domestic aviation represents 2.04% (40.72 Gg $CO_2$e). The international aviation bunkers will not be calculated in the national total emissions but reported as memo item with 42.62 Gg $CO_2$e in 2014.

Table 2.7 shows emissions of source categories within the energy sector. The GHG emission ($CH_4$, $N_2O$) from all categories of energy sector was estimated by using IPCC default methodology and combined with default and country-specific emission factors (CS EFs) for some types of coal.

Table 2.7 GHG emissions within energy sector in 1990-2014

| Years | 1.A.1 Energy Industries | 1.A.2 Manufacturing industries and Construction | 1.A.3 Transport | | |
|---|---|---|---|---|---|
| | 1.A.1.a Electricity & Heat production | | 1.A.3.a Civil aviation | 1.A.3.b Road transportation | 1.A.3.c Railways |
| | Gg of $CO_2$e | | | | |
| 1990 | 5,209.46 | 2,535.38 | 10.50 | 1,169.57 | 259.58 |
| 1991 | 6,859.17 | 3,152.22 | 30.54 | 756.85 | 191.94 |
| 1992 | 6,641.70 | 2,430.69 | 44.85 | 705.76 | 120.72 |
| 1993 | 5,967.53 | 2,227.26 | 50.58 | 624.87 | 206.43 |
| 1994 | 5,465.64 | 1,675.79 | 55.67 | 557.67 | 103.07 |
| 1995 | 5,374.38 | 1,792.04 | 55.67 | 623.51 | 92.57 |
| 1996 | 4,581.79 | 922.79 | 69.66 | 639.33 | 96.14 |
| 1997 | 4,300.48 | 1,268.19 | 43.90 | 598.55 | 99.92 |
| 1998 | 4,881.22 | 831.64 | 34.99 | 702.32 | 103.70 |
| 1999 | 4,788.08 | 758.56 | 27.67 | 649.06 | 121.77 |
| 2000 | 5,126.45 | 571.47 | 32.13 | 781.23 | 121.77 |
| 2001 | 4,998.02 | 561.63 | 39.44 | 753.03 | 132.69 |

| | | | | | |
|---|---|---|---|---|---|
| 2002 | 5,432.83 | 601.56 | 37.54 | 819.16 | 147.18 |
| 2003 | 5,058.33 | 645.38 | 51.85 | 872.81 | 161.68 |
| 2004 | 5,182.93 | 671.51 | 46.12 | 920.37 | 190.46 |
| 2005 | 6,201.15 | 716.30 | 34.35 | 873.20 | 201.17 |
| 2006 | 6,060.46 | 2,666.97 | 70.94 | 932.37 | 262.09 |
| 2007 | 6,446.99 | 1,929.58 | 71.57 | 1,227.44 | 241.08 |
| 2008 | 6,362.45 | 1,976.21 | 55.35 | 1,322.66 | 242.56 |
| 2009 | 6,671.26 | 1,608.01 | 23.86 | 1,206.98 | 215.23 |
| 2010 | 7,110.12 | 1,888.93 | 29.58 | 1,139.36 | 231.64 |
| 2011 | 7,598.97 | 2,231.90 | 47.40 | 1,365.64 | 266.29 |
| 2012 | 8,244.55 | 2,829.49 | 73.16 | 1,618.76 | 286.22 |
| 2013 | 9,120.42 | 2,714.87 | 73.16 | 1,639.09 | 285.61 |
| 2014 | 9,474.70 | 2,313.48 | 40.72 | 1,674.49 | 282.04 |

| Years | 1.A.4 Other Sectors | | | 1.A.5 Non-specified | 1.B Fugitive emissions from fuels | |
|---|---|---|---|---|---|---|
| | 1.A.4.a Commercial/ Institutional | 1.A.4.b Residential | 1.A.4.c Agriculture/ Forestry | 1.A.5.a Stationary | 1.B.1.a Coal mining & handling | 1.B.2.a.iii.2 Oil Production and Upgrading |
| | Gg of $CO_2e$ | | | | | |
| 1990 | 85.09 | 787.94 | 291.33 | 611.38 | 130.91 | - |
| 1991 | 610.66 | 795.38 | 191.79 | 162.73 | 128.71 | - |
| 1992 | 301.54 | 196.34 | 130.35 | 539.16 | 114.26 | - |
| 1993 | 576.72 | 288.71 | 145.77 | 217.01 | 102.74 | - |
| 1994 | 583.96 | 244.97 | 79.74 | 232.86 | 94.35 | - |
| 1995 | 171.31 | 233.20 | 64.35 | 421.83 | 91.80 | - |
| 1996 | 161.01 | 210.14 | 48.50 | 466.94 | 93.47 | 1.12 |
| 1997 | 229.69 | 252.10 | 45.15 | 165.52 | 90.06 | 0.95 |
| 1998 | 158.75 | 187.90 | 46.82 | 159.42 | 92.50 | 5.01 |
| 1999 | 169.38 | 157.58 | 82.04 | 322.79 | 90.80 | 7.22 |
| 2000 | 307.65 | 288.11 | 50.60 | 148.07 | 94.84 | 6.58 |
| 2001 | 182.85 | 305.42 | 52.13 | 419.93 | 94.03 | 8.32 |
| 2002 | 118.92 | 538.59 | 57.27 | 200.32 | 101.41 | 13.99 |
| 2003 | 112.24 | 569.15 | 67.61 | 312.48 | 97.11 | 18.40 |
| 2004 | 87.69 | 566.79 | 76.03 | 264.93 | 98.77 | 19.86 |
| 2005 | 38.13 | 1,070.70 | 112.21 | 333.48 | 137.48 | 20.13 |
| 2006 | 41.75 | 630.68 | 96.94 | 551.50 | 152.91 | 36.64 |
| 2007 | 30.55 | 813.18 | 111.12 | 803.03 | 172.48 | 83.73 |
| 2008 | 28.29 | 659.93 | 125.25 | 841.33 | 187.81 | 117.97 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2009 | 27.04 | 1,488.95 | 133.00 | 664.15 | 264.30 | 188.55 |
| 2010 | 34.85 | 1,509.17 | 146.45 | 456.93 | 461.17 | 219.14 |
| 2011 | 34.73 | 1,431.51 | 196.00 | 848.09 | 541.36 | 261.88 |
| 2012 | 35.53 | 1,306.55 | 198.44 | 889.03 | 483.08 | 393.12 |
| 2013 | 28.85 | 1,620.19 | 221.21 | 1,039.72 | 473.70 | 545.29 |
| 2014 | 33.04 | 1,188.95 | 200.37 | 903.37 | 412.35 | 744.27 |

### 2.4.1.1. Fugitive emissions from solid fuels (CRF 1.B)

In Mongolia, fugitive emissions from fuels occur in the coal mining and handling and oil industries. Mongolia does not yet have any petroleum refining industries. The fugitive emissions from fuels were calculated from the surface mining industry because the underground mines are not occurring in Mongolia.

The overview of total fugitive emissions from fuels and the share of fuels within the fugitive emissions have been presented in the following figures.

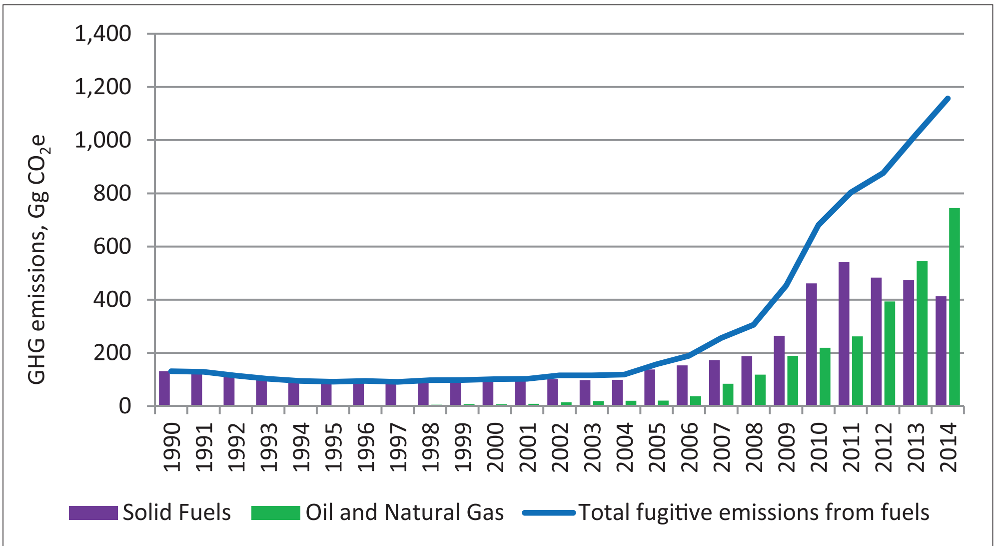



Figure 2.15 Total fugitive emissions from fuels for the period 1990-2014

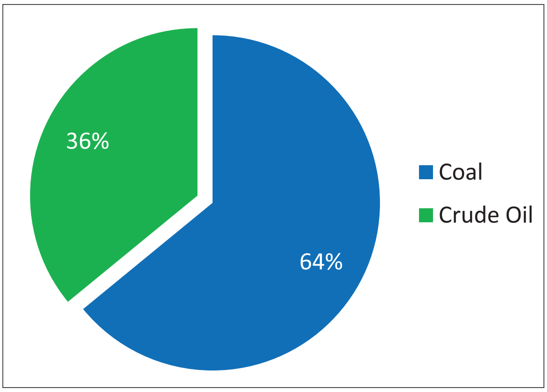



Figure 2.16 The share of fugitive emissions from coal and crude oil production over the years 1990-2014

From the figure above can be seen that the fugitive emissions from coal mining and handling were relatively constant until 2011 and further have been slightly declined. On the contrary, the fugitive emissions from oil production have risen steadily. Over the years the share of fugitive emissions from solid fuels represents 64% and from crude oil 36%.

### 2.4.1.2. Comparison of the Sectoral Approach (SA) with the Reference Approach (RA)

In the context of international climate protection, the reporting on fuel combustion related $CO_2$ emissions due to the dominant share of the total emissions are of the utmost importance.

The Reference Approach (RA) is a top-down approach, using a country's energy supply data to calculate the $CO_2$ emissions from mainly fossil fuels combustion. The RA is a straight forward method that can be applied on the basis of relatively easily available energy supply statistics. Excluded carbon has increased the requirements for data to some extent. However, improved comparability between the sectoral and reference approaches continues to allow a country to produce a second independent estimate of $CO_2$ emissions from fuel combustion with limited additional effort and data requirements (IPCC, 2006).

The RA is designed to calculate the emissions of $CO_2$ from fuel combustion, starting from high-level energy supply data. The assumption is that carbon is conserved so that, for example, carbon in crude oil is equal to the total carbon content of all the derived products. The RA does not distinguish between different source categories within the energy sector and only total $CO_2$ emissions from source category fuel combustion (CRF 1.A) (IPCC, 2006).

The RA has been executed for all inventory years from 1990 until 2014. The basis for this is essentially provided by the figures for the national energy balances on primary energy consumption, but in the case of Mongolia, it is provided by coal balances of national and IEA statistics.

The difference of energy consumption for total fuels between the RA and SA gives an average deviation of -0.35% overall years and the average difference of $CO_2$ emissions between RA and SA is 2.29% overall years.

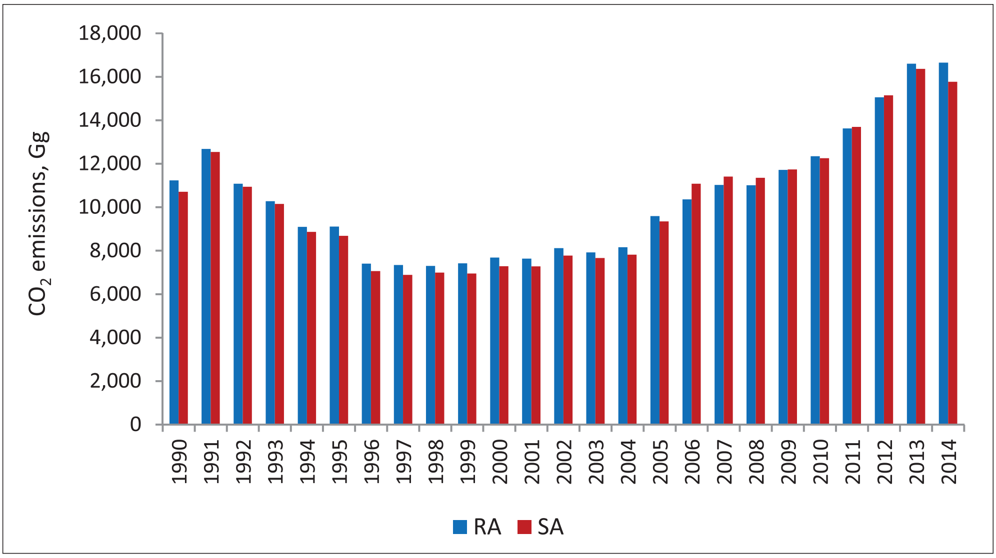



Figure 2.17 The difference of $CO_2$ emissions between RA and SA in 1990-2014

## 2.4.2. Industrial processes and product use (IPPU)

The GHG emissions from IPPU sector cover emissions estimation from mineral industry (CRF 2.A), metal industry (CRF 2.C), non-energy products from fuels and solvent use (CRF 2.D), and product uses as substitutes for ozone-depleting substances (CRF 2.F). Other subcategories under IPPU sector were not estimated, because they either do not occur in Mongolia (e.g. 2.A.3. Glass production, 2.B. Chemical industry and some metal industries) or the availability of activity data is poor/insufficient. The $CO_2$ and HFCs were the main direct GHGs estimated and reported under IPPU sector.

The main contributor to the total emissions from IPPU sector is the mineral industry (cement and lime production). The share of mineral industry in the total GHG emissions of IPPU sector was around 69% in 2014. As a second contributor to the total emissions was the emissions from the use of fluorinated substitutes for ozone-depleting substances (CRF 2.F) and represents around 29% (see Figure 2.18).

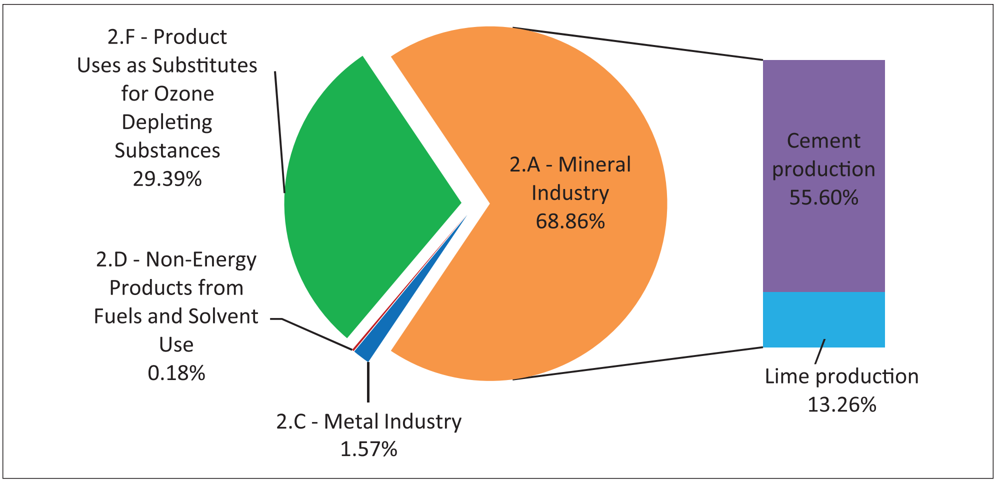



Figure 2.18 The share of each subsector in total GHG emissions of IPPU, 2014

The next table below provides the GHG emissions and percentages of IPPU categories.

Table 2.8 GHG emissions from IPPU by source categories, Gg $CO_2e$

| Categories | Emissions | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|
| Mineral Industry | Gg | 206.34 | 78.62 | 62.02 | 134.15 | 209.20 | 225.89 |
| | % | 94.36 | 94.93 | 96.99 | 95.51 | 83.14 | 68.86 |
| Metal Industry | Gg | NA | 1.25 | 1.04 | 5.24 | 5.14 | 5.15 |
| | % | NA | 1.51 | 1.63 | 3.73 | 2.04 | 1.57 |
| Non-energy Products from Fuels and Solvent Use | Gg | 12.32 | 2.95 | 0.88 | 1.06 | 1.77 | 0.59 |
| | % | 5.64 | 3.56 | 1.38 | 0.76 | 0.70 | 0.18 |
| Product Uses as Substitutes for Ozone Depleting Substances | Gg | NA | NA | NA | NA | 35.53 | 96.43 |
| | % | NA | NA | NA | NA | 14.12 | 29.39 |
| IPPU Total | Gg | 218.66 | 82.81 | 63.95 | 140.46 | 251.63 | 328.06 |
| | % | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

According to the table above, the metal industry occurs in Mongolia since 1995 and GHG emissions from this source category for the period 1990-1995 have not been estimated. Regarding the GHG emissions from product uses as substitutes for ozone-depleting substances the activity data were available only from 2012, so the emissions have been back-calculated to the year of introduction. According to IPCC 2006, volume 3, part 2, if there is Tier 1 method was applied for emissions estimation from HFCs then it back-calculates the development of banks of a refrigerant from the current reporting year to the year of its introduction. The year of introduction for HFC-134a (mobile air conditioning) was 2007.

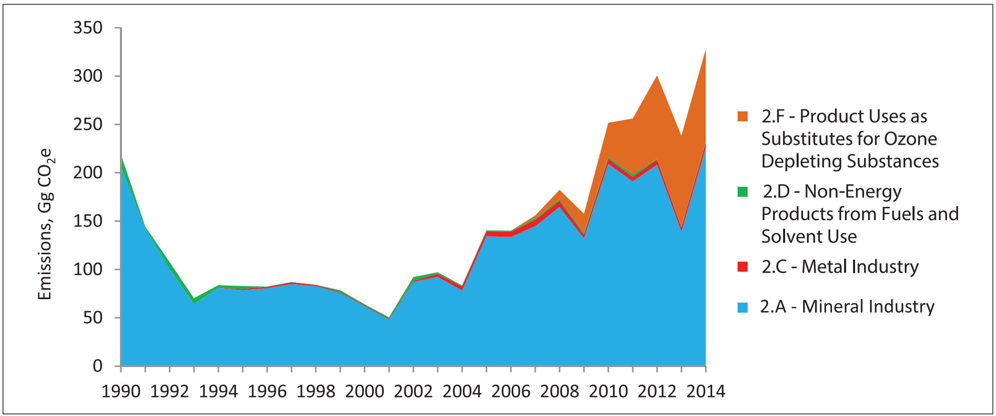



Figure 2.19 GHG emissions from IPPU sector by source categories, Gg $CO_2e$

From the Figure 2.20 can be seen two major rises in 2010 and in 2014. In Mongolia, there were two main cement plants operating until 2013 namely Darkhan cement plant, built in 1968 and Khutul cement plant, built in 1982. Both had a wet cement processing technology. In 2014, the Khutul cement plant introduced the dry processing technology and started its operations generating a capacity of 1 million tonnes of cement per year. From 2008-2009 there was an economic downturn in Mongolia and after this, in 2010 the economy has grown back.

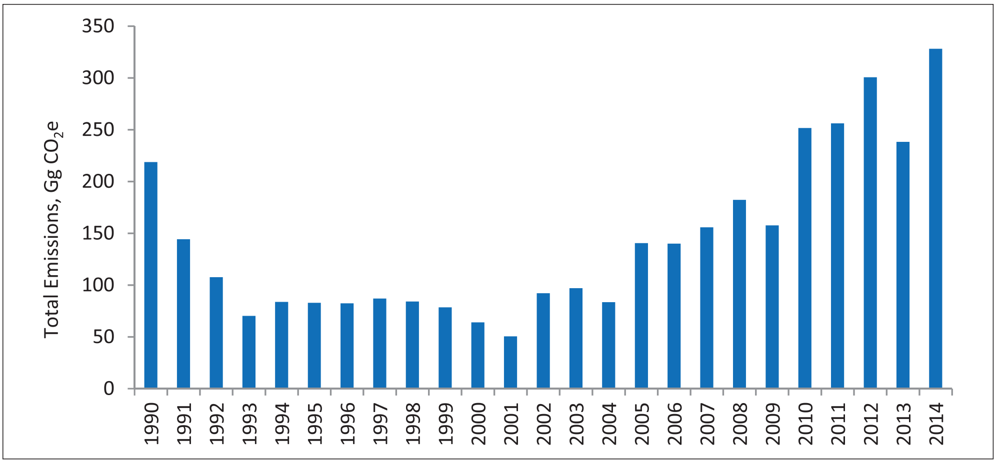



Figure 2.20 Total GHG emissions from IPPU sector over the years 1990-2014, Gg $CO_2e$

The total GHG emissions from IPPU sector are given in the following Table 2.9 for the years 1990-2014.

Table 2.9 Total GHG emissions from IPPU sector over the years 1990-2014, Gg $CO_2e$

| Years | Emissions, Gg $CO_2e$ | | | | |
|---|---|---|---|---|---|
| | 2.A-Mineral industry | 2.C-Metal industry | 2.D-Non-energy products from fuels and solvent use | 2.F-Product uses as substitutes for ozone-depleting substances | Total IPPU |
| 1990 | 206.34 | NA | 12.32 | NA | 218.66 |
| 1991 | 141.99 | NA | 2.24 | NA | 144.23 |
| 1992 | 100.37 | NA | 7.19 | NA | 107.57 |
| 1993 | 64.08 | NA | 6.07 | NA | 70.15 |
| 1994 | 80.94 | NA | 2.77 | NA | 83.71 |
| 1995 | 78.62 | 1.25 | 2.95 | NA | 82.81 |
| 1996 | 80.49 | 1.54 | 0.24 | NA | 82.26 |
| 1997 | 84.84 | 1.82 | 0.29 | NA | 86.95 |
| 1998 | 82.55 | 1.30 | 0.24 | NA | 84.09 |
| 1999 | 75.88 | 1.05 | 1.47 | NA | 78.41 |
| 2000 | 62.02 | 1.04 | 0.88 | NA | 63.95 |
| 2001 | 47.88 | 0.80 | 1.71 | NA | 50.39 |
| 2002 | 87.04 | 1.27 | 3.71 | NA | 92.03 |
| 2003 | 92.24 | 3.14 | 1.59 | NA | 96.97 |
| 2004 | 78.08 | 4.39 | 1.00 | NA | 83.47 |
| 2005 | 134.15 | 5.24 | 1.06 | NA | 140.46 |
| 2006 | 133.50 | 5.60 | 0.88 | NA | 139.99 |
| 2007 | 144.60 | 6.43 | 1.53 | 3.17 | 155.73 |
| 2008 | 164.44 | 6.51 | 1.65 | 9.67 | 182.27 |
| 2009 | 132.11 | 4.01 | 1.71 | 19.73 | 157.57 |
| 2010 | 209.20 | 5.14 | 1.77 | 35.53 | 251.63 |
| 2011 | 190.95 | 4.80 | 2.83 | 57.47 | 256.05 |
| 2012 | 208.12 | 5.45 | 0.65 | 86.42 | 300.64 |
| 2013 | 138.95 | 4.48 | 0.29 | 94.48 | 238.21 |
| 2014 | 225.89 | 5.15 | 0.59 | 96.43 | 328.06 |

*Source: GHG Inventory prepared by CCPIU under MET.*

### 2.4.3. Agriculture, forestry and other land use (AFOLU)

#### 2.4.3.1. Agriculture

The GHG inventory for the agriculture sector is conducted for three categories: enteric fermentation, manure management, and aggregated sources and non-$CO_2$ emissions on land. The GHG emissions from these three categories were directly dependent on the livestock population in the country, even though there are four discrete source categories in the Mongolian agriculture sector as follows: (i) extensive livestock, which is the traditional semi-nomadic pastoral system, where camels, horses, cattle, sheep, and goats are grazed together; (ii) mechanized large-area crop production of cereals and fodder crops; (iii) intensive farming, producing potatoes and other vegetables, with both mechanized and simple production methods; and (iv) intensive livestock, with housed dairy cattle, pigs and poultry. The livestock sector dominates, contributing 84.9% of total agricultural production. Since the 1990s, the total number of animals generally increased and reached 52,159.6 thou. heads in 2014. However, there is a unique natural disaster to Mongolia named dzud in which large numbers of livestock die due to severe, cold winter occasionally. In 1999-2000, 2000-2001 and 2001-2002, Mongolia was hit by three dzuds in a row, in which 3,341.4 thou.heads (10%), 4,152.2 thou.heads (14%), 2,177.6 thou.heads (8%) animals were lost respectively excluding swine and poultry population number. A second harsh winter within GHG inventory period of 1990-2014 happened in 2009-2010, and over 11 million livestock lost and decreased by circa 26% from previous year's total. As a result, methane and nitrous oxide emissions from domestic livestock fluctuate following those long and short-term impact. The livestock numbers between 1990 and 2014 are given in the Table 2.10 by animal category.

Table 2.10 Animal population data in Mongolia within 1990-2014, thou. heads

| Year | Cattle | Horses | Camels | Sheep | Goats | Total livestock | Swine | Poultry* (AAP) | Total animal |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 2,848.7 | 2,262.0 | 537.5 | 15,083.0 | 5,125.7 | 25,856.9 | 134.7 | 53.6 | 26,045.2 |
| 1991 | 2,822.0 | 2,259.3 | 476.0 | 14,721.0 | 5,249.6 | 25,527.9 | 83.3 | 36.7 | 25,647.9 |
| 1992 | 2,819.2 | 2,200.2 | 415.2 | 14,657.0 | 5,602.5 | 25,694.1 | 48.6 | 30.2 | 25,772.9 |
| 1993 | 2,730.5 | 2,190.3 | 367.7 | 13,779.2 | 6,107.0 | 25,174.7 | 28.7 | 21.6 | 25,225.0 |
| 1994 | 3,005.2 | 2,408.9 | 366.1 | 13,786.6 | 7,241.3 | 26,808.1 | 23.4 | 12.2 | 26,843.7 |
| 1995 | 3,317.1 | 2,684.4 | 367.5 | 13,718.6 | 8,520.7 | 28,608.3 | 23.5 | 16.3 | 28,648.1 |
| 1996 | 3,476.3 | 2,770.5 | 355.6 | 13,718.6 | 9,134.8 | 29,455.8 | 23.5 | 9.5 | 29,488.8 |
| 1997 | 3,612.9 | 2,893.2 | 355.4 | 13,560.6 | 10,265.3 | 30,687.4 | 19.1 | 10.7 | 30,717.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1998 | 3,725.8 | 3,059.1 | 356.5 | 14,165.6 | 11,061.9 | 32,368.9 | 20.7 | 10.9 | 32,400.5 |
| 1999 | 3,824.7 | 3,163.3 | 355.6 | 15,191.3 | 11,033.9 | 33,568.8 | 21.9 | 12.8 | 33,603.5 |
| 2000 | 3,097.6 | 2,660.7 | 322.9 | 13,876.4 | 10,269.8 | 30,227.4 | 14.7 | 14.7 | 30,256.8 |
| 2001 | 2,069.6 | 2,191.8 | 285.2 | 11,937.3 | 9,591.3 | 26,075.2 | 14.8 | 8.9 | 26,098.9 |
| 2002 | 1,884.3 | 1,988.9 | 253.0 | 10,636.6 | 9,134.8 | 23,897.6 | 13.3 | 10.1 | 23,921.0 |
| 2003 | 1,792.8 | 1,668.9 | 256.7 | 10,756.4 | 10,652.9 | 25,127.7 | 13.7 | 14.9 | 25,156.3 |
| 2004 | 1,841.6 | 2,005.3 | 256.6 | 11,686.4 | 12,238.0 | 28,027.9 | 17.2 | 29.2 | 28,074.3 |
| 2005 | 1,963.6 | 2,029.1 | 254.2 | 12,884.5 | 13,267.4 | 30,398.8 | 22.7 | 23.3 | 30,444.8 |
| 2006 | 2,167.9 | 2,114.8 | 253.5 | 14,815.1 | 15,451.7 | 34,803.0 | 32.8 | 34.8 | 34,870.6 |
| 2007 | 2,425.8 | 2,239.5 | 260.6 | 16,990.1 | 18,347.8 | 40,263.8 | 36.0 | 48.5 | 40,348.3 |
| 2008 | 2,503.4 | 2,186.9 | 266.4 | 18,362.3 | 19,969.4 | 43,288.4 | 29.3 | 59.2 | 43,376.9 |
| 2009 | 2,599.3 | 2,221.3 | 277.1 | 19,274.7 | 19,651.5 | 44,023.9 | 25.8 | 65.7 | 44,115.4 |
| 2010 | 2,176.0 | 1,920.3 | 269.6 | 14,480.4 | 13,883.2 | 32,729.5 | 24.8 | 70.0 | 32,824.3 |
| 2011 | 2,339.7 | 2,112.9 | 280.1 | 15,668.5 | 15,934.6 | 36,335.8 | 30.4 | 98.1 | 36,464.3 |
| 2012 | 2,584.6 | 2,330.4 | 305.8 | 18,141.4 | 17,558.7 | 40,920.9 | 40.4 | 77.2 | 41,038.5 |
| 2013 | 2,909.5 | 2,619.4 | 321.5 | 20,066.4 | 19,227.6 | 45,144.4 | 51.9 | 80.4 | 45,276.7 |
| 2014 | 3,413.9 | 2,995.8 | 349.3 | 23,214.8 | 22,008.9 | 51,982.7 | 46.3 | 130.6 | 52,159.6 |
| % Change 1990/2014 | 19.84% | 32.44% | -35.01% | 53.91% | 329.38% | 101.04% | -65.63% | 143.66% | 100.27% |
| * annual average population of poultry is estimated according to equation 10.1 (IPCC, 2006) | | | | | | | | | |

*Source: Statistical Yearbooks of Agriculture 1990-2014. www.1212.mn*

In 2014, agriculture sector accounted for 48.51% (16.726.97 Gg $CO_2e$) of total national direct GHG emissions (without LULUCF), is the second major source of GHG emissions after the 'Energy' sector in the country (Figure 2.21).

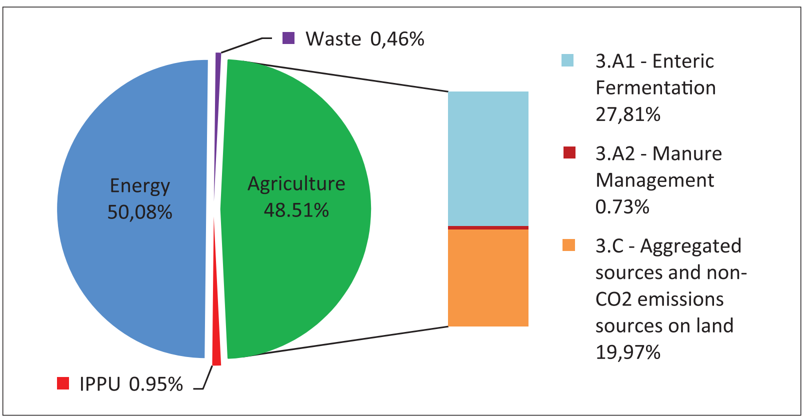



Figure 2.21 $CO_2e$ emissions from the agriculture sector compared to the total GHG emissions (excl. LULUCF) in Mongolia in 2014)

Within the agriculture sector, enteric fermentation contributes the highest to the GHG emissions with circa 57.33% followed by aggregated sources and non-$CO_2$ emissions sources on land (41.17%) and manure management with 1.5% (Table 2.11).

Table 2.11 GHG Emissions from agriculture by source categories, Gg $CO_2$e

| Categories | Emissions | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|
| 3.A1 - Enteric Fermentation | Gg | 6,310.67 | 6,979.31 | 6,910.66 | 5,697.06 | 6,112.72 | 9,588.85 |
| | % | 59.62 | 59.55 | 58.61 | 57.65 | 57.47 | 57.33 |
| 3.A2 - Manure Management | Gg | 175.23 | 190.47 | 188.12 | 153.18 | 160.44 | 251.22 |
| | % | 1.66 | 1.63 | 1.60 | 1.55 | 1.51 | 1.50 |
| 3.C – Aggregated sources and non-$CO_2$ emissions sources on land | Gg | 4,099.40 | 4,550.01 | 4,691.75 | 4,031.10 | 4,362.54 | 6,886.94 |
| | % | 38.73 | 38.82 | 39.79 | 40.80 | 41.02 | 41.17 |
| Agriculture Total | Gg | 10,585.30 | 11,719.79 | 11,790.52 | 9,881.33 | 10,635.70 | 16,726.98 |
| | % | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Between 1990 and 2014, the total GHG emissions originated from the agriculture sector tended to higher values, increasing by 58.02%, from 10,585.29 to 16,726.97 Gg $CO_2$e (Table 2.12), in particular, due to increasing the number of domestic livestock which increased 25,856.9 million to 51,982.7 million in 1990-2014. However, the animal number was fluctuated within the inventory period due to the dzud occurrence as explained above (Figure 2.22).

Table 2.12 Emissions from agriculture sector in 1990 and 2014

| Sector | Gas | Gg $CO_2$e | | Change from 1990 (Gg $CO_2$e) | Change from 1990 (%) |
|---|---|---|---|---|---|
| | | 1990 | 2014 | | |
| 3.A1 - Enteric Fermentation | $CH_4$ | 6,310.67 | 9,588.82 | 3,278.15 | 51.95% |
| 3.A2 - Manure Management | $CH_4$ | 175.23 | 251.22 | 75.99 | 43.36% |
| 3.C - Aggregated sources and non-$CO_2$ emissions sources on land | $CH_4$, $N_2O$ | 4,099.40 | 6,886.94 | 2,787.55 | 68.00% |
| 3. Total of Agriculture | $CH_4$, $N_2O$ | 10,585.30 | 16,726.98 | 6,141.68 | 58.02% |

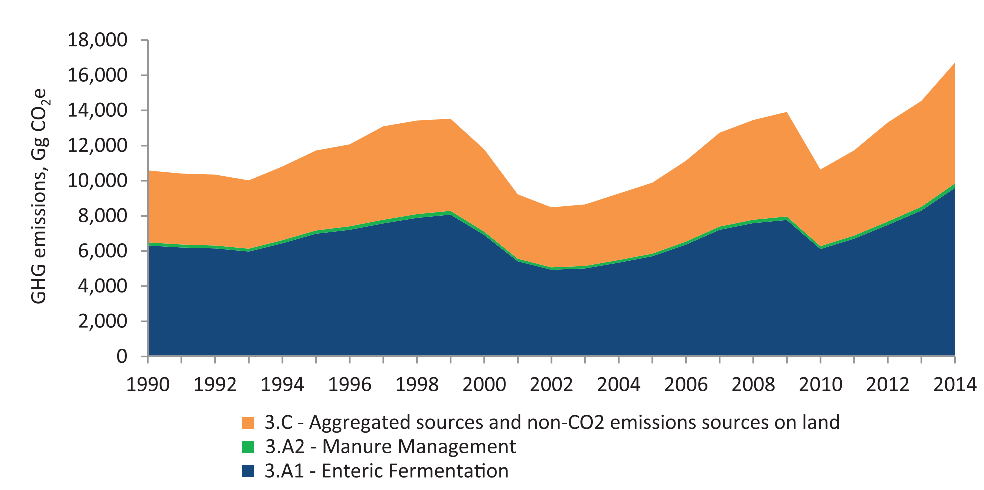



Figure 2.22 Trend in aggregated emissions by subcategories within the agriculture sector for the period 1990-2014, Gg $CO_2e$

### 2.4.3.2. Land Use, Land Use Change and Forestry (LULUCF)/ Forestry and other land use (FOLU)

In the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006), the AFOLU (Agriculture, Forestry and Land Use) category combines two previously distinct sectors LULUCF (Land Use, Land Use Change and Forestry) and agriculture defined in the 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories (revised IPCC 1996). The structure of 6 land use categories under LULUCF was retained. Although, only Forest land remaining forest land (CRF 3.B.1) of Land category and Harvested wood products (CRF 3.D.1) of other (CRF 3.D) category are covered under the LULUCF sector for this submission (Table 2.13). The emissions and removals from the HWP were less than one percent for all years of the inventory. The changes of a trend in percentage between 1990/2014 and 2013/2014 are given below of the following table.

Table 2.13 GHG emissions from LULUCF by source categories, Gg $CO_2e$

| Year | 3.B.1 – Forest land | 3.D.1 - Harvested Wood Products | Total Forestry, and Other Land Use (LULUCF) |
|---|---|---|---|
| 1990 | -22,795.13 | -229.05 | -23,024.18 |
| 1991 | -22,930.61 | -20.09 | -22,950.70 |
| 1992 | -23,094.90 | 102.86 | -22,992.04 |
| 1993 | -23,233.74 | 134.29 | -23,099.45 |
| 1994 | -23,372.71 | 159.93 | -23,212.78 |

| | | | |
|---|---|---|---|
| 1995 | -23,511.80 | 147.65 | -23,364.15 |
| 1996 | -23,651.01 | 54.13 | -23,596.88 |
| 1997 | -23,790.35 | 28.13 | -23,762.22 |
| 1998 | -24,351.87 | -55.57 | -24,407.44 |
| 1999 | -25,274.34 | -54.48 | -25,328.82 |
| 2000 | -25,134.97 | -53.41 | -25,188.38 |
| 2001 | -25,776.59 | -52.36 | -25,828.96 |
| 2002 | -25,833.03 | -51.33 | -25,884.36 |
| 2003 | -25,497.11 | -50.33 | -25,547.44 |
| 2004 | -25,590.34 | -49.34 | -25,639.68 |
| 2005 | -25,609.71 | -48.37 | -25,658.09 |
| 2006 | -24,702.76 | -47.43 | -24,750.19 |
| 2007 | -24,711.09 | -46.50 | -24,757.59 |
| 2008 | -24,670.51 | -45.58 | -24,716.09 |
| 2009 | -24,906.26 | -44.69 | -24,950.95 |
| 2010 | -24,627.06 | -43.81 | -24,670.87 |
| 2011 | -24,593.38 | -42.95 | -24,636.33 |
| 2012 | -24,560.00 | 182.95 | -24,377.05 |
| 2013 | -24,733.68 | 186.02 | -24,547.66 |
| 2014 | -24,634.30 | 182.37 | -24,451.93 |
| Diff % 1990/2014 | 8.07% | -179.62% | 6.20% |
| Diff % 2013/2014 | -0.40% | -1.96% | -0.39% |

### 2.4.3.3 Land use

GHG emissions from the Land use, Land use change, and Forestry sector consist largely of carbon dioxide gas, generated mainly through cropland, grassland, and forest management activities, including carbon gain and losses linked to anthropogenic land use changes. According to the IPCC methodology, estimation on this sector should consider all six land categories: forest land, cropland, grassland, wetland, settlement, and another land. Due to some limitations regarding activity data generation and time series consistency, only forest land remaining forest land category is reported for this submission. The Figure 2.23 shows that 24 years' trend of $CO_2$ removal in Mongolia.

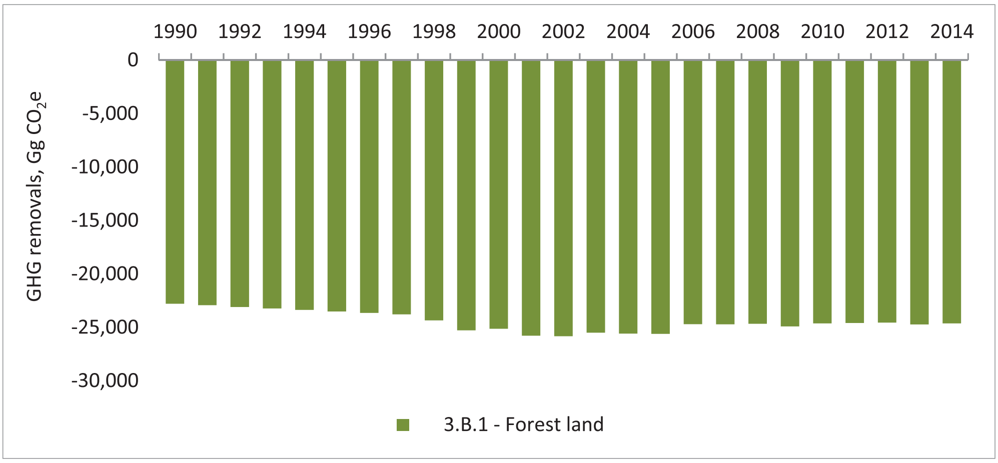



Figure 2.23 GHG removal trend in Land source category for the period 1990-2014, Gg $CO_2e$

The forest resources which cover about 10% of the country are split in Mongolia: in the north, the more boreal type of forest is found whilst in the southern regions the predominant forest type is Saxaul. The question of the definition of forest is controversial in Mongolia and thus under constant debate. The different agencies and institutions rely on different attributes of their forest definitions for several purposes. Nevertheless, there is a vital discussion on-going in Mongolia about the necessity of one or more definitions of forest land and woody biomass ecosystems in general. This might influence also the reporting in the successional submissions of the NIR. In the GHG inventory sense, the IPCC definition of Forest land was applied: *This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.*

For the consistent representation of lands, their utilization throughout the time series, available data from the Administration of Land Affairs, Geodesy and Cartography (ALAGAC) have been applied. The national land use classification consists of a 3 level hierarchical stratification, starting from the country total (level 0) to broad land use classes (level 1: Agricultural Land; Settlements; Road, Line and Network; Land with Forest Resource; Land with Water Resources; Land for Special Utilisation*)* and even more detailed land use sub-classes (level 2). Particular is the class "Land for Special Utilisation" since its level 2 strata can be further divided into the level 1 classes of the land use classes other than "Land for Special Utilisation". Thus it represents a subset of the respective land use class, but with another function, defined by ALAGAC. This split is important for domestic reporting but not for the areas' potential in sequestering and emit GHGs, therefore we re-allocated the areas under "special utilization" to the relevant land-use classes without the restriction of special use.

The aggregation of the ALAGAC land use classification into the applied seven sub-classes is based on the definitions available from ALAGAC plus expert knowledge (Table 2.14).

Table 2.14 Land conversion key from ALAGAC definition to IPCC land use class

| ALAGAC Level 1 class | | ALAGAC Level 2 class | IPCC Land Use Class |
|---|---|---|---|
| 1 | Agricultural land | Pastureland | Grassland |
| | | Hayfields | Grassland |
| | | Cropland | Cropland |
| | | Fallow land | Grassland |
| | | Lands under agricultural constructions | Settlement |
| | | Lands not suitable for agricultural use | Other land |
| 2 | Land of cities, villages and other urban settlements | Lands under construction and buildings | Settlement |
| | | Lands for public use | Settlement |
| | | Industrial land | Settlement |
| | | Mining area | Settlement |
| | | Residential areas | Settlement |
| 3 | Road and line network | Railway | Settlement |
| | | Transport | Settlement |
| | | Air transport | Settlement |
| | | Water transport | Settlement |
| | | Cable, network, lines etc. | Settlement |
| 4 | Land with forest resources | Land covered forest including Saxaul forest | Forest land |
| | | Logged areas | Forest land |
| | | Tree nursery | Forest land |
| | | Lands reserved for forest expansion | Woody Grassland |
| | | Other land of forest | Forest land |
| 5 | Land with water resources | River, stream | Wetlands |
| | | Lake, pond, marsh | Wetlands |
| | | Spring | Wetlands |
| | | Glaciers and lands covered with perpetual snows and ice-river | Other land |

Especially when it comes to forest area further clarification, consolidation and country-wide harmonization have to be done: The forest in Mongolia consists of two major types of forest:

1. Boreal conifer forests in the north end
2. Saxaul forest in the south of the country.

The forest area for the boreal forests, their coverage and characteristics are assessed in a national forest inventory (NFI) whilst more detailed information on Saxaul forests remain sparse. For that reason, in this submission, the definitions for the forest is applied following the ALAGAC land classification. Nevertheless, it is planned to incorporate new area information on both forest types (and thus the remaining land-use classes) as soon as they are available.

The area aggregation of the ALAGAC land use data into the applied IPCC six land classes is shown in the Table 2.15.

Table 2.15 National land use totals, thou. hectares

| Year | Forest land | Cropland | Grassland | Wetlands | Settlements | Other land |
|---|---|---|---|---|---|---|
| | Thou. ha | | | | | |
| 1989 | 15,581.88 | 1,305.65 | 134,431.54 | 1,747.19 | 661.36 | 2,683.92 |
| 1990 | 15,660.48 | 1,283.45 | 134,407.39 | 1,759.15 | 679.88 | 2,621.20 |
| 1991 | 15,726.66 | 1,261.34 | 134,395.15 | 1,771.28 | 698.47 | 2,558.66 |
| 1992 | 15,817.86 | 1,239.00 | 134,359.03 | 1,783.10 | 716.95 | 2,495.61 |
| 1993 | 15,896.64 | 1,216.74 | 134,334.83 | 1,795.09 | 735.51 | 2,432.75 |
| 1994 | 15,975.48 | 1,194.47 | 134,310.60 | 1,807.08 | 754.08 | 2,369.84 |
| 1995 | 16,054.38 | 1,172.19 | 134,286.36 | 1,819.09 | 772.66 | 2,306.88 |
| 1996 | 16,133.34 | 1,149.88 | 134,262.10 | 1,831.10 | 791.26 | 2,243.88 |
| 1997 | 16,212.35 | 1,127.56 | 134,237.82 | 1,843.12 | 809.87 | 2,180.82 |
| 1998 | 16,497.59 | 954.34 | 133,979.16 | 1,656.80 | 737.67 | 2,586.00 |
| 1999 | 16,937.59 | 904.14 | 133,764.86 | 1,657.00 | 806.37 | 2,341.60 |
| 2000 | 16,937.63 | 808.21 | 134,047.81 | 1,659.16 | 824.95 | 2,133.80 |
| 2001 | 17,277.94 | 753.45 | 133,761.49 | 1,659.91 | 833.37 | 2,125.41 |
| 2002 | 17,278.33 | 757.46 | 133,760.99 | 1,659.89 | 830.08 | 2,124.80 |
| 2003 | 17,119.61 | 719.51 | 134,159.51 | 2,272.54 | 859.60 | 1,280.78 |
| 2004 | 17,135.54 | 719.60 | 134,116.67 | 2,295.89 | 867.69 | 1,276.15 |
| 2005 | 17,193.85 | 710.93 | 134,038.05 | 2,295.89 | 896.71 | 1,276.13 |
| 2006 | 16,730.47 | 711.68 | 134,769.30 | 1,994.20 | 929.42 | 1,276.49 |
| 2007 | 16,738.27 | 717.84 | 134,726.73 | 1,994.20 | 958.04 | 1,276.47 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2008 | 16,739.07 | 849.08 | 134,563.20 | 1,994.12 | 989.61 | 1,276.47 |
| 2009 | 16,827.81 | 919.38 | 134,379.56 | 1,994.12 | 1,014.22 | 1,276.47 |
| 2010 | 16,767.12 | 946.28 | 134,293.83 | 2,011.37 | 1,116.44 | 1,276.51 |
| 2011 | 16,758.12 | 978.30 | 134,184.82 | 2,015.42 | 1,198.38 | 1,276.51 |
| 2012 | 16,789.29 | 1,044.96 | 134,043.77 | 2,015.42 | 1,241.59 | 1,276.52 |
| 2013 | 16,839.32 | 1,000.69 | 134,039.24 | 2,015.31 | 1,242.38 | 1,274.62 |
| 2014 | 16,864.77 | 1,026.62 | 133,951.98 | 2,015.05 | 1,278.10 | 1,275.04 |
| Diff % 1990/2014 | 7.69% | -20.01% | -0.34% | 14.55% | 87.99% | -51.36% |
| Diff % 2013/2014 | 0.15% | 2.59% | -0.07% | -0.01% | 2.87% | 0.03% |

Chapter 2

Since ALAGAC area data only gives a broad forest class with no separation in the two forest types, a general split of 75% boreal to 25% saxaul forest was applied based on a recent report (Report on Forest, 2014 approved by Ministry of Environment and Tourism) and expert judgment. Figure 2.24 shows the total forest area of Mongolia based on National Land Agency (ALAGAC) data.

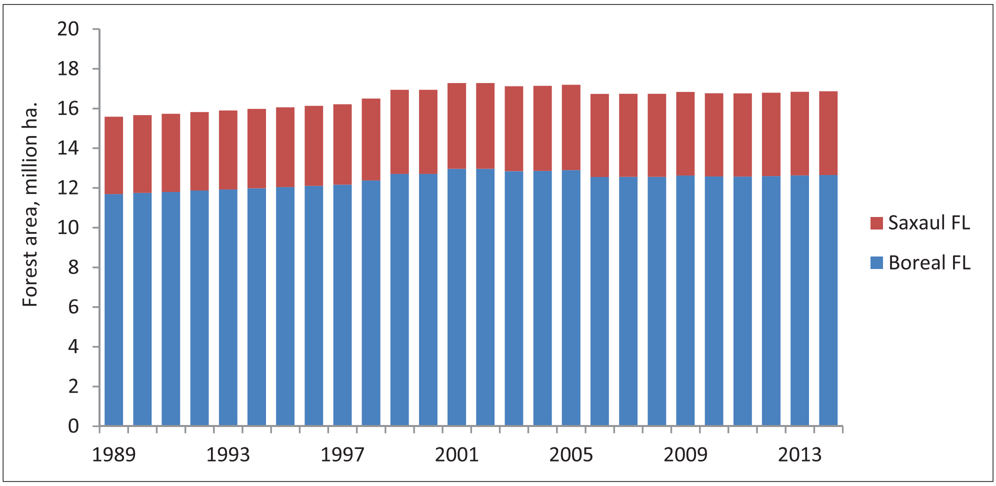



Figure 2.24 The total forest area by two sub-categories

The IPCC 2006 methodology was followed to estimate the gains and losses. The emission factors like below-ground carbon and expansion factors (BECFs), carbon fractions, above-ground biomass and below-ground biomass ratio (AGB-BGB-ratios) are taken from the IPCC tables (IPCC 2006, Table 4.4) and national information like on growth and stocks (The Multipurpose National Forest Inventory of Mongolia, 2016). The main factors used for the forest land GHG estimation are shown in the Table 2.16.

Table 2.16 Emission factors applied in Forest Land emission and removal estimation

| Emission factor | Unit | Boreal forest | Saxaul forest | Source |
|---|---|---|---|---|
| Above-ground biomass growth | [t d.m./ha/yr] | 1 | 0.4 | IPCC 2006, Vol. 4, Ch. 4, Table 4.12 (4.9/4.10) |
| Below-ground to above-ground biomass ratio | [t BGB d.m./(t AGB d.m.)] | 0.30 | 0.30 | NFI 2016, p101 |
| Carbon fraction | [t C/(t d.m.)] | 0.51 | 0.47 | IPCC 2006, Vol. 4, Ch. 4, Table 4.3 |
| Biomass carbon and expansion factor | [-] | 0.55 | 0.75 | IPCC 2006, Vol. 4, Ch. 4, Table 4.5 |
| Default litter stocks | [t C/ha] | 15.9 | 7.95 | NFI 2016, Saxaul is assumed to have half the litter biomass than boreal forest |
| Above-ground biomass stocks | [t d.m./ha] | 60.2 | 25 | NFI 2016, p103-104; IPCC 2006, Vol. 4, Ch. 4, Table 4.8 |
| Split between Boreal and Saxaul forest | [%] | 75 | 25 | Report on Forest, 2014, Ministry of Environment and Tourism |

The activity data of wood harvest collected from the National Statistical Information Database (http://1212.mn). Information on harvested wood is available from 1999 to date. Despite the fact that data is available on the provincial-disaggregation level, the nation-wide data was used. It is assumed that fuelwood is only collected in whole tree form, thus the same methodology is applied as for the harvest removals. Further, it is assumed that wood harvest and fuelwood collection only happens on Forest Land Remaining Forest Land.

The information of disturbance consolidated the NFI which found 18.60% of the forested area (11.3 million ha) was burned. That results in 2,101,800 ha. Further, it assumed that the forest effect can be detected in the NFI for about 10 years. Thus the assumption taken was 2,101,800 ha divided by 10 years equals 210,180 ha/year. Based on this assumption, disturbed area is taken as 200,000 ha in every year in the Forestland estimation.

### 2.4.3.4 Other - Harvested Wood Products

Much of the wood that is harvested from Forest Land, Cropland and other types of land use remain in products for differing lengths of time. Harvested Wood Product (HWP) constitutes a carbon reservoir. The time carbon is held in products will vary depending on the product and its uses (IPCC 2006, Vol. 4, p12.5).

For the HWP UN FAO's FAOSTAT database have been applied. The category is a bit different from the land use categories since the data source is rather clear and well described by for example FAOSTAT. The emission and removal trend from the HWP category is given in the Table 2.13 and Figure 2.25.

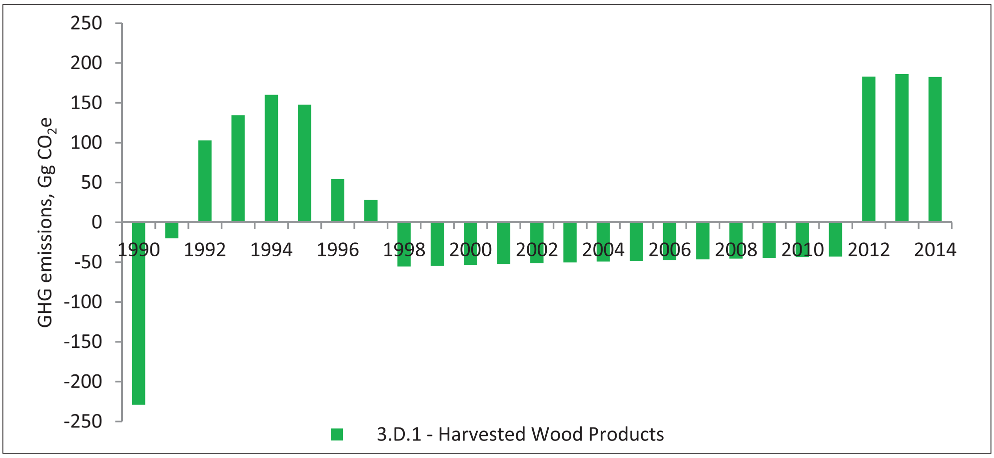



Figure 2.25 Emission trends of Harvested Wood Products

### 2.4.4 Waste

This chapter includes information on the GHG emissions from the waste sector. The categories and activities for estimation methane ($CH_4$) and nitrous oxide ($N_2O$) emissions are described in detail. The GHG inventory of the waste sector is based on estimating of methane from solid waste disposal sites, methane emissions from wastewater treatment and discharge and nitrous oxide from human sewage.

$CO_2$ equivalent emissions from waste sector in 2014 were 159.91 Gg and account for 0.46% of the national totals (Figure 2.26).

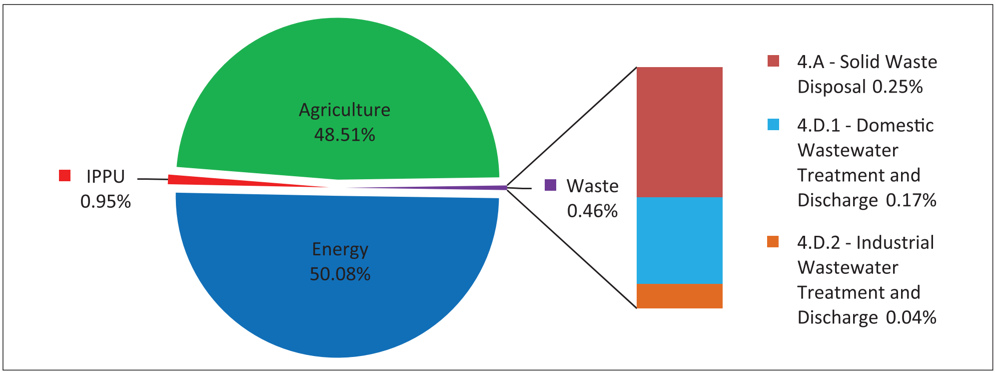



Figure 2.26 $CO_2$ equivalent emissions from the waste sector compared to the total GHG emissions (Excl. LULUCF) in Mongolia in 2014

Total aggregated emissions from the Waste sector have increased by 104.29 Gg $CO_2$e (187.49%) from the 1990 level of 55.62 Gg $CO_2$e. The total $CO_2$e emission from waste sector in 2014 increased 7.93% compared to 2013.

Table 2.17 Emissions from waste sector in 1990 and 2014

| Sector | Gas | Gg $CO_2$e | | Change from 1990 (Gg $CO_2$e) | Change from 1990 (%) |
|---|---|---|---|---|---|
| | | 1990 | 2014 | | |
| 4.A - Solid Waste Disposal | $CH_4$ | 15.33 | 86.39 | 71.06 | 463.35% |
| 4.D.1 - Domestic Wastewater Treatment and Discharge | $CH_4$ | 19.45 | 36.48 | 17.03 | 87.56% |
| 4.D.1 - Domestic Wastewater Treatment and Discharge | $N_2O$ | 12.39 | 21.02 | 8.63 | 69.71% |
| 4.D.2 - Industrial Wastewater Treatment and Discharge | $CH_4$ | 8.46 | 16.02 | 7.56 | 89.48% |
| 4. Total Waste | $CO_2$e | 55.62 | 159.91 | 104.29 | 187.49% |

In 2014, the methane emissions from solid waste disposal (SWD) increased 463.35% and the methane emission from industrial wastewater treatment and discharge has increased 89.48%, methane and nitrous oxide emissions from domestic wastewater treatment and discharge have increased 87.56% and 69.71% separately, compared to the base year.

The GHG emissions trends in this sector are presented in Table 2.18 and Figure 2.27.

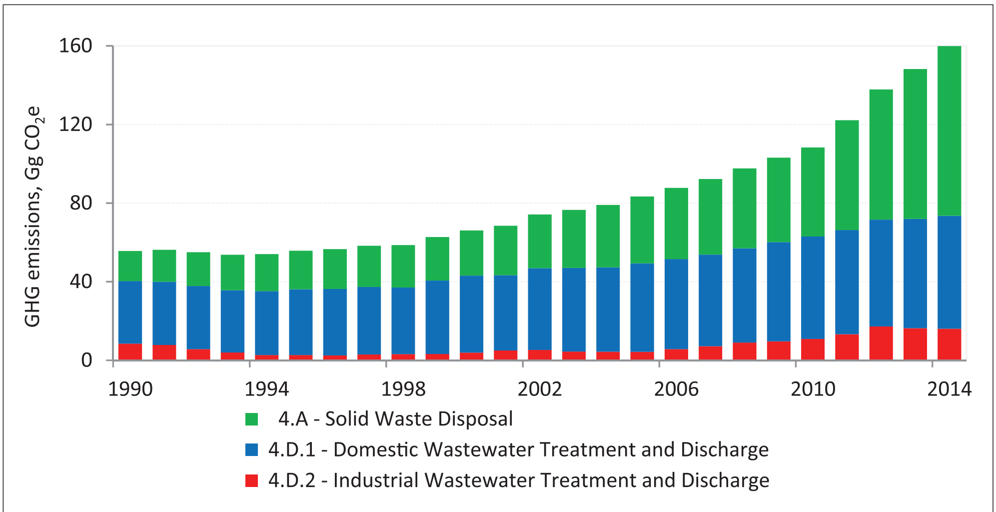



Figure 2.27 Trend of GHG emissions in the waste sector by source categories in 1990-2014, Gg $CO_2$e

The emissions from solid waste disposal sites (SWDS) contribute 54.02%, domestic wastewater treatment and discharge 35.96% and industrial wastewater treatment and discharge 10.02% to waste sector's total emissions in 2014 (detailed in Table 2.18).

Table 2.18 GHG emissions from the waste sector by source categories, Gg $CO_2e$

| Categories | Emissions | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|
| 4.A-Solid Waste Disposal Sites | Gg | 15.33 | 19.60 | 22.92 | 34.00 | 45.27 | 86.39 |
| | % | 27.56 | 35.18 | 34.71 | 40.80 | 41.82 | 54.02 |
| 4.D.1-Domestic Wastewater | Gg | 31.83 | 33.49 | 39.25 | 45.03 | 52.14 | 57.50 |
| | % | 57.23 | 60.11 | 59.43 | 54.04 | 48.17 | 35.96 |
| 4.D.2-Industrial Wastewater | Gg | 8.46 | 2.62 | 3.87 | 4.29 | 10.85 | 16.02 |
| | % | 15.21 | 4.70 | 5.86 | 5.15 | 10.02 | 10.02 |
| 4. Waste Total | Gg | 55.62 | 55.71 | 66.04 | 83.33 | 108.26 | 159.91 |
| | % | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

As seen from the Figure 2.27 and Table 2.18, $CH_4$ and $N_2O$ emissions from SWDS and domestic wastewater treatment and discharge have increased continuously year after year in relation to the population increase, especially in urban areas. $CH_4$ emission has rapidly increased for last five years due to waste disposed to well-managed landfills which are covered with soil since 2010, in Ulaanbaatar. Meanwhile, the emission trend of methane from industrial wastewater treatment and discharge was fluctuating due to the certain year's economic condition.

### 2.4.4.1. Solid Waste Disposal (SWD)

The $CH_4$ emissions from solid waste disposal sites (SWDS) cover managed and un-managed waste disposal sites. Emissions from both disposal sites are estimated by using the first order decay (FOD) method from the year 1970.

Total emissions from the SWDS have increased by 71.06 Gg $CO_2e$ (463.35%) from the 1990 level of 15.33 Gg $CO_2e$. $CH_4$ emissions from SWDS are presented in Figure 2.28.

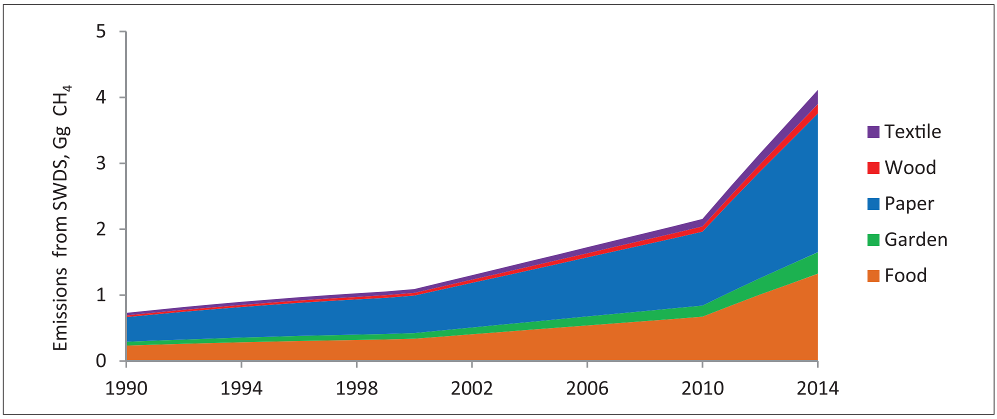



Figure 2.28 Quantities of $CH_4$ emission from biodegradable solid waste disposed of in landfills 1990–2014, Gg

As seen from the Figure 2.27, the quantities of emitted methane from solid waste disposal (SWD) are an increasing trend and it depends on the population growth especially in urban areas. The methane emissions have rapidly increased for last five years, due to waste disposed to well-managed landfills which are covered with soil since 2010, in Ulaanbaatar. Another main factor which affected to the increase of emission estimation is the application of the FOD method for the SWD source category for the first time.

Incomplete data for municipal solid waste (MSW) in Mongolia makes it difficult to accurately determine GHG emissions from the waste sector. The amount of generation of waste is available only from Ulaanbaatar city. The exact amounts of MSW generated from other urban and rural areas of Mongolia are not available. Therefore, the amounts of MSW from the urban areas were calculated by multiplying per capita waste generation rates with the number of urban population. Data on urban population was obtained from the dataset of the NSO.

The generation rates were assumed as the follows and it can be divided into three periods:

- 1970-1999: 0.334 kg/cap/day[2],
- 2000-2009: 0.6 kg/cap/day[3],
- 2010-2014: 0.84 kg/cap/day[4]

The fraction of the MSW disposed to SWDS is assumed as 65% by local

2 *Report WMO, Cal Recovery, 2003*
3 *What a waste, World bank*
4 *Namkhainyam B.et al. (2014), Studies on country-specific GHG emission and removal factors for Mongolia, technical report*

experts (Namkhainyam B. et al. “Studies on country-specific GHG emission and removal factors for Mongolia, 2014”). The assumption was used for the whole inventory period.

The country-specific data of waste composition were taken from the research report from Namkhainyam B. et al. “Studies on country-specific GHG emission and removal factors for Mongolia, 2014”. The composition of waste is presented in the Figure 2.29, which was used for the entire period of 1990 – 2014.

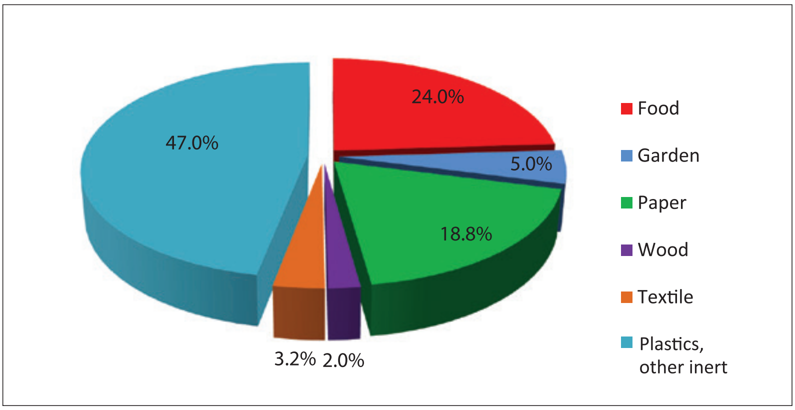



Figure 2.29 Composition of waste

In 2014, Mongolia’s total urban population was 1,990,320 and 2/3 of the total urban population lives in Ulaanbaatar city. Therefore, it was assumed that approximately 2/3 of the total waste is generated only from Ulaanbaatar city. There are 3 operational controlled landfill sites in Ulaanbaatar city. In Mongolia’s case, the first regulated municipal solid waste disposal site, namely Moringiin Davaa which started its operation in 1970. Thus, to estimate the $CH_4$ emissions from SWDS by using the FOD method, the time series for disposed waste amounts were developed from the 1970s (detailed in Table 2.19).

Table 2.19 Urban population and estimated MSW in urban areas of Mongolia

| Indicators | Units | 1970 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| Population | thou. person | 541.6 | 839.0 | 964.2 | 1,226.53 | 1,202.3 | 1,361.27 | 1,579.39 | 1,910.75 | 1,990.32 |
| Generated Waste | Gg | 66.03 | 102.28 | 117.55 | 149.53 | 146.57 | 298.12 | 345.89 | 586.22 | 610.63 |
| Deposited MSW | Gg | 42.92 | 66.48 | 76.4 | 97.19 | 95.27 | 193.78 | 224.83 | 381.04 | 396.91 |
| Biodegradable waste | Gg | 22.75 | 35.24 | 40.49 | 51.51 | 50.49 | 102.7 | 119.16 | 201.95 | 210.36 |

All solid waste disposal sites in Mongolia, particularly in Ulaanbaatar city, were un-managed before 2009 using mainly up to 5 meters of soil cover. Landfill technology was first used at the operational SWDSs of Ulaanbaatar city from the end of 2009 and 8-10 ha areas are processing annually on these sites. Thus, calculations made under solid waste disposal comprise of managed as well as un-managed disposal sites. The SWDS in Mongolia attribute to the un-managed shallow type according to IPCC guidelines before 2009 and since 2010 it divided into un-managed and managed types. Based on this national circumstances, the methane correction factor (MCF) was chosen differently for the inventory period. MCF of 0.4 was taken as a default value for emission estimation between 1970 and 2009. Then in the later period of the inventory (2010-2014), MCF of 1.0 was applied to the managed landfill sites and 0.4 (default value) for un-managed sites for the emission estimation.

### 2.4.4.2 Wastewater Treatment and Discharge

This subsector covers emissions generated during municipal and industrial wastewater treatment. When the wastewater is treated anaerobically, methane is produced. Wastewater handling can also be a source of $N_2O$. Therefore $N_2O$ emissions from human sewage are also part of the inventory.

The GHG emissions trends from the Wastewater treatment and discharge are presented in Table 2.20 and Figure 2.30.

Table 2.20 $CH_4$ and $N_2O$ emissions from wastewater treatment and discharge

| Year | Domestic wastewater | Domestic wastewater | Industrial wastewater | Wastewater treatment and discharge |
|---|---|---|---|---|
| | $CH_4$ Emissions (Gg) | $N_2O$ Emissions (Gg) | $CH_4$ Emissions (Gg) | Total emissions (Gg $CO_2$e) |
| 1990 | 0.93 | 0.04 | 0.40 | 40.29 |
| 1991 | 0.94 | 0.04 | 0.37 | 39.91 |
| 1992 | 0.92 | 0.04 | 0.27 | 37.77 |
| 1993 | 0.94 | 0.04 | 0.19 | 35.63 |
| 1994 | 0.94 | 0.04 | 0.13 | 35.15 |
| 1995 | 0.95 | 0.04 | 0.12 | 36.11 |
| 1996 | 0.96 | 0.04 | 0.12 | 36.24 |
| 1997 | 0.97 | 0.05 | 0.14 | 37.30 |
| 1998 | 0.99 | 0.04 | 0.15 | 37.02 |
| 1999 | 1.08 | 0.05 | 0.15 | 40.58 |
| 2000 | 1.11 | 0.05 | 0.18 | 43.12 |

| | | | | |
|---|---|---|---|---|
| 2001 | 1.15 | 0.05 | 0.23 | 43.31 |
| 2002 | 1.19 | 0.05 | 0.25 | 46.81 |
| 2003 | 1.24 | 0.05 | 0.21 | 46.96 |
| 2004 | 1.28 | 0.05 | 0.21 | 47.26 |
| 2005 | 1.34 | 0.05 | 0.20 | 49.33 |
| 2006 | 1.38 | 0.05 | 0.27 | 51.50 |
| 2007 | 1.42 | 0.05 | 0.34 | 53.77 |
| 2008 | 1.47 | 0.06 | 0.43 | 56.95 |
| 2009 | 1.53 | 0.06 | 0.46 | 60.13 |
| 2010 | 1.61 | 0.06 | 0.52 | 62.99 |
| 2011 | 1.63 | 0.06 | 0.63 | 66.26 |
| 2012 | 1.67 | 0.06 | 0.82 | 71.61 |
| 2013 | 1.72 | 0.06 | 0.78 | 71.93 |
| 2014 | 1.74 | 0.07 | 0.76 | 73.52 |

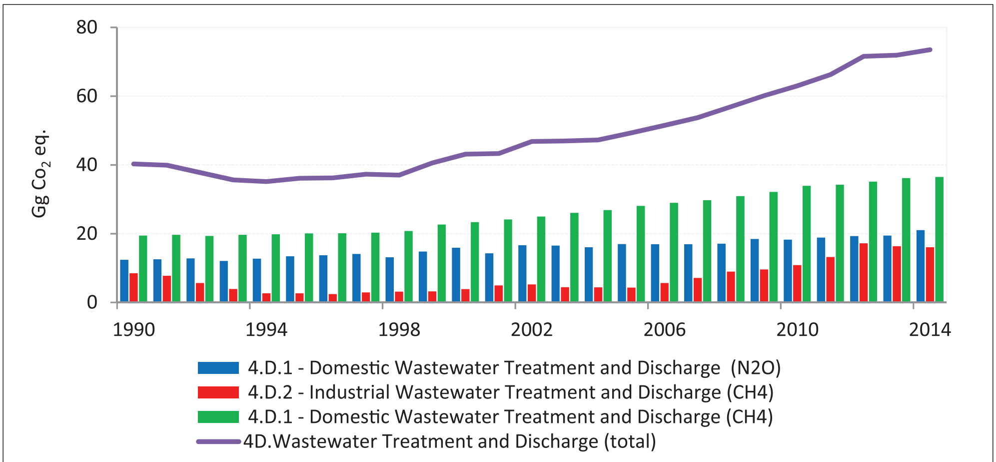



Figure 2.30 Emissions of methane and nitrous oxide from wastewater treatment by source categories

### 2.4.4.3 Domestic Wastewater Treatment and Discharge

GHG emissions from the Domestic wastewater treatment and discharge sector have increased by 25.66 Gg $CO_2$e (80.6%) from the 1990 level of 31.84 Gg $CO_2$e. The total $CO_2$e emission from waste sector in 2014 increased by 3.4% compared to 2013.

Mongolia is administratively divided into the capital Ulaanbaatar, 21 provinces called aimag and aimags into soums. Therefore, the population of Ulaanbaatar city was considered as an urban high-income group, the population of 21 provinces as an urban low-income group and population of soums as a rural group.

In 2015, approximately 25.19% of households were connected to centralized aerobic wastewater treatment plants. 47.58% of households use latrines, 26.8% of households lack wastewater disposal points and only 0.42% use septic tanks. Table 2.21 summarizes degrees of treatment utilization (T) for each income group (U) based on population and housing census of Mongolia, 2015.

Table 2.21 Degrees of treatment utilization (T) for each income group (U)

| Income group | Type of treatment and discharge pathways | Treatment utilization, (%) |
|---|---|---|
| Urban high income | To centralized aerobic treatment plant | 24.76 |
| | Latrine | 29.28 |
| | Septic tank | 0.33 |
| Urban low income | To centralized aerobic treatment plant | 8.20 |
| | Latrine | 18.69 |
| | Septic tank | 0.17 |
| Rural | To centralized aerobic treatment plant | 1.45 |
| | Latrine | 17.03 |
| | Septic tank | 0.08 |

*Note: Columns do not add up to 100% due to rounding.*

For domestic wastewater, biochemical oxygen demand (BOD) is the recommended parameter used to measure the degradable organic component of the wastewater. The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. According to the Mongolian standard the BOD value[5] is 40 g/cap/day (14,600 kg/1,000persons/yr). The IPCC default as well as national standards value of 40 g BOD/person/day or 14,600 kg BOD/1,000person/year was used for emission calculations.

The Ulaanbaatar Water Supply and Sewerage Company (USUG) manage the centralized system that serves the apartment area and a very small proportion of the ger areas. The main water treatment plant is the central wastewater treatment plant which has a capacity of 170,000 $m^3$ per day. The volume of wastewater now far exceeds the physical and technical capacity of these plants which have obsolete technical equipment dating from the socialist era. As a result, 170,000 to 190,000 $m^3$ of improperly treated wastewater

5 *БНбД 40-01-06, Water supply, outdoor sewerage network, and facilities, Order no. 27/17.03.2006 of the Minister of Construction and Urban Development*

is discharged into the Tuul River daily[6]. As reported above, 2/3 of the total urban population lives in Ulaanbaatar. Therefore, methane correction factor for centralized aerobic treatment plant default IPCC value of 0.3 was used for emission calculations.

Methane conversion factors (MCFs) were applied depending on the treatment type and level. The IPCC default values were used as a source of MCF value. However, expert judgment was performed to choose values applicable for Mongolian conditions (Table 2.22).

Table 2.22 MCF values applied depending on type and level of treatment

| Type of treatment or discharge | Maximum Methane Producing Capacity, $B_0$ | Methane Correction Factor, $MCF_j$ | Emission Factor, $EF_j$ |
|---|---|---|---|
| | (kg $CH_4$/kg BOD) | ( - ) | (kg $CH_4$/kg BOD) |
| Centralized aerobic treatment plant | 0.6 | 0.3 | 0.18 |
| Latrine | 0.6 | 0.1 | 0.06 |
| Septic system | 0.6 | 0.5 | 0.3 |

In the case of Mongolia, even in the capital city and other main cities, wastewater treatment facilities do not have an operational device for the methane recovery or gas combustion in gas flare for energy. Originally, at the centralized aerobic treatment plants of big cities including Ulaanbaatar city has been installed methane recovery devices and those are never used due to the lack of human capacity and later all of them became out of use[7].

Therefore for emissions calculations, the IPCC default value of "zero" was used for the amount of methane recovered.

The total amount of $N_2O$ emissions from domestic wastewater treatment in 2014 was 0.07 Gg. This represented a 69.71% increase from 1990 and 8.14% increase from 2013.

Approximately 25.19% of the population was connected to centralized aerobic wastewater treatment plants. The average consumption of protein per inhabitant in every individual year has been obtained from the nutrition statistics of NSO. Due to a very high global warming potential of $N_2O$, relatively low amounts of $N_2O$ formation can substantially contribute to GHG emissions. Referring to the second IPCC assessment report (SAR), 1 g $N_2O$ has the greenhouse effect of 310 g $CO_2$.

6 *Green Development Strategic Action Plan for Ulaanbaatar 2020*

7 *Namkhainyam B.et al. (2014), Studies on country-specific GHG emission and removal factors for Mongolia, technical report*

### 2.4.4.5 Industrial Wastewater Treatment and Discharge

The GHG emissions from the Industrial wastewater treatment and discharge have increased by 7.57 Gg $CO_2$e (89.48%) from the 1990 level of 8.46 Gg $CO_2$e.

Assessment of $CH_4$ production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater is the chemical oxygen demand (COD), the volume of wastewater, industrial sectors and ways of wastewater treatment. Data on industrial output for industries with the largest potential for wastewater methane emissions identified as follows:

- meat processing (slaughterhouse)
- alcohol production
- beer production
- dairy products
- wine production
- vegetable oil production.

Data on industrial output were taken from a dataset of NSO, for the period of 1990-2014. The missing data were assessed by interpolation/extrapolation method. Some industrial outputs were reported in $m^3$; therefore converted units from $m^3$ to tonnes by using the density of alcohol, wine, beer, dairy products were taken as 0.789 kg/l, 0.998 kg/l, 1.01 kg/l, and 1.028 kg/l respectively.

The data of degradable organic component and wastewater produced for per tonne production of those industries as a country-specific value were taken from the IPCC 2006 and other sources. The above values are presented in Table 2.23, which was used for the entire period of 1990 – 2014.

Table 2.23 Wastewater generation coefficient and COD concentration according to industrial product

| Industry type | Wastewater generation W, ($m^3$/t) | COD ($kg/m^3$) | Reference |
|---|---|---|---|
| Alcohol | 24 | 11 | IPCC 2006, Vol 5, Table 6.9, p 6.22 |
| Beer | 6.3 | 2.9 | IPCC 2006, Vol 5, Table 6.9, p 6.22 |
| Dairy products | 7 | 2.7 | IPCC 2006, Vol 5, Table 6.9, p 6.22 |
| Wine | 23 | 1.5 | IPCC 2006, Vol 5, Table 6.9, p 6.22 |
| Vegetable oils | 3.2 | 0.8* | IPCC 2006, Vol 5, Table 6.9, p 6.22 |
| Meat | 13 | 4.1 | IPCC 2006, Vol 5, Table 6.9, p 6.22 |

**-IPCC default value is unavailable. Therefore COD for vegetable oils were taken from Russian NIR-2015 due to same technologies for this product.*

The wastewater production was estimated by multiplying the industrial production by the wastewater generation coefficients. The total organically degradable material was estimated by multiplying the wastewater production by the wastewater generated by the COD coefficient of each industrial product.

The main meat processing factory uses a septic tank + lagoon system for its wastewater treatment while the alcohol, beer, and dairy production industry directly discharge into the central sewer systems with aerobic treatment. The MCF and EF were used for calculations are presented in the Table 2.24.

Table 2.24 Emission factors and parameters used in calculations

| Type of treatment or discharge | Maximum Methane Producing Capacity, $B_0$ | Methane Correction Factor, $MCF_j$ | Emission Factor, $EF_j$ |
|---|---|---|---|
| | (kg $CH_4$/kg COD) | ( - ) | (kg $CH_4$/kg COD) |
| Aerobic treatment plant | 0.25 | 0.3 | 0.075 |
| Anaerobic shallow lagoon | 0.25 | 0.2 | 0.050 |

## 2.5. Summary of GHG inventories for 1990–2014

More numbers of GHG inventories for the period of 1990 to 2014 are presented in Table 2.25. From 1990 the total emissions (source) reduced by 13% and net emissions (source and sink), i.e. removals increased by 81% until 2000 and from 2000 the total emissions increased by 77% and net emissions, i.e. removals decreased by 43% until 2014. The main source of GHG emissions is the energy sector and its share in the total emissions was 51% in 1990 and remained almost constant with 50% in 2014. The second largest source is the agriculture sector with its share in the total emissions 48% in 1990 and 49% in 2014.

Table 2.25 Mongolia's GHG inventory in Gg $CO_2$e (1990-2014)

| Sector | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|
| Total emissions (source) | 21,950.73 | 20,778.97 | 19,449.40 | 19,843.41 | 24,222.94 | 34,482.73 |
| Net emissions (source and sink) | -1,073.46 | -2,585.18 | -5,738.98 | -5,814.68 | -447.93 | 10,030.80 |
| **1. Energy** | **11,091.14** | **8,920.66** | **7,528.89** | **9,738.30** | **13,227.35** | **17,267.79** |
| 1.A - Fuel Combustion Activities | 10,960.24 | 8,828.86 | 7,427.47 | 9,580.69 | 12,547.03 | 16,111.16 |
| 1.A.1 - Energy Industries | 5,209.46 | 5,374.38 | 5,126.45 | 6,201.15 | 7,110.12 | 9,474.70 |
| 1.A.2 - Manufacturing and Construction | 2,535.38 | 1,792.04 | 571.47 | 716.30 | 1,888.93 | 2,313.48 |
| 1.A.3 - Transport | 1,439.66 | 771.75 | 935.12 | 1,108.73 | 1,400.58 | 1,997.25 |
| 1.A.4 - Other Sectors* | 1,164.36 | 468.85 | 646.36 | 1,221.04 | 1,690.48 | 1,422.37 |
| 1.A.5 - Non-specified | 611.38 | 421.83 | 148.07 | 333.48 | 456.93 | 903.37 |
| 1.B - Fugitive Emissions from Fuels | 130.91 | 91.80 | 101.42 | 157.60 | 680.31 | 1,156.62 |
| 1.B.1 - Solid Fuels | 130.91 | 91.80 | 94.84 | 137.48 | 461.17 | 412.35 |
| 1.B.2 - Oil and Natural Gas | NO** | NO | 6.58 | 20.12 | 219.14 | 744.27 |
| **2. Industrial processes** | **218.66** | **82.81** | **63.95** | **140.46** | **251.63** | **328.06** |
| 2.A - Mineral Industry | 206.34 | 78.62 | 62.02 | 134.15 | 209.20 | 225.89 |
| 2.B - Chemical Industry | NO | NO | NO | NO | NO | NO |
| 2.C - Metal Industry | NA | NA | 1.04 | 5.24 | 5.14 | 5.15 |
| 2.D - Non-Energy Products from Fuels and Solvent Use | 12.32 | 2.95 | 0.88 | 1.06 | 1.77 | 0.59 |
| 2.E - Electronic Industry | NO | NO | NO | NO | NO | NO |
| 2.F - Product Uses as Substitutes for Ozone Depleting Substances | NA | NA | NA | NA | 35.53 | 96.43 |
| 2.G - Other Product Manufacture and Use | NA | NA | NA | NA | NA | NA |
| 2.H - Other | NA | NA | NA | NA | NA | NA |
| **3. Agriculture** | **10,585.30** | **11,719.79** | **11,790.52** | **9,881.33** | **10,635.70** | **16,726.98** |
| 3.A - Livestock | 6,485.90 | 7,169.77 | 7,098.77 | 5,850.23 | 6,273.15 | 9,840.04 |
| 3.A.1 - Enteric Fermentation | 6,310.67 | 6,979.31 | 6,910.66 | 5,697.06 | 6,112.72 | 9,588.82 |
| 3.A.2 - Manure Management | 175.23 | 190.47 | 188.12 | 153.18 | 160.44 | 251.22 |
| 3.C - Aggregate sources and non-$CO_2$ emissions sources on land | 4,099.40 | 4,550.01 | 4,691.75 | 4,031.10 | 4,362.55 | 6,886.94 |
| 3.C.1 - Emissions from biomass burning | 106.63 | 106.63 | 170.97 | 4.65 | 3.03 | 2.58 |
| 3.C.2 - Liming | NO | NO | NO | NO | NO | NO |
| 3.C.3 - Urea application | NO | NO | NO | NO | NO | NO |
| 3.C.4 - Direct $N_2O$ Emissions from managed soils | 2,974.67 | 3,311.37 | 3,352.83 | 2,940.44 | 3,190.72 | 5,037.18 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.C.5 - Indirect $N_2O$ Emissions from managed soils | 1,018.10 | 1,132.01 | 1,167.95 | 1,086.01 | 1,168.79 | 1,847.19 |
| 3.C.6 - Indirect $N_2O$ Emissions from manure management | NO | NO | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | NO | NO | NO | NO | NO | NO |
| 3.C.8 - Other | NA | NA | NA | NA | NA | NA |
| **Forestry and Other Land Use/ LULUCF** | **-23,024.18** | **-23,364.15** | **-25,188.38** | **-25,658.09** | **-24,670.87** | **-24,451.93** |
| 3.B - Land | -22,795.13 | -23,511.80 | -25,134.97 | -25,609.71 | -24,627.06 | -24,634.30 |
| 3.B.1 - Forest land | -22,795.13 | -23,511.80 | -25,134.97 | -25,609.71 | -24,627.06 | -24,634.30 |
| 3.B.2 - Grassland | NE | NE | NE | NE | NE | NE |
| 3.B.3 - Cropland | NE | NE | NE | NE | NE | NE |
| 3.B.4 - Wetlands | NE | NE | NE | NE | NE | NE |
| 3.B.5 - Settlements | NE | NE | NE | NE | NE | NE |
| 3.B.6 - Other Land | NE | NE | NE | NE | NE | NE |
| 3.D - Other | -229.05 | 147.65 | -53.41 | -48.37 | -43.81 | 182.37 |
| 3.D.1 - Harvested Wood Products | -229.05 | 147.65 | -53.41 | -48.37 | -43.81 | 182.37 |
| 3.D.2 - Other | NA | NA | NA | NA | NA | NA |
| **4. Waste** | **55.62** | **55.71** | **66.04** | **83.33** | **108.26** | **159.91** |
| 4.A - Solid Waste Disposal | 15.33 | 19.60 | 22.92 | 34.00 | 45.27 | 86.39 |
| 4.B - Biological Treatment of Solid Waste | NO | NO | NO | NO | NO | NO |
| 4.C - Incineration and Open Burning of Waste | NO | NO | NO | NO | NO | NO |
| 4.D - Wastewater Treatment and Discharge | 40.29 | 36.11 | 43.12 | 49.33 | 62.99 | 73.52 |
| **5. Other** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |

# Chapter 3

# PRESENT CLIMATE CHANGE AND ITS FUTURE PROJECTION

# 3. Present climate change and its future projection

## 3.1. Present climate change

According to climate trends of global climate model simulation and annual growth of tree ring in last 2000, climate change, which has been observed in last 40 years and also will be projected to face several decades of years in future, never happened before since engaging with nomadic lifestyle and animal husbandry during several thousands of years in the history. Therefore, climate change consequence will be serious in socio-economy sectors in the country as well.

*Air temperature.* Near-surface temperature and its annual mean over Mongolia have increased by 2.24˚C between 1940-2015 periods according to 48 meteorological stations, which are evenly distributed in the territory (Figure 3.1). Warming intensity is higher in a mountainous region and less in the steppe and Gobi region. The warmest 10 years in last 76 years occurred since 2000.

One of clear feature and change is a sudden increase of hot and consecutive days and a decrease of frozen and cold days.

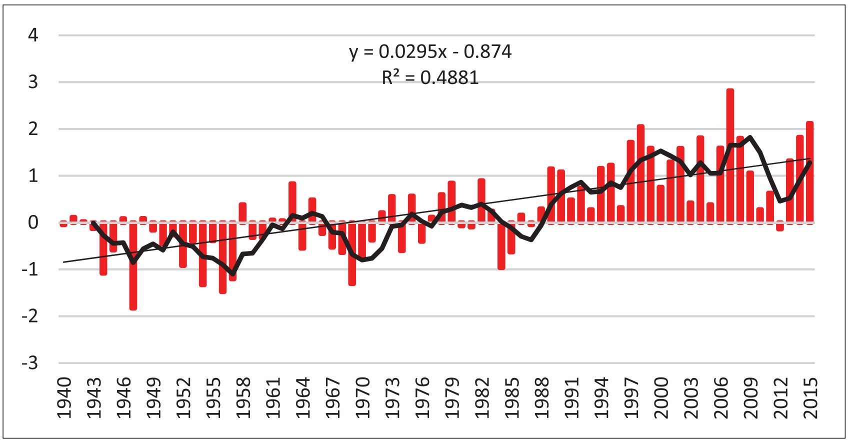



Figure 3.1 Annual mean temperature deviation respects to 1961-1990 climate baseline

*Precipitation.* In Mongolia, 85% of total precipitation falls in the warm season and only 3% even less precipitated as snow in winter. Therefore, annual precipitation dynamics is characterized by summer rainfall, which is equal to 70% of total precipitation. Figure 3.2 shows the interannual deviation of annual precipitation compares to 1961-1990 climate baselines.

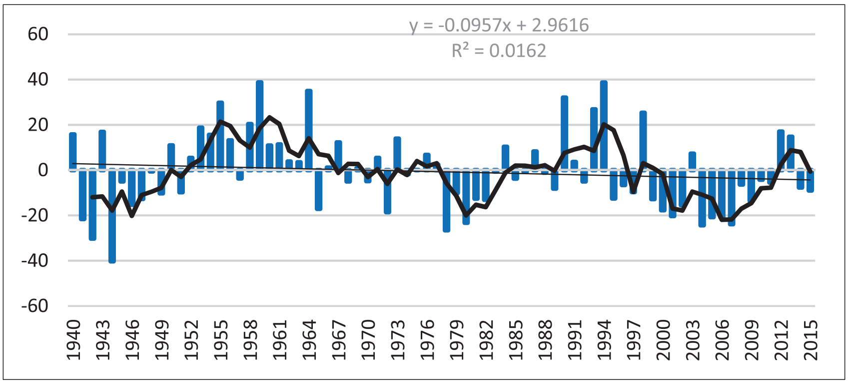



Figure 3.2 Annual precipitation deviations with respect to 1961-1990 climate baselines

There was no significant change in annual precipitation during last 76 years, only small 7% decrease is detected. However, winter snow is getting to increase (Figure 3.3). Since 1940, it was increased by 22% and also 40% since 1961. It indicates that winter snow suddenly increased due to high-intensity global warming.

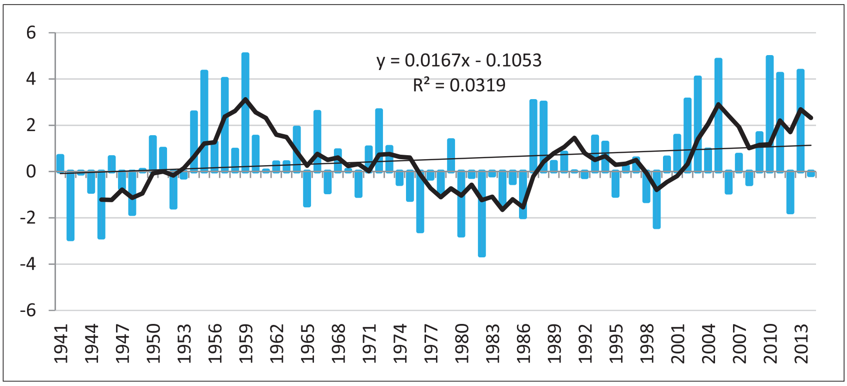



Figure 3.3 Winter precipitation deviation with respect to 1961-1990 climate baselines

In terms of spatial pattern, warm season and summer precipitation have increased slightly in Altai Mountain, the western Gobi in Altai region and south-eastern part of the country since 1961, and decreased by 0.1-2.0 mm/year in all remaining territory of Mongolia. There is statistically significant decreasing in the central part of the country and slightly increasing in the western Gobi in Altai region as well.

One of the changes in precipitation regime over Mongolia during plant growing season, is the increase in total amount of precipitation due to increased percentage of high-intensity rainfall, while also maximum daily rainfall is increasing. This increase was detected over steppe, forest-steppe and Gobi region, where desertification and land degradation is going on with a certain degree. However, the trends are not statistically significant.

***Change of climate extremes***. It is more important to consider climate extreme value in the climate change study. Climate extreme indices, which indicate Mongolian extreme climate condition, were considered at meteorological stations between 1961-2007 (MARCC, 2009; Choi G et al., 2008) and were additionally updated in 1961-2010 period (Davaanyam E, Gomboluudev P., 2013).

We selected 9 core indices, which are possible to use in socio-economic sectors. These indices are estimated at 53 meteorological stations in order to assess present change and trends (Table 3.1).

Table 3.1 Climate extreme indices definition

| № | Indices | Name | Definition | Unit |
|---|---|---|---|---|
| 1 | FD0 | Frost days | Annual count when daily minimum temperature < $0^{O}C$ | Days |
| 2 | SU25 | Summer days | Annual count when daily maximum > $25^{O}C$ | Days |
| 3 | GSL | Growing season length | Annual count of the first span of at least 6 days with daily mean temperature >5ºC and first span after July 1 of 6 days with daily mean temperature TM<5ºC | Days |
| 4 | TXx | Maximum of daily maximum temperature | Monthly maximum of daily maximum temperature | ˚C |
| 5 | TNn | Minimum of daily minimum temperature | Monthly minimum of daily minimum temperature | ˚C |
| 6 | WSDI | Warm spell duration indicator | Annual count of days with at least 6 consecutive days when daily maximum temperature >90th percentile | Days |
| 7 | R20mm | Number of very heavy precipitation | Annual count when daily precipitation >=20mm | Days |
| 8 | CDD | Consecutive dry days | Maximum number of consecutive days with daily precipitation <1mm | Days |
| 9 | CWD | Consecutive wet days | Maximum number of consecutive wet days with daily precipitation P>1mm | Days |

Daily maximum and minimum temperature and precipitation of 53 meteorological stations from 1971 to 2015 are used to estimate climate extreme indices and their trends. Figure 3.4 shows trends of some indices averaged by meteorological stations.

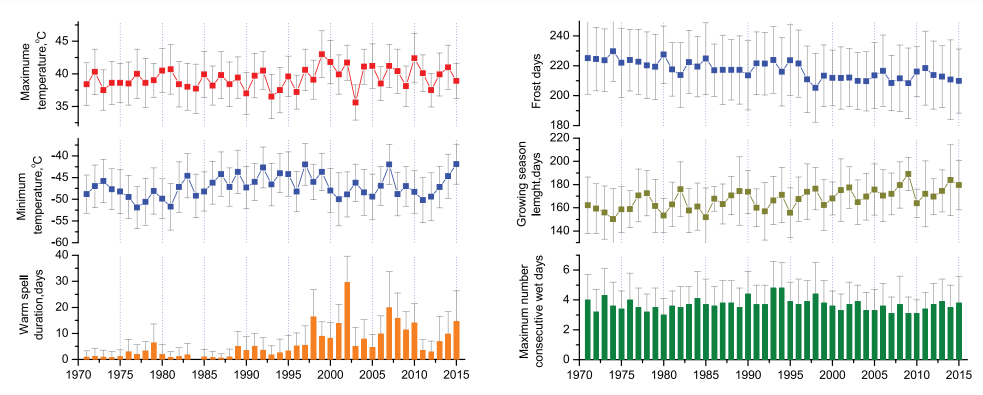



Figure 3.4 Trends of some extreme climate indices, 1971-2015

According to linear trends, frost days are decreased by nearly 15 days, while summer days are increased by 19 days in last 45 years, between 1971-2015. Monthly maximum of daily maximum temperature is increased by 2.6˚C, while the monthly minimum is increased by 0.3˚C. Also, warm spell duration indicator is increased by 13 days (Table 3.2). Maximum and minimum values of change for extreme climate indices at meteorological stations are shown in bracket.

Table 3.2 Climate extreme indices change, 1971-2015

| No | Indices | Unit | Change value (maximum and minimum) |
|---|---|---|---|
| 1 | Frost days | Days | -15 (-28~-3) |
| 2 | Summer days | Days | 24 (4~37) |
| 3 | Growing season length | Days | 19 (9~34) |
| 4 | Maximum of daily maximum temperature | ˚C | 2.6 (1.0~5.4) |
| 5 | Minimum of daily minimum temperature | ˚C | 0.3 (-4.1~3.7) |
| 6 | Warm spell duration indicator | Days | 13 (5~28) |
| 7 | Number of very heavy precipitation | Days | -0.2 (-2~1) |
| 8 | Consecutive dry days | Days | -0.1 (-2~2) |
| 9 | Consecutive wet days | Days | -22 (-77~19) |

Thermal resource of vegetation is increasing due to global warming. For example, the sum of temperature higher than 10°C is increased by 150-360°C during 1961-2015 periods (Figure 3.5).

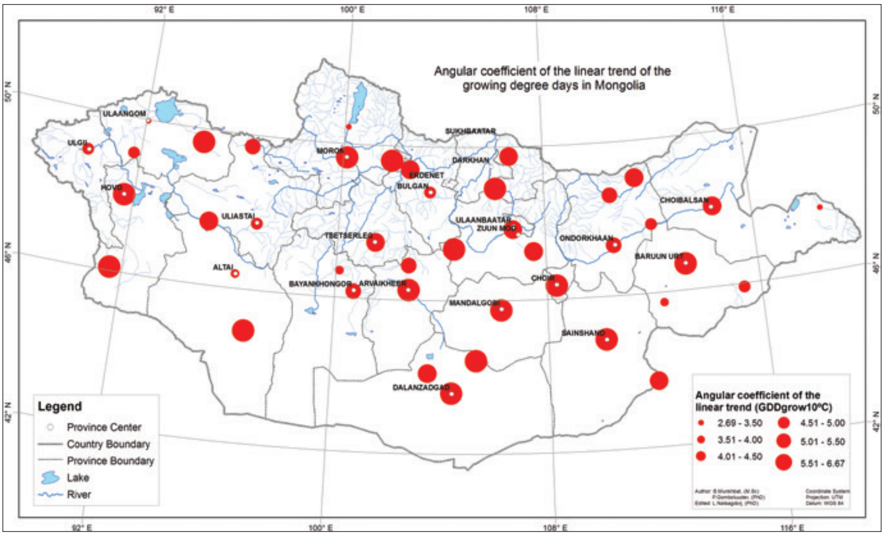



Figure 3.5 Linear trends of sum temperature higher than 10°C, 1961-2015

The geographical pattern of change for warm spell duration indicator is shown in Figure 3.6. A change of these indices has increased in the whole territory of the country, only their intensity is different. Relatively high-intensity change is detected in central, north-western part of Mongolia.

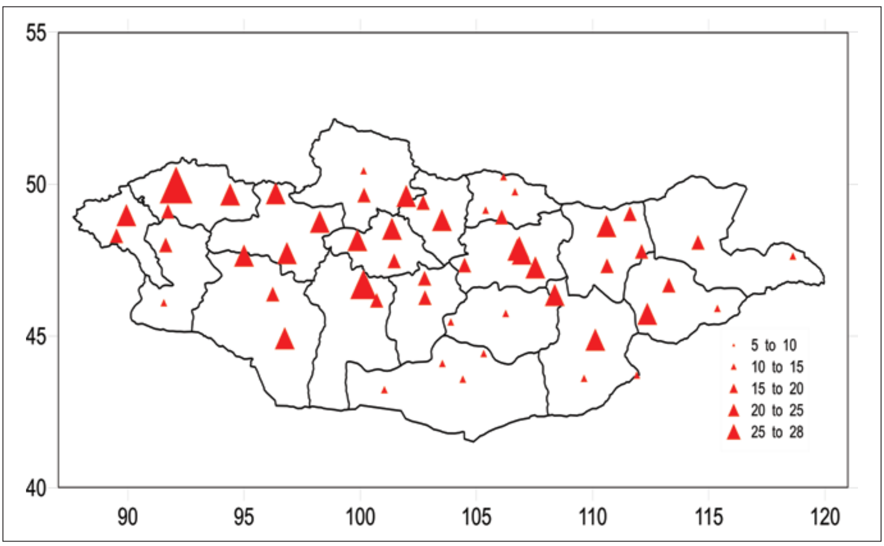



Figure 3.6 Change of warm spell duration indicator, 1971-2015

Generally, the number of days with heavy precipitation and a maximum number of consecutive days with precipitation have slightly decreased (Table

3.1.2). A maximum number of consecutive days without precipitation are decreased by 22 days, because of winter precipitation increasing in most of the territory of the country.

The geographical pattern of a maximum number of consecutive days with precipitation is shown in Figure 3.7. It is different depending on the region. Decreasing pattern is mainly detected in the region, where has agriculture sector such as arable farming.

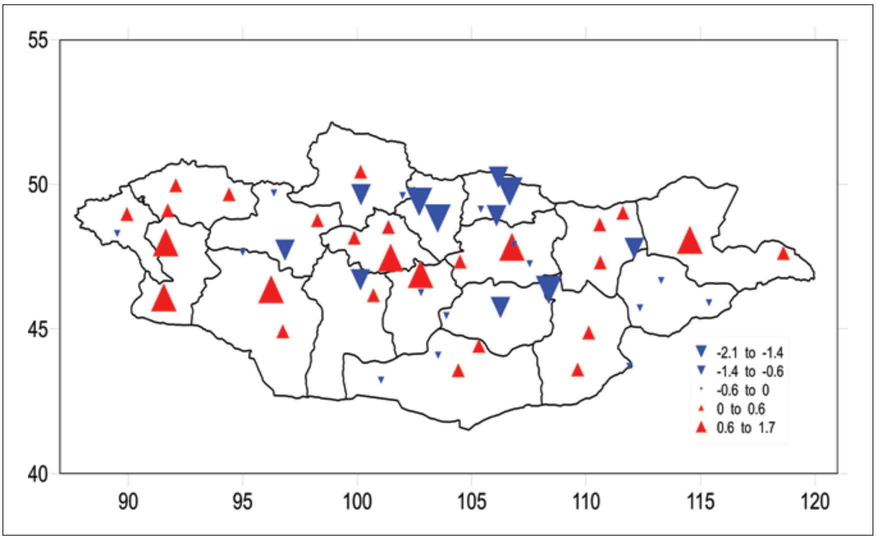



Figure 3.7 Change of maximum number of consecutive days with precipitation, 1971-2015

***Drought and Dzud.*** These are main extreme climate events in Mongolia, which cause huge damage and loss in the country's socio-economy. Damage and loss are not exactly estimated currently, especially in terms of drought. For example, in case of summer in 2015, around 340 thou.ha could not have been harvested.

Generally, drought occurs 1-2 times in mountain, forest and steppe zone every 10 years, in desert-steppe every two years, and in the transition zone of desert-steppe in Mongolia every three years (Natsagdorj et al., 2002).

Drought-summer condition over Mongolia is expressed as an index as proposed by Russian scientist Ped (Ped, 1975) in 1975 and its interannual change is shown in Figure 3.8.

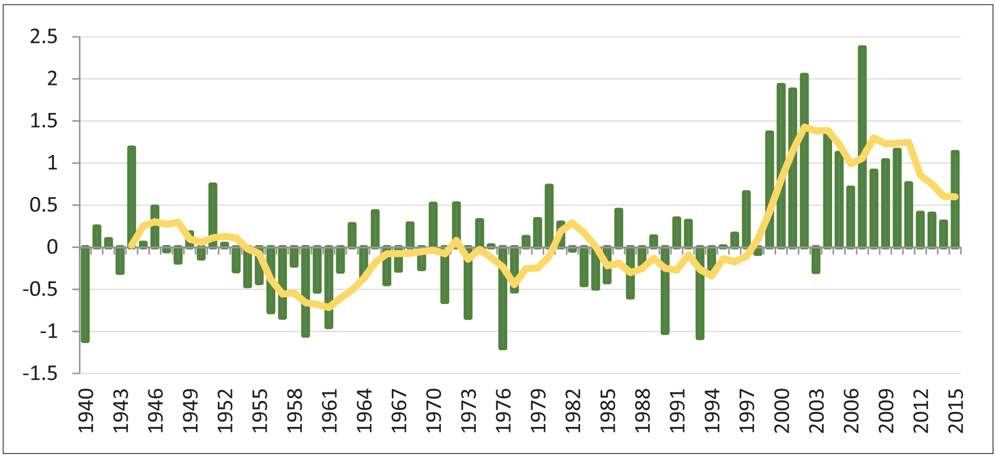



Figure 3.8 Interannual change of drought-summer condition index (averaged by May-August) over Mongolia (negative value refers good summer condition, while positively refers to drought condition)

Since 1940, drought condition has been increased; especially consecutive drought years are continued since 2000. Among them, 2000, 2002 and 2015 are mostly affected to socio-economy in the country (Figure 3.8).

White dzud (heavy snow and large coverage) occurs every two years in Tes river basin, every three years in Khangai, Khentii, Khankhohii, Kharhiraa and Turgen mountain region, and frequently in the northern part of Dundgovi aimag compare to surrounding area (Natsagdorj, 2001). There is good agreement between livestock loss and winter index, which is expressed by a combination of air temperature (cold) and precipitation (snowy) anomaly from November to February.

In Mongolia, winter snow is increasing, however, harsh winter conditions are weakening due to increasing winter temperature since 1940. Figure 3.9 shows an interannual change of winter index and increasing frequency of winter with harshness and dzud condition since 1990s.

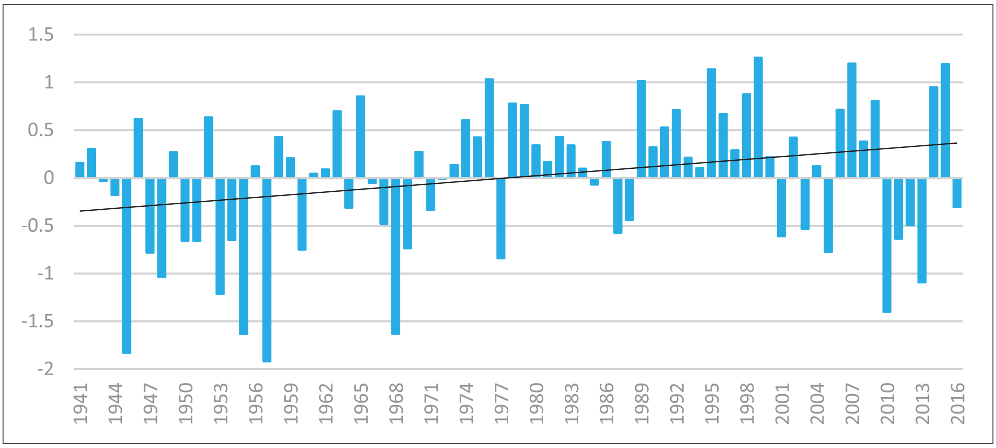



Figure 3.9 Interannual change of winter index (averaged by Nov-Feb) over Mongolia (positive refers mild winter condition, while negatively refers to harsh condition). Note: horizontal axes takes value from 1941 to 2016 winter.

If there is a severe drought in summer and harsh condition next winter, the mass number of livestock loss occurs as usual. Therefore, dzud is evaluated by a combination of summer and winter conditions (Natsagdorj, 2001).

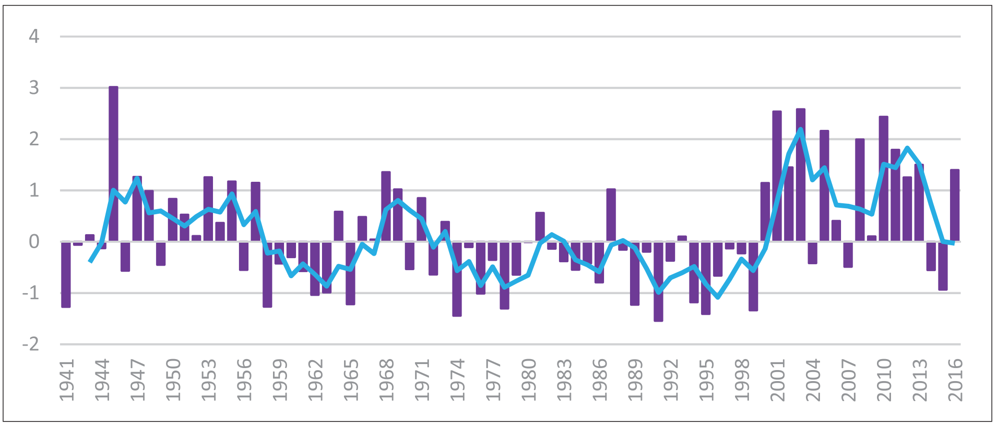



Figure 3.10 Interannual change of dzud index over Mongolia (positive refers dzud condition, while negatively refers to mild winter). Note: horizontal axes takes value from 1941 to 2016 winter.

Figure 3.10 shows increasing of dzud intensity in Mongolia since 1990s. Among them, dzud in 1999-2000, 2001-2002 and 2009-2010 are most severe and consequently, damages and losses were relatively higher compared to other years.

## 3.2. Future climate change projection

In human-induced climate change due to increasing of greenhouse gas and its future projection assessment, driving forces and climate system response to such change are significantly important.

Fifth assessment report of Intergovernmental Panel on Climate Change (AR5, IPCC) is released representative GHG concentration pathway (RCP's) depending on socio-economic development future trends (IPCC-WG I, 2014). This integrated into global climate model (GCM) and produces future climate change projection as quantitatively. Based on results, impact and risk assessment of different sectors are done and finally, adaptation is formed for reducing this vulnerability and risk.

Many international centers, institutes and universities are involved with running GCM in the world. Historical simulation from 1860-2005 and future projection from 2006 to 2100 have been done by about 40 GCMs in 28 centers under different GHG emission scenarios. There are four GHG emission scenarios, which are increased radiation budget by 2.6, 4.5, 6.0 and 8.5 $w/m^2$ as corresponding to each RCP (Taylor K.E et al., 2012).

Among the GCMs, ten have selected based on an assessment of model simulation skill for baseline climate period 1986-2005. The ranking is done by multi-criteria analysis using pattern correlation and bias between model monthly output and gridded observation data (http://www.cru.uea.ac.uk/cru/data/hrg/). Domain covers Mongolia including 41.5-52° latitude and 87.5-120.0° longitude.

In future projection, the time slice is selected as near future 2016-2035 and far future 2081-2100 under different RCPs as respectively.

*Climate model assessment.* Global 40 GCMs skill is evaluated by statistical measures such as spatial correlation and normalized standard error compare to observation in winter and summer season. These measures are selected as criteria of analysis and results were weighted and ranked. Table 3.3 shows selected GCMs name and corresponding institutions.

Table 3.3 Global climate model and developed institutions

| Model abbreviation | Model | Center, institution and university |
|---|---|---|
| CNRM-CERFACS | CNRM-CM5 | Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique |
| EC-EARTH | EC-EARTH | EC-EARTH consortium |
| MIROC | MIROC5 | Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology |
| MOHC | HadGEM2-ES | Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais) |
| MPI-M | MPI-ESM-LR<br>MPI-ESM-MR | Max Planck Institute for Meteorology (MPI-M) |
| MRI | MRI-CGCM3 | Meteorological Research Institute |
| NOAA GFDL | GFDL-CM3<br>GFDL-ESM2G | Geophysical Fluid Dynamics Laboratory |
| NSF-DOE-NCAR | CESM1(CAM5) | National Science Foundation, Department of Energy, National Center for Atmospheric Research |

Above mentioned GCMs are atmosphere-ocean coupled and earth system, model. Their output is available in CMIP5 has a different format and spatial resolution varies from 120 to 300 km. These model outputs are regarded to Gaussian T62 (1.8°) nearly 200 km using bilinear interpolation and finally have used in the assessment of climate change future projection.

In terms of model skills of selected 10 GCMs, there is good agreement such as spatial correlation varies 0.83-0.96 for monthly seasonal temperature and 0.71-0.96 for precipitation. Normalized standard error ranges 0.02-3.5 for temperature and 0.1-8.1 for precipitation. Generally models are reasonably simulated, however, there is a relatively low skill in the winter season, especially 5-10 times precipitation overestimation.

***An ensemble mean of global climate model outputs.*** Future projection of winter, summer and annual mean of temperature and precipitation over Mongolia are estimated by ensemble mean of 10 GCMs from 2016 to 2100 under high (RCP8.5), mid (RCP6.0) and low (RCP2.6) GHG emission scenarios (Figure 3.11-3.12).

Generally, temperature change directly depends on the intensity of GHG emission. However, winter temperature change slightly low and interannual variability is higher than compared to summer temperature change (Figure 3.11a, b). The intensity of temperature changes are similar for all RCP's scenarios until the first half of this century and then it gives different results while increasing year to year. In near future 2016-2035, the seasonal temperature change will range only 2.0-2.3˚C, but it will be expected as 2.4-6.3˚C depending on each RCP scenarios in far future 2081-2100 (Table 3.4).

For precipitation change, winter snow is expected to increase and summer rainfall has no significant change, there is only a slight increase with less than 10% for all scenarios (Figure 3.12a, b). Winter snow will be increased by 10.1-14.0% depending on each scenario in near future and by 15.5-50.2% in far future respectively (Table 3.4).

Changes in temperature and precipitation for all seasons are shown in Table 3.4 under all RCPs.

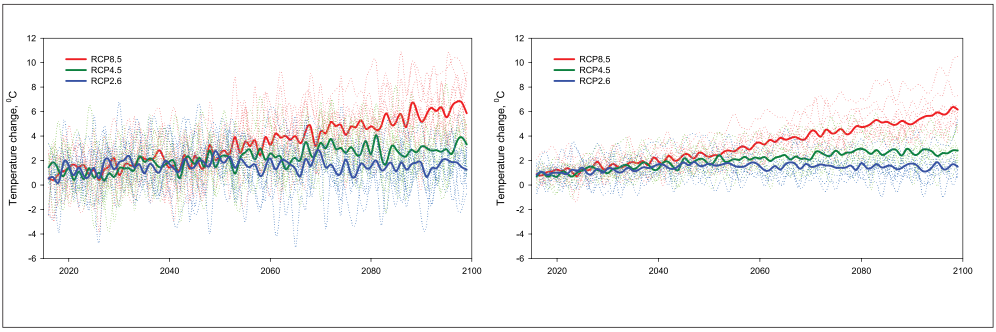



Figure 3.11 a) winter b) summer temperature change, 2016-2100

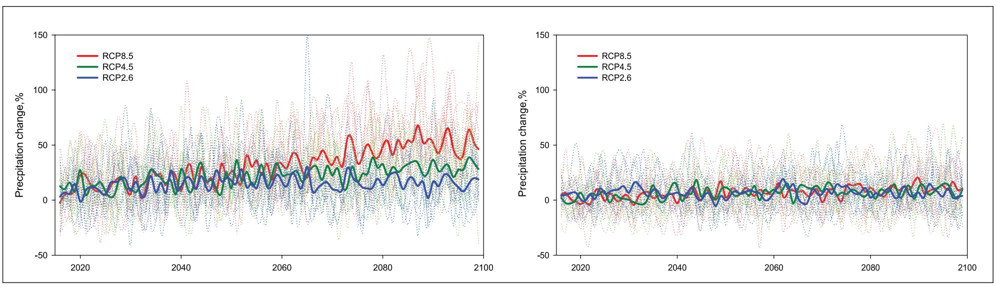



Figure 3.12 a) winter b) summer precipitation change, 2016-2100

Table 3.4 Seasonal climate change over Mongolia under different GHG scenarios (by ensemble mean of 10 GCMs)

| GHG emission | Season | Near future, 2016-2035 | | Far future, 2081-2100 | |
|---|---|---|---|---|---|
| | | Temperature change,˚C | Precipitation change, % | Temperature change,˚C | Precipitation change, % |
| RCP2.6 | Winter | 2.3 | 10.1 | 2.5 | 15.5 |
| | Spring | 2.3 | 9.2 | 2.4 | 11.7 |
| | Summer | 2.2 | 6.2 | 2.5 | 5.1 |
| | Autumn | 2.1 | 7.6 | 2.4 | 7.6 |
| RCP4.5 | Winter | 2.1 | 12.3 | 3.7 | 28.7 |
| | Spring | 2.0 | 7.8 | 3.4 | 17.4 |
| | Summer | 2.1 | 1.1 | 3.5 | 7.8 |
| | Autumn | 2.0 | 8.1 | 3.4 | 11.7 |
| RCP8.5 | Winter | 2.2 | 14.0 | 6.3 | 50.2 |
| | Spring | 2.2 | 9.8 | 5.6 | 28.6 |
| | Summer | 2.2 | 2.4 | 6.0 | 8.7 |
| | Autumn | 2.2 | 6.4 | 6.1 | 24.1 |

The high intensity of warming by 6.0-6.5˚C under RCP8.5 scenario will be projected over western and eastern part of Mongolia in winter (Figure 3.13a) and western part of the country in summer season (Figure 3.13b) in far future. Winter snow will be increased by 50-75% central, western and eastern part of Mongolia (Figure 3.14a), while summer rainfall will be decreased by 5-10% in the western part and slight increase up to 10% in remaining territory of the country (Figure 3.14b).

Spatial patterns of temperature and precipitation change in near (2016-2035) and mid future (2046-2065) are similar and they differentiate each other by low intensity compare to far future change.

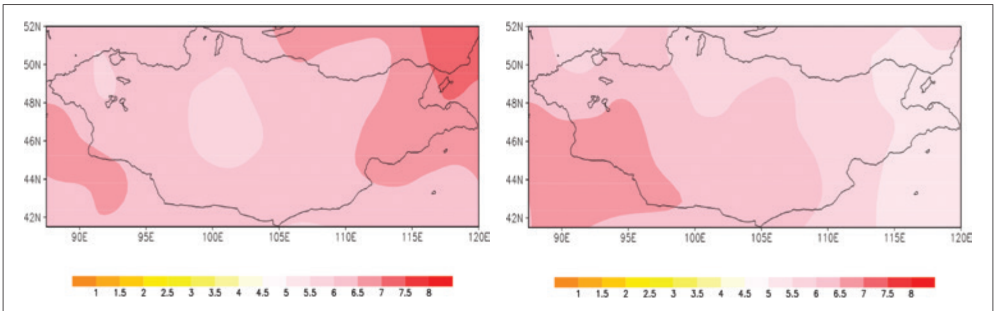



Figure 3.13 Spatial pattern of a) winter b) summer temperature change, °C (2081-2100)

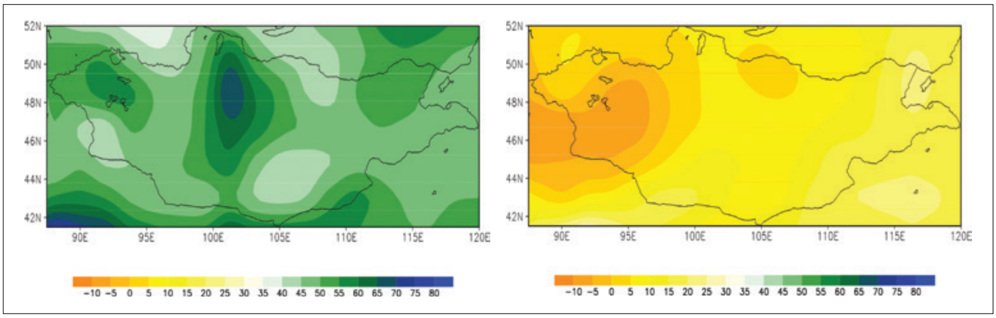



Figure 3.14 Spatial pattern of a) winter b) summer precipitation change, % (2081-2100)

***Downscaled by a regional climate model.*** Based on previous GCMs skill assessment and availability of data, 2 GCMs output such as ECHAM5 (Max Plank Institute for Meteorology, Germany) and HadGEM2 (Hadley Center, UK), have downscaled by regional climate model RegCM4 as dynamically (note further as RegCM4-ECHAM5, RegCM4-HadGEM2).

Figure 3.15 shows regional model domain and its topography with grid resolution 30km. It could be captured mesoscale atmospheric feature over Mongolia. Integration is done under RCP8.5 scenarios including baseline 1986-2005, future time slices such as 2016-2035, 2046-2065 and 2081-2100 periods. In the analysis, the territory of Mongolia is selected area between 41.5-52.0° latitude and 87.5-120.0° longitude.

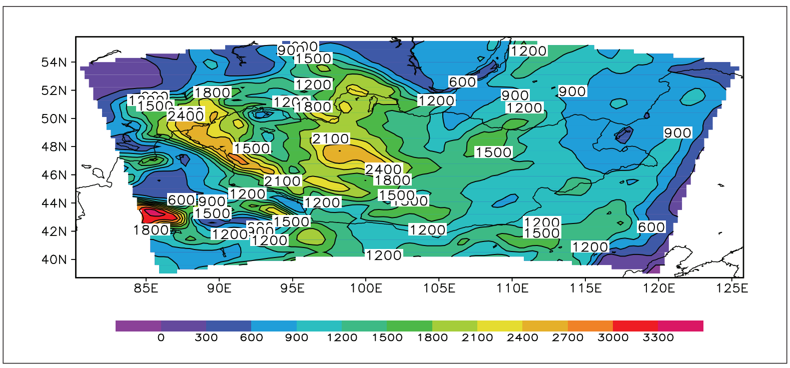



Figure 3.15 Regional climate model topography, m

Downscaled climate change projection assessment is summarized respect to 1986-2005 baseline climate periods in Figure 3.16. RegCM4-HadGEM2 gives the relatively high intensity of temperature and precipitation change than RegCM4-ECHAM5 (Figure 3.16b). In both models result, winter temperature and snow will increase higher than summer compare to their climate. Summer rainfall will increase slightly up to 10.7% in RegCM4-ECHAM5 and up to 21.4% in RegCM4-HadGEM2. However, there is decreasing up to 10% in central part of the country in summer season according to its spatial pattern in both models output for all time slices of future (Figure 3.19b-3.20b).

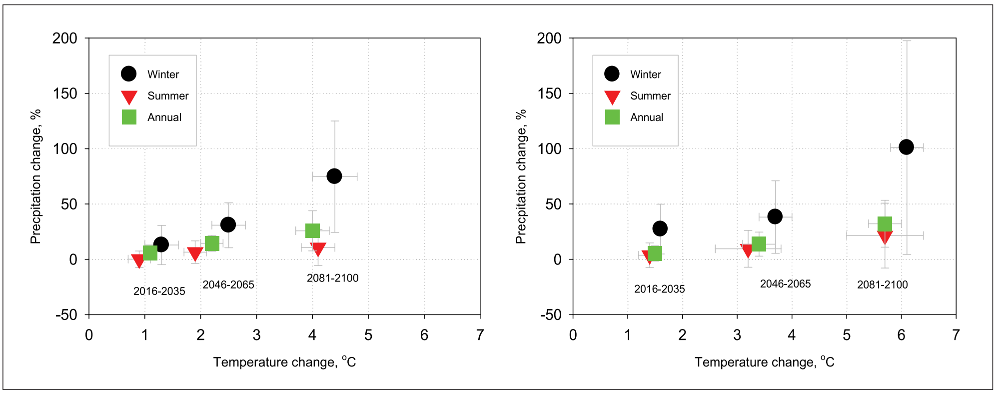



Figure 3.16 Winter and summer season, and annual temperature and precipitation change over Mongolia: a) by RegCM4-ECHAM5 b) by RegCM4-HadGEM2

An area average of Mongolia for a seasonal and annual change of temperature and precipitation is shown in Table 3.5-3.6 under both models with standard deviation. The corresponding spatial pattern of winter and summer seasons and annual temperature and precipitation are depicted in Figure 3.17-3.20.

Table 3.5 Seasonal and annual change of temperature and precipitation projected by RegCM4-ECHAM5 under RCP8.5

| Season | RegCM4-ECHAM5 | | | | | |
|---|---|---|---|---|---|---|
| | Temperature, ˚C | | | Precipitation, % | | |
| | 2016-2035 | 2046-2065 | 2081-2100 | 2016-2035 | 2046-2065 | 2080-2099 |
| Winter | 1.3 [±0.3] | 2.5 [±0.3] | 4.4 [±0.4] | 12.9 [±17.7] | 30.8 [±20.3] | 74.7 [±50.3] |
| Spring | 1.4 [±0.2] | 2.3 [±0.2] | 3.8 [±0.4] | 14.1 [±6.1] | 23.9 [±11.1] | 47.6 [±27.3] |
| Summer | 0.9 [±0.2] | 1.9 [±0.2] | 4.1 [±0.3] | 0.1 [±7.4] | 6.5 [±10.2] | 10.7 [±16.2] |
| Fall | 0.8 [±0.1] | 2.0 [±0.3] | 3.9 [±0.4] | 9.5 [±10.3] | 24.4 [±18.8] | 35.1 [±26.1] |
| Year | 1.1 [±0.1] | 2.2 [±0.2] | 4.0 [±0.3] | 5.6 [±5.9] | 14.5 [±7.2] | 25.8 [±18.1] |

Table 3.6 Seasonal and annual change of temperature and precipitation projected by RegCM4-HadGEM2 under RCP8.5

| Season | RegCM4-HadGEM2 | | | | | |
|---|---|---|---|---|---|---|
| | Temperature, °C | | | Precipitation, % | | |
| | 2016-2035 | 2046-2065 | 2081-2100 | 2016-2035 | 2046-2065 | 2080-2099 |
| Winter | 1.6 [±0.1] | 3.7 [±0.3] | 6.1 [±0.3] | 27.3 [±22.5] | 38.2 [±32.8] | 101.0 [±96.5] |
| Spring | 1.5 [±0.2] | 3.2 [±0.3] | 5.3 [±0.4] | 7.7 [±9.9] | 20.4 [±12.5] | 43.3 [±22.4] |
| Summer | 1.4 [±0.2] | 3.4 [±0.6] | 5.7 [±0.7] | 3.7 [±11.1] | 9.5 [±16.7] | 21.4 [±29.3] |
| Fall | 1.4 [±0.1] | 3.2 [±0.2] | 5.8 [±0.3] | 8.9 [±14.9] | 18.9 [±20.1] | 47.9 [±40.3] |
| Year | 1.5 [±0.1] | 3.4 [±0.3] | 5.7 [±0.3] | 5.3 [±6.9] | 13.7 [±10.9] | 32.1 [±21.2] |

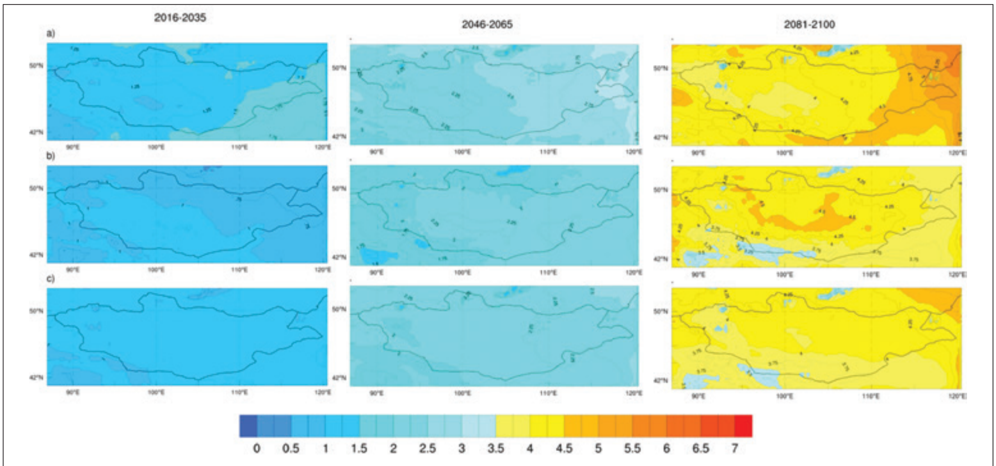



Figure 3.17 Temperature change projected by RegCM4-ECHAM5 under RCP8.5, ˚C a) winter b) summer c) annual

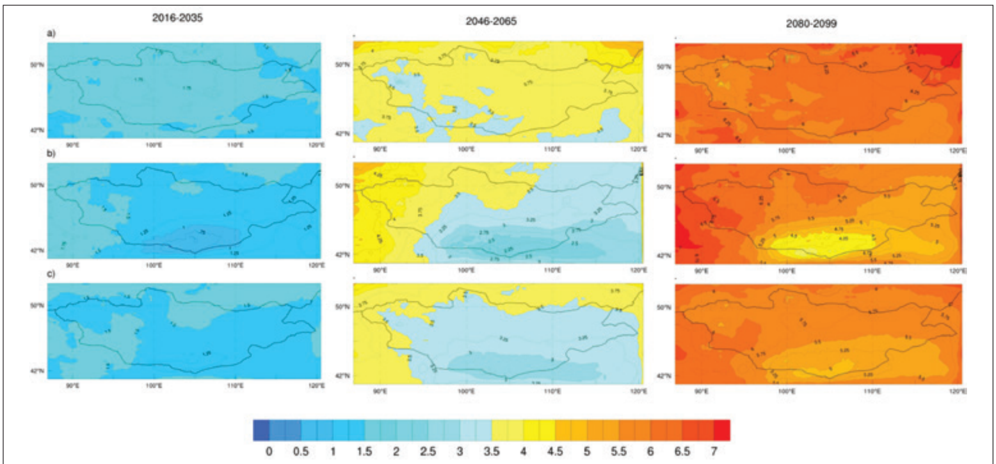



Figure 3.18 Temperature change projected by RegCM4-HadGEM2 under RCP8.5, ˚C. a) winter b) summer c) annual

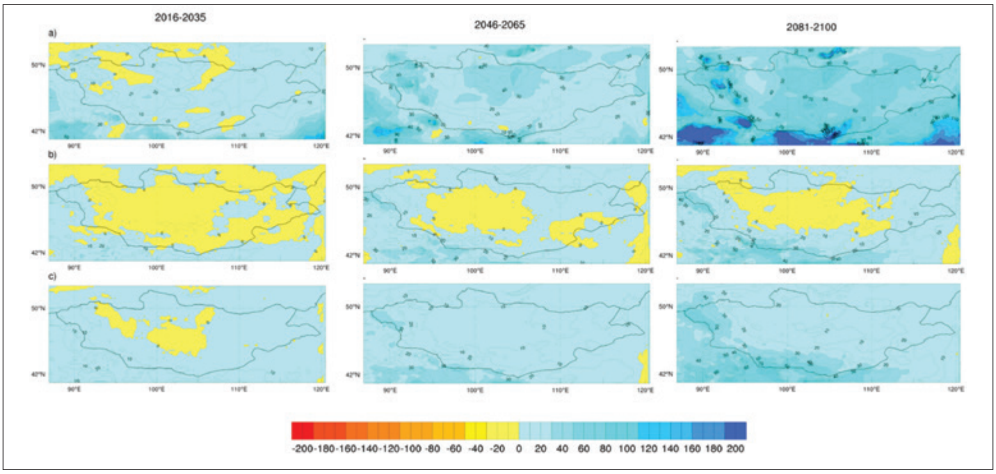



Figure 3.19 Precipitation change projected by RegCM4-ECHAM5 under RCP8.5, %
a) winter b) summer c) annual

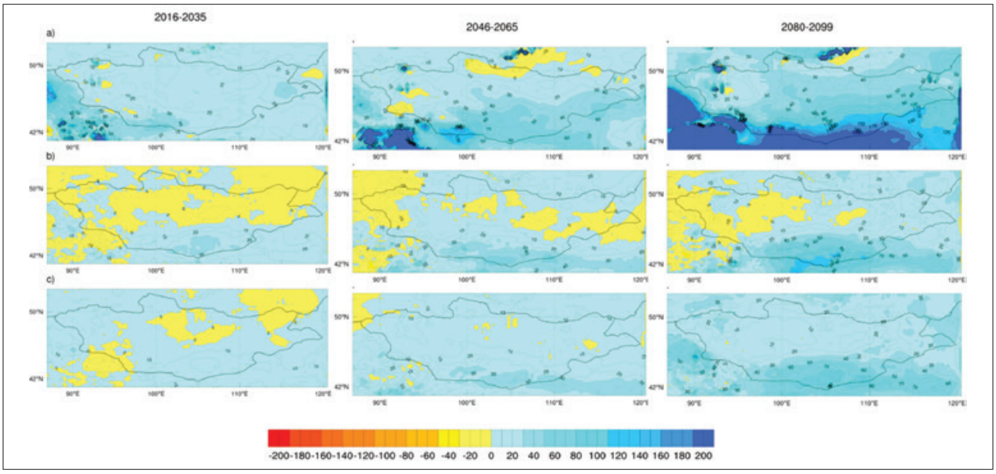



Figure 3.20 Precipitation change projected by RegCM4-HadGEM2 under RCP8.5, %
a) winter b) summer c) annual

Downscaled results with a 30km spatial resolution for both models are consistent with each other in terms of their similar trends and change values. However, change in intensity is different. It is indicating that every climate model has a different response (timing and spatial pattern) under same GHG emission scenarios. This was reduced model uncertainty. Therefore, detailed impact assessment of socio-economic sectors in Mongolia will be done by not only single model output in next impact and vulnerability assessment.

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# Chapter 4

## CLIMATE CHANGE IMPACT, VULNERABILITY AND ADAPTATION ASSESSMENT

# 4. Climate change impact, vulnerability and adaptation assessment

## 4.1. Impact of natural resource

### 4.1.1. Water resource

*Current changes in surface water.* The annual total river flow since 1978 varies, gradually increasing and reaches its maximum value of 78.4 km$^3$ in 1993. Long lasting low flow period steadily continues since 1996 and reaches its minimum of 16.7 km$^3$ in 2002. 22.7 km$^3$ of annual, total river flow was formed in 2015, which is lower than its long-term mean by 11.9 km$^3$ (Figure 4.1).

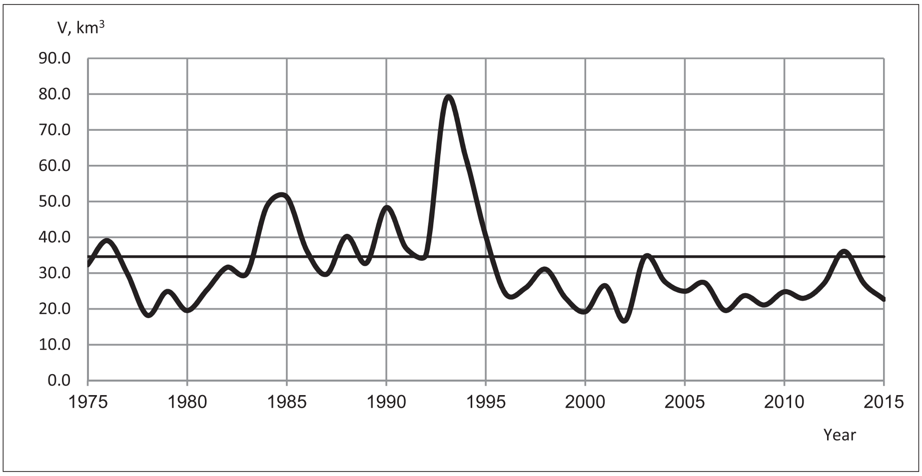



Figure 4.1 Annual, total river flow variation in Mongolia, km$^3$/year

There were 4,296 lakes, covering total water surface area of 15,514.7 km$^2$, acquired from a topographic map scaled as 1:100,000, compiled, based on aerial photos taken in the 1940s. The lake area data, retrieved from LANDSAT ETM, TM and L8 satellite images show that there were 4,069 lakes with total surface area of 15,384.3 in 2000; 3,825 lakes with total surface area of 14,696.6 km$^2$ in 2006; 3,699 lakes with total surface area of 14,393.2 km$^2$ in 2010; 3,727 lakes with total surface area of 14,305.6 km$^2$ in 2014 and 3,464 lakes with total surface area of 14,312.6 km$^2$ in 2015 respectively. Accordantly, total lake area reduced by 0.8% or 130.3 km$^2$ and 227 lakes were dried out in 2000, by 5.3% or 818.1 km$^2$ and 471 lakes were dried out in 2006, by 7.2% or 1,121.5 km$^2$ and 597 lakes were dried out in 2010, by 7.8% or 12,09.1 km$^2$ and 569 lakes were dried out in 2014 and by 7.8% or 1,201.9 km$^2$ and 832 lakes were dried out in 2015, respectively, in comparisons with data of 1940s (Figure 4.2).

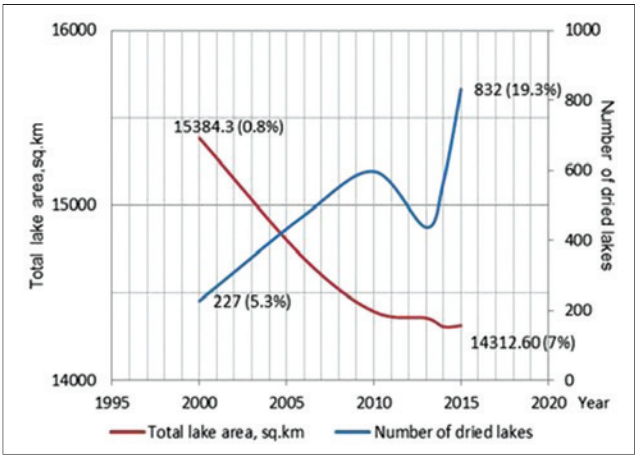



Figure 4.2 Changes in total lake areas and number of dried lakes

The water level of large, big and bigger lakes tends to decrease in last 20 years. The water level of lakes and natural lagoons, located in a floodplain, watered once during a high flood event, remains low. The water level of lakes and natural lagoons, located in deserts steppe and Gobi deserts, such as Khyargas, Boontsagaan, Orog Lake and etc. steadily decreases.

Detailed comparisons of areas of individual glacier massifs derived from different sources of data show that areas of glacier massifs tend to be overestimated with topographic map compiled in 1940s. Total glacier area, distributed in 42 mountain massifs, derived from a topographic map, scaled as 1:100000, was 535.0 sq.km in 1940$^{th}$. Glacier areas, retrieved from LANDSAT satellite data, were 470 sq.km in 1990, 451 sq.km in 2000, 389 sq.km in 2011. Accordantly, glacier areas retreated by 12.1% in the period from 1940 to 1990, by 4% in 1990-2000, and by 13.75 in 2000-2011 periods. Totally glaciers retreated by 29.9 in last 70 years. Glacier retreat and shrinkage intensified after 1990s and most intensive ablation occurred in last 10 years (Davaa G, 2015).

Potanin and Aleksandr glaciers in 1905, by V.V. Sapojnikov

Potanin and Aleksandr glaciers in August, 2018, by Z.Batjargal

Dynamics of glacier massif areas show that more intensive retreating occurs in flat top glaciers in the Tsambagarav, less retreating occurs in Corrie glacier dominated massif in the Munkhhairkhan, the average retreating rate is observed in glacier complexes of the Tavanbogd, Kharkhiraa and Turgen Mountains due to climate warming.

The first evidence of the glaciers on Mongolian Altay was reported in the literature in connection with Potanin's expeditions to northwestern Mongolia (1877-1879) and later, with the expedition of Polish geologists (Rutkowski and Slowanski, 1970). The observations made by those expeditions contained first, very general, descriptions of separate glaciers in the immediate vicinity of the expedition's routes.

One hundred years later, in summer 2010, a US–Mongolian expedition retraced portions of the 1910 expedition. Analyses of field data, repeated photographs from 1910 and 2010, topographic maps from 1970, and satellite imagery from 1992 and 2010 were used to describe the changes in the glacial system. The results suggest that while the snow and ice volume on the summits appears to be intact, lower elevation glaciers show significant recession and ablation. From 1910 to 2010, West Turgen Glacier receded by *c*. 600 m and down-wasted by *c*. 70 m (Ulrich Kamp et.al, 2013).

Cumulative ablation rates decreasing upwards along the Potanin glacier in the 2004-2015 periods were 41.15-48.65 m at the altitude of 2977-2998 m, 33.85-40.63 m at 3033-3057 m, 31.15-36.76 m at 3116-3123 m, 27.33-33.04 m at 3234-3247 m and 19.18-27.57m at 3339-3366 m.

The same cumulative ablations of Southern Ulaan-Am flat top glacier at the Tsambagarav Mts. in 2004-2014 period were 13.56 m at the altitude of 3607 m, 11.18 m at the altitude of 3621 m, 10.88 m at the altitude of 3700 m, 8.59 m at the altitude of 3732 m, 5.93 m at the altitude of 3771 m, 5.70 m at the altitude of 3814 m.

US NASA (National Aeronautics and Space Agency) and German space agency, DLR (Deutsches Zentrum fьr Luft- und Raumfahrt) jointly launched a pair of the satellite units as GRACE (Gravity Recovery and Climate Experiment) on the same orbit. Detailed estimation of changes in Earth's gravity field is made through precise measurements of the distance between the units. Since the measured gravity field, at monthly timescales, is the integration of that from the atmosphere, the ocean, the solid earth and the terrestrial water storage (TWS), the terrestrial water storage change (TWSC) can be derived through the independent estimation of the others. It is derived that TWSC having a horizontal resolution of approximately 300-400km, and a temporal resolution of about a month for the period of 2005-2011 (Kenshi Kobayashi, Jun Asanuma, 2013). TWSC from GRACE is the sum of changes in vertically integrated water mass, such as groundwater, soil moisture, and snow accumulation and so on. They used Level-3, gridded 0.5o data set, including the northern part of China (Figure. 4.3). There are remarkable temporal changes of TWS in each region. In the region “a”, including some part of the Altay Mts., Great Lake hollow and Northern part of China, continuous decrease in TWS can be found, which can be attributed to the glacier retreat, lowering the water level of lakes and groundwater. TWS continuously decreases in the area “c” covering the Central Mongolian Economy region, centered by Ulaanbaatar. These are in marked contrast with the area “d” where TWS shows fairly constant. It is also noted that these 4 areas show a seasonal change of TWS. Among these, the area “a” exhibits the largest seasonal change in TWS and decrease in 30 mm. This can be partly consistent with seasonal snowfall, its melted water, and a decrease in groundwater level.

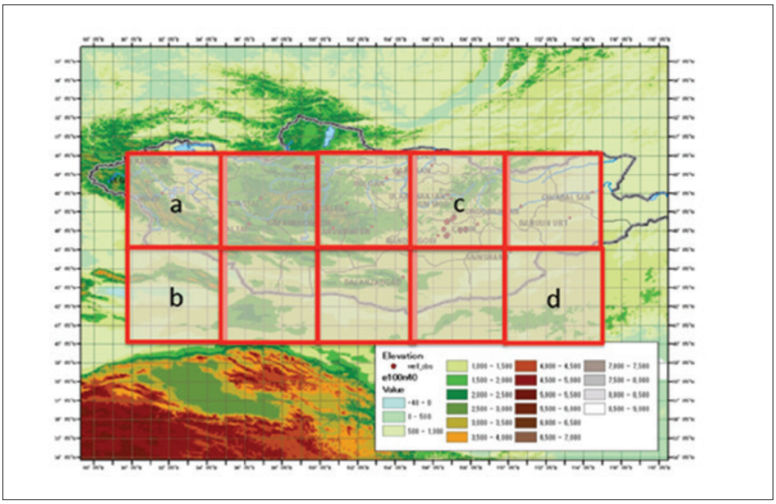



Figure 4.3 Target region and the subareas subject to the analyses

***Future climate change impact on water.*** NCEP reanalysis climate data have been used for initial and boundary conditions of a RegCM4 climate model. Past climate data have been simulated with RegCM4 climate model in the period of 1986-2005. Using climate data simulated with RegCM4 have been estimated water balance elements such as precipitation, runoff, and evaporation from the open water surface, evapotranspiration and etc. for the period of 1986-2005. Estimated and gridded runoff depth has been compared with observed runoff depth, derived from its map. The correlation coefficient between observed and simulated runoff depth is 0.74 and mean absolute error was 0.51 mm.

Hydrological network comparably well-developed and pleasant natural conditions are in the Arctic Ocean basin (AOB), Mongolia. Therefore, basin average precipitation in the basin is higher by 27% than that in the Pacific Ocean basin (POB) and much higher by 80% than that in Asian Internal Drainage basin (AIDB), Mongolia. Hence, average runoff depth is 1.95 times higher and evapotranspiration is also higher by 11% in the AOB than that is in POB. Runoff depth 4.7 times higher and evapotranspiration is also much higher by 44% in the AOB than that is in AIDB. Average water temperature for the period of April to October in the AOB is less by 3.1-3.3°C and evaporation from the open water surface is also less by 30-39% than these are in the POB and AIDB (Table 4.1).

Table 4.1 Average values of water balance elements, mm and average water temperature, 1986-2005

| Regional river basins | Precipitation | Runoff depth | Evapotranspiration | Evaporation from open water surface | Average water temperature (Apr.-Oct.),°C |
|---|---|---|---|---|---|
| Arctic Ocean basin | 246.3 | 70.9 | 175.4 | 517.0 | 8.4 |
| Pacific Ocean basin | 194.1 | 36.3 | 157.8 | 851.9 | 11.7 |
| Asian Internal Drainage basin | 137.0 | 15.0 | 122.0 | 738.5 | 11.5 |

An average water temperature for the period of Apr.-Oct. has been estimated with air and soil surface temperatures, projected by RegCM4-ECHAM5 and RegCM4-HadGEM2 models and regression equations expressing the dependency between water and soil, air temperatures in accordance with RCP8.5 GHG scenarios. An average water temperature, projected by RegCM4-ECHAM5 model output results will increase by 0.7-1.5°C and 3.2°C in periods of 2016-2035, 2046-2065 and 2080-2099 in the AOB and by 1.5°C, 1.6°C, and 3.3°C in the POB and by 0.8°C, 1.6°C and 3.1°C in the AIDB in comparisons with a water temperature of the 1986-2005 period.

The projected average water temperature by RegCM4-HadGEM2 is expected even higher than that projected by RegCM4-ECHAM5 model. These projected by RegCM4-HadGEM2 values will be higher in 2016-2035, 2046-2065, 2080-2099 periods by 0.4°C, 1.1°C, and 1.3°C in the AOB, by 0.4°C, 1.0°C and 1.2°C in the POB and by 0.2°C, 0.9°C and 1.3°C in the AIDB than that projected with RegCM4-ECHAM5 model, respectively (Figure 4.4 and Table 4.1.2).

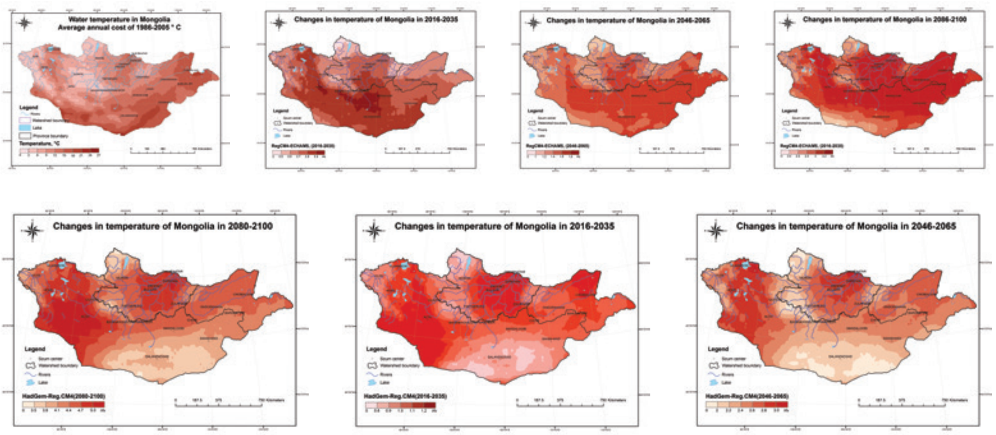



Figure 4.4 Spatial distributions of current average (Apr.-Oct.) water temperature and its changes, projected by RegCM4-ECHAM5 and RegCM4-HadGEM2 models

Chapter 4

An annual mean precipitation, projected by RegCM4-ECHAM5 is expected to increase in 2016-2035, 2046-2065 and 2080-2099 periods by 0.01 mm, 30.6 mm, 53.7 mm in the AOB, by 0.01 mm, 20.6 mm, 32.9 mm in the POB and by 0.02 mm, 19.9 mm, 41.4 mm in the AIDB, respectively comparisons with the annual mean precipitation observed in 1986-2005 period. Annual mean precipitation, projected by RegCM4-HadGEM2 model results is higher than that projected by the RegCM4-ECHAM5. That will be higher in the 2016-2035 periods by 20.1 mm in the AOB, by 14.8 mm in the POB and by 18.9 mm in the AIDB and changes in the precipitation will be nearly the same as projected by RegCM4-HadGEM2 and RegCM4-ECHAM5 models in 2046-2065 and 2080-2099 periods (Figure 4.5 and Table 4.2).

Table 4.2 Projected future changes in water balance elements and temperature

| Regional basins | | AOB | POB | AIDB | AOB | POB | AIDB |
|---|---|---|---|---|---|---|---|
| Used models | | RegCM4-ECHAM5 | | | RegCM4-HadGEM2 | | |
| Changes in annual mean precipitation, mm | 2020 | 0.01 | 0 | 0.02 | 20.1 | 14.8 | 18.9 |
| | 2050 | 30.6 | 20.6 | 19.9 | 31.1 | 23.7 | 27.7 |
| | 2080 | 53.7 | 32.9 | 41.4 | 54.7 | 59.8 | 51.4 |
| Changes in annual evaporation from open surface of water, mm | 2020 | 143.5 | 164.7 | 106.8 | 26.8 | 38.6 | 34.3 |
| | 2050 | 162.3 | 364.5 | 96.1 | 70.1 | 106.4 | 108.4 |
| | 2080 | 221.6 | 370.2 | 150.2 | 106.3 | 155.7 | 175.2 |
| Changes in runoff depth (May-October) in mm | 2020 | 0 | 0 | 0 | 6 | 2.7 | 1.8 |
| | 2050 | 8.9 | 4 | 2.1 | 9.2 | 4.4 | 2.5 |
| | 2080 | 15.6 | 6.2 | 4.3 | 16.1 | 10.8 | 4.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Changes in average water temperature (Apr.-Oct.), °C | 2020 | 0.7 | 0.7 | 0.8 | 1.1 | 1.1 | 1 |
| | 2050 | 1.5 | 1.6 | 1.6 | 2.5 | 2.6 | 2.4 |
| | 2080 | 3.2 | 3.3 | 3.1 | 4.5 | 4.4 | 4.4 |
| Changes in annual evapotranspiration, mm | 2020 | 0 | 0 | 0 | 14.1 | 12.1 | 17.1 |
| | 2050 | 21.7 | 16.6 | 17.8 | 21.9 | 19.3 | 25.2 |
| | 2080 | 38.1 | 26.7 | 37.1 | 38.6 | 49 | 46.9 |

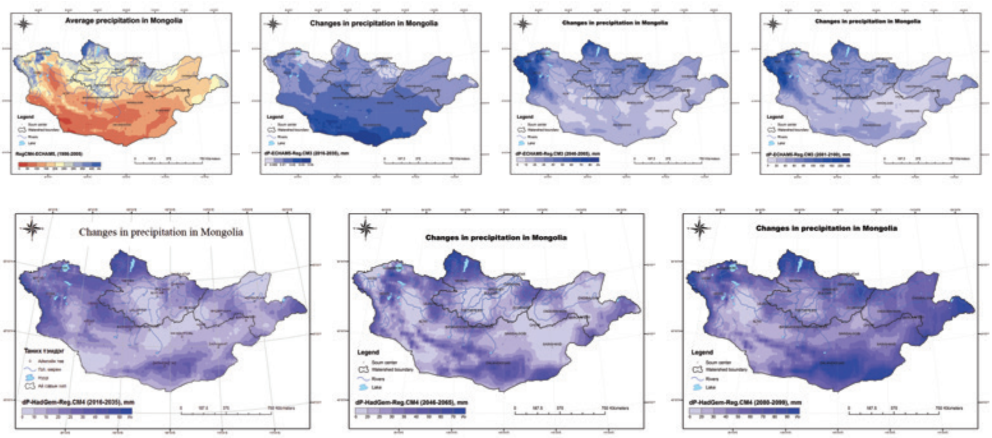



Figure 4.5 Spatial distributions of current annual precipitation and its changes, projected by RegCM4-ECHAM5 and RegCM4-HadGEM2 models

An annual mean (Apr-Oct) evaporation from open surface of water, projected by RegCM4-ECHAM5 is expected to drastically increase in 2016-2035, 2046-2065 and 2080-2099 periods by 143.5 mm, 162.3 mm, 221.6 mm in the AOB, by 164.7 mm, 364.5 mm, 370.2 mm in the POB and by 106.8 mm, 96.1 mm, 150.2 mm in the AIDB, respectively comparisons with the annual mean evaporation from open surface of water, observed in 1986-2005 period. The evaporation, projected by RegCM4-HadGEM2 model results is less than that projected by the RegCM4-ECHAM5. That will be 2.08-5.35 times less in the AOB and POB in all future periods and by 3.11 times less in the period 2016-2035 and by 11-14% in AIDB in the periods of 2046-2065 and 2080-2099 periods than that projected by the RegCM4-ECHAM5 model (Figure 4.6 and Table 4.1.2).

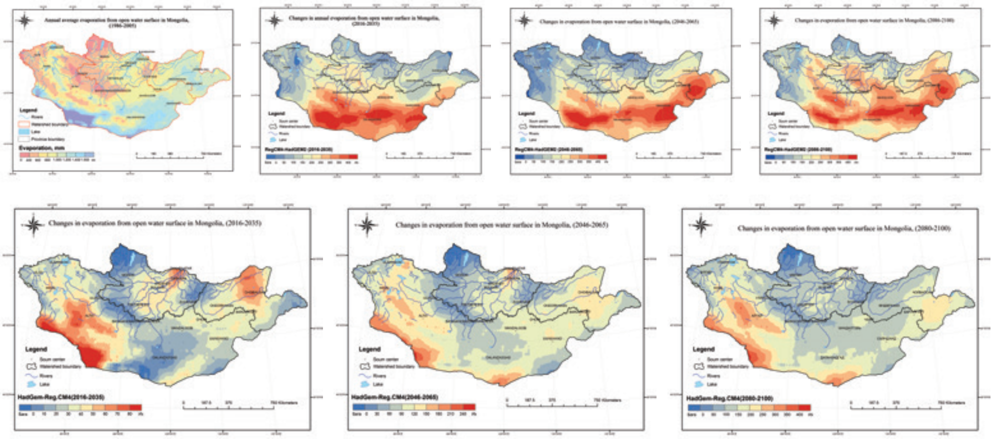


Figure 4.6 Spatial distribution of the current annual mean (Apr-Oct) evaporation from the open surface of the water and its changes, projected by RegCM4-ECHAM5 and RegCM4-HadGEM2 models

An annual mean runoff depth, projected by RegCM4-ECHAM5 is expected to increase in 2016-2035, 2046-2065 and 2080-2099 periods by 0.0 mm, 8.9 mm, 15.6 mm in the AOB, by 0.0 mm, 4.0 mm, 6.2 mm in the POB and by 0.0 mm, 2.1 mm, 4.3 mm in the AIDB, respectively comparisons with the annual mean runoff depth, observed in 1986-2005 period. The runoff, projected by RegCM4-HadGEM2 model results is less than that projected by the RegCM4-ECHAM5. That will be less in the period of 2016-2035 by 6.0 mm in the AOB, by 2.7 mm in the POB and by 1.8 mm in the AIDB and changes in the runoff will be nearly the same as projected by RegCM4-HadGEM2 and RegCM4-ECHAM5 models in 2046-2065 and 2080-2099 periods (Figure 4.7 and Table 4.1.2).

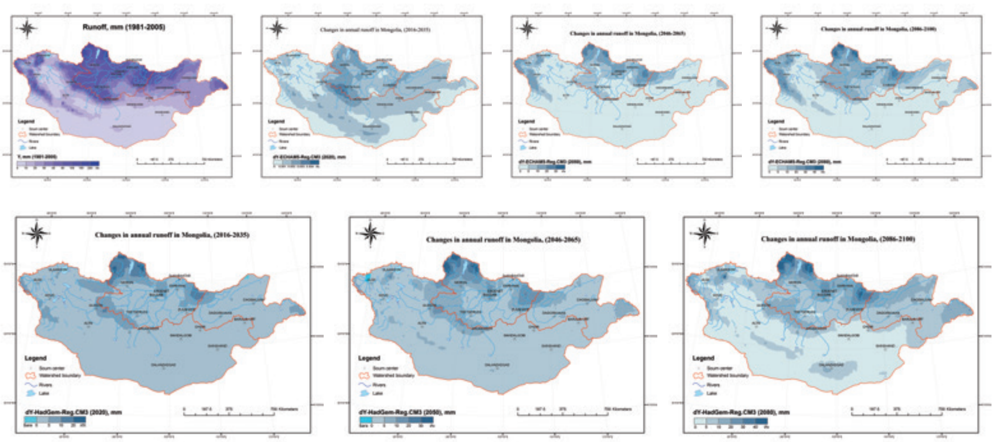


Figure 4.7 Spatial distributions of current annual runoff depth and its changes, projected by RegCM4-ECHAM5 and RegCM4-HadGEM2 models

Changes in water balance elements, projected by the RegCM4-ECHAM5 model are basin specific. Almost no changes in precipitation and accordantly no changes in runoff are expected in the period of 2016-2035. However, annual mean (Apr-Oct) evaporation from open surface of water is projected to increase by 128 in the Tuul, by 71 in the Kharaa, by 52 in the Eroo, by 115 in the middle reach of the Selenge and Orkhon rivers, by 60-174 in their upper reaches, respectively mm/year, in the AOB. Changes in this evaporation are expected to increase by 95 in the Kherlen, by 88 in the Onon, by 52 in the Ulz, by 67 in the Galyin, and by 41 in the Khalkh river basins, respectively mm/year in the POB and by 74 in the Khovd, by 138 in the Zavkhan, by 107 in the Khungui, by 85 in the Baruunturuun, by 45 in the Turgen, by 130 in the Tes, by 20-30 in the river basins draining from southern slope of Altay Mts., by 182-313 in the river basins draining from southern slope of Khangai Mts., by 299 in the river basins draining from southern slope of Govi-Altai Mts., by 160-295 in the Galba-Oush-Dolood Gobi basins, respectively mm/year, in the AIDB. However, precipitation and respectively runoff are projected to increase and simultaneously, evaporation from water surface and evapotranspiration are expected drastically increase, that will lead to an imbalance of water, drying effect will be prevailing in a river basin (Figure 4.8).

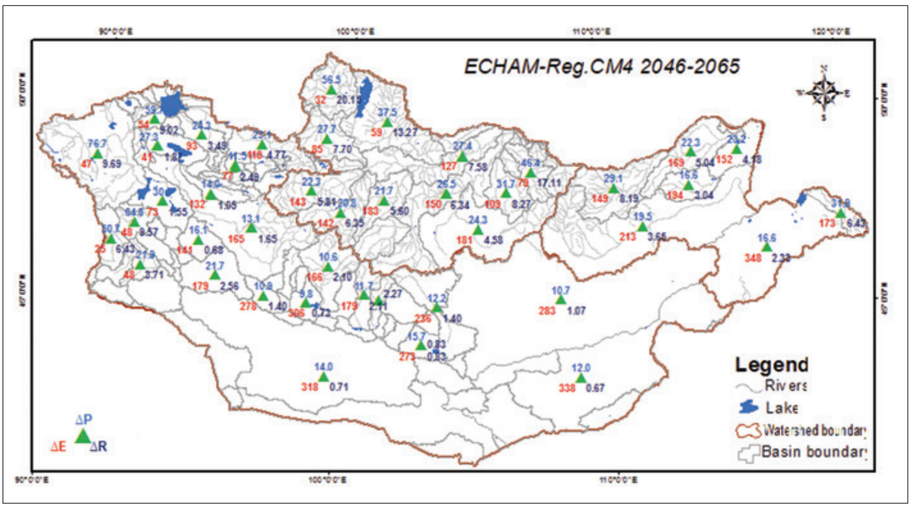



Figure 4.8 Spatial distributions of changes in annual precipitation, runoff depth and evaporation from the surface of the water, projected by the RegCM4-ECHAM5 model in 2046-2065 periods

These changes will lead to changes in water balance elements of lakes. The water level of the Khuvsugul and Uvs lakes are expected to increase, while, the water level of the Khyargas and Khar-Us lakes is expected to remain as it is at the present. However, water levels of lakes located in steppe, dry steppe, desert steppe and Gobi deserts are expected to decrease and lead to water imbalance and drying processes will be intensified (Figure 4.9).

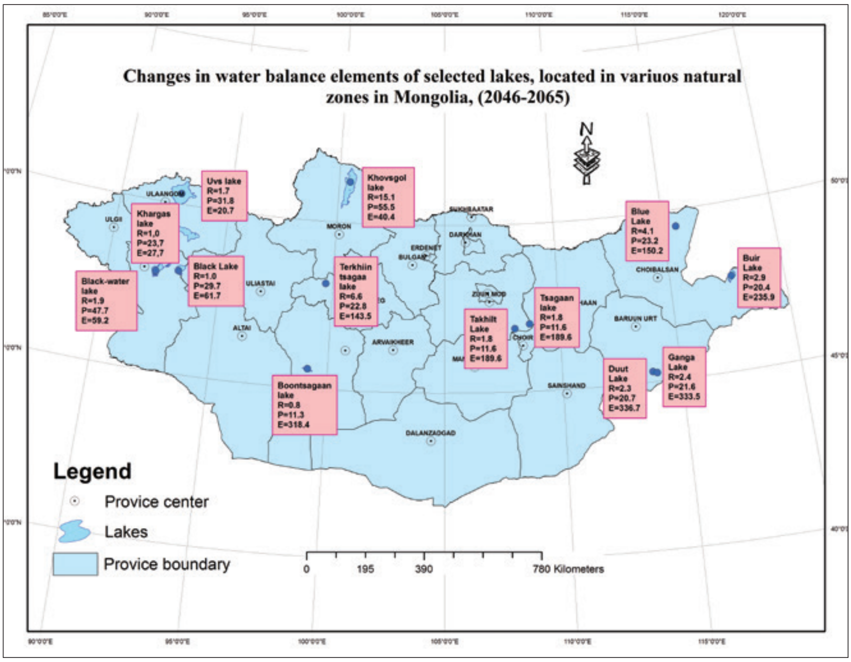



Figure 4.9 Projected changes in water balance elements of selected lakes located in various natural zones

The mean annual ablation rate has been estimated as 3.11, 3.21, 4.04, and 5.19 m/year in the period of 1982-2010, 1911-2030, 2046-2065 and 2080-2099 respectively. An annual ablation rate in the period of 2011-2030 is projected to slightly increase by 3 percent that will increase by 29.9 percent in 2046-2065 and 67.0 percent in the 2080-2099 periods in comparisons with the current. Accordantly, a mean annual mass balance has been estimated as -1.68, -1.76, -2.40, and -3.63 m/year in the period of 1982-2010, 1911-2030, 2046-2065 and 2080-2099, respectively. Its mean annual value in the period of 2011-2030 is projected to decrease by 5 percent that will decrease by 43.3 percent in 2046-2065 and 116 percent in the 2080-2099 year's period in comparisons with the current. The total glacier in the Kharkhiraa river basin is projected to decrease till 13.7 sq.km by 2030 and will be significantly decreasing by 2050 (Davaa G, 2014).

### 4.1.2. Forest resource

*Change of forest cover.* Recently, the forest cover of Mongolia is significantly changing due to the combined effect of climate change and human influences. Direct causes of such changes are logging, frequent forest fire, epidemics of insects and mining activities etc. Among the mentioned factors affecting on forest resource, logging, animal grazing, and mining activities are considered as local human-related activities. Due indiscriminately illegal logging permafrost of pseudo taiga forest which grows under harsh and dry climate in the Altai and Central part of Khangai mountains melts down till 3m and it causes drying of the upper layer of forest soil. Other consequences of deforestation appear in the sub taiga forest of Khangai and Khentii mountains where the gramineous plant is becoming predominant and hinder recovery of the forest. The above-mentioned factors result in a reduction of forest area which is altered from the forested area into meadow steppe. Besides, other reasons of reduction of forest area are a frequent forest fire, harmful insects spread and animal grazing in the forest and related continuous forest degradation and forest recovery process becomes unable (Dorjsuren Ch, 2009).

According to forest inventory, forest area of Mongolia was 13.1 million of ha in 1999 while forest area is estimated to be 12.3 million ha in 2015. It reduced by 806.0 thou.ha or by 6.6% (approximately by 50.4 thou.ha or 0.41% in every year). As for last 5 years (2010-2015 онд), forest area has reduced by 759.0 thou.ha or 6.2% (reduction rate is 47.5 thou.ha or 0.39 percent per year).

Statistics of 1999-2015 show that 11.1 million $m^3$ of wood logged in country scale (which is equivalent to 3.3 million ha of forest), every year on average 206 thou.ha of area forest area destroyed by a forest fire and harmful insects spread out in 571 thou.ha area (total area is 9.1 million of ha) during this period.

The area affected by forest fire is increased by 650.8 thou.ha or 38.1% (annually 130.0 thou.ha or 7.6% in a year) in 2010-2015 and are disrupted by harmful insects also increased by 76.0 thou.ha or 127.0% (increase of destroyed forest area due to harmful insects by 15.2 thou.ha or 25.5%) in same period and all these indicate intensifying of forest degradation (Table 4.3).

Table 4.3 Changes occurred in the forest area of Mongolia (1995-2015)

| Indicators | 1999 | 2006 | 2010 | 2015 |
|---|---|---|---|---|
| | ha | ha | ha | ha |
| Total forest area | 17,037.2 | 17,557.2 | 17,590.1 | 17,911.1 |
| Area covered by trees | 13,086.0 | 13,348.4 | 13,039.2 | 12,280.0 |
| Natural forest | 12,670.3 | 12,740.4 | 12,331.1 | 11,500.4 |
| Shrubs | 415.6 | 607.7 | 706.2 | 777.5 |
| Planted forest | 0.1 | 0.3 | 1.9 | 2.1 |
| Area without trees | 3,951.2 | 4,208.8 | 4,550.9 | 5,631.1 |
| Sparse forest | 2,900.4 | 2,892.7 | 2,987.2 | 3,495.3 |
| Burned area | 417.8 | 707.1 | 1,057.5 | 1,708.3 |
| Logged area | 193.7 | 202.5 | 240.2 | 106.1 |
| Forested area | 438.8 | 405.9 | 197.0 | 174.0 |
| Planted area | 0.5 | 0.6 | 8.3 | 10.7 |
| Insect affected area | - | - | 59.8 | 135.8 |
| Windfall area | - | - | 0.9 | 0.9 |

Consequences of climate change in forestry revealed by an increase in the frequency of forest fire, forest disease, harmful insect's outbreak and changes of forest plant species, annual growth of biomass and seed production. Mongolia as semi-arid and arid country belongs to a region with high risk of drought. Drought is a primary condition of forest fire harmful insect's outbreak and such dry condition also much effect on the planting of the forest. Especially, in dying of regrowth planted on the fore side of a hill or on edge of the forest.

Mainly due to drought and dryness regrowth planted on the fore side of high hills also along the narrow strip on the edge of the forest in the Uvurkhangai, Arkhangai, and Zavkhan provinces die. Also, a large amount of regrowth of pine, planted in Durgee Nars of Bulgan province and Tujiin Nars in Selenge province is dead due to drought in 2009.

One of the main changes occurred in the forest resource is the increasing occurrence of forest fire and extension of burnt forest area. Improper human activity accounts for up to 90% of the total occurrences of fire. A study done by scientist L.Natsagdorj based on data between 1963-2015 shows that a number of forest fire occurrence and size of fire affected area has a close correlation with spring dryness (drought-summer condition) index where correlation coefficient reached 0.62 (Figure 4.10-4.11).

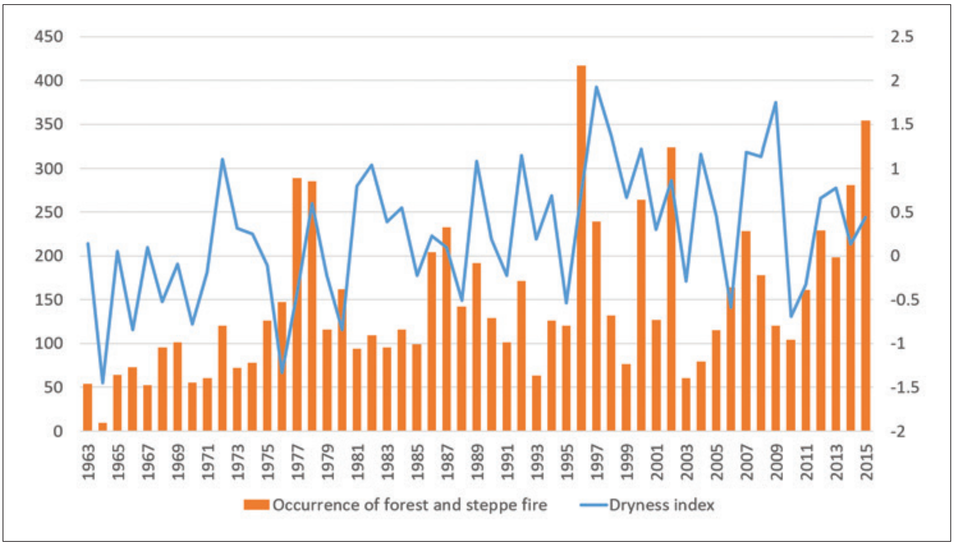



Figure 4.10 Number of occurrence forest and steppe fire, and spring dryness index, 1963-2015

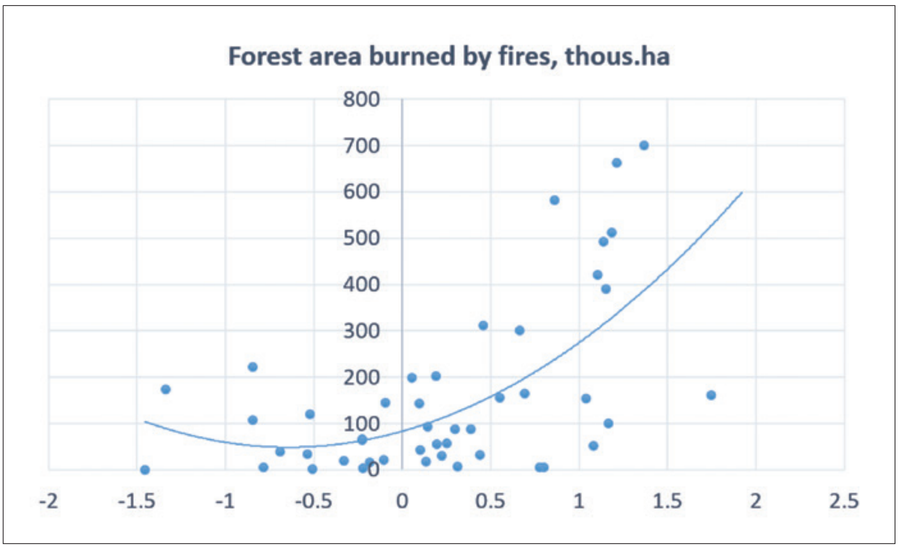



Figure 4.11 Correlation between size of burnt forest area and spring dryness index, 1963-2015

80% of fires occur in dry spring season while 5.8% occurs during the autumn season. Certainly, if the snowfall is high during the winter-spring season then fewer fire occurrences are expected and on the other hand, during the dry spring-summer season, the frequency of forest fire much increases significantly. There is observed tendency of early occurrence of fire in spring and late occurrence in autumn and duration of fire danger condition is becoming longer (Chuluunbaatar, 1998). Climate change projection shows that even forest fire may occur much early or late in spring and increase the summer fire occurrence in Mongolia.

Since 1980s, forest area has been affected by the harmful insects mainly caused by climate change and intensification of dryness and drought (Figure 4.12). There exists a quite good correlation between dryness index and size of forest area affected by harmful insects and propagation of harmful insects much extends when drought is more severe in summer season (Figure 4.13).

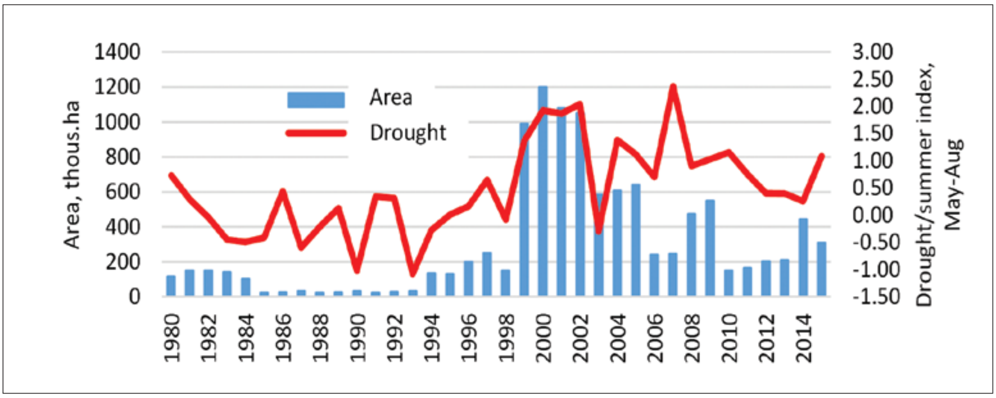



Figure 4.12 Size of forest area affected by harmful insects and drought index (1980-2015)

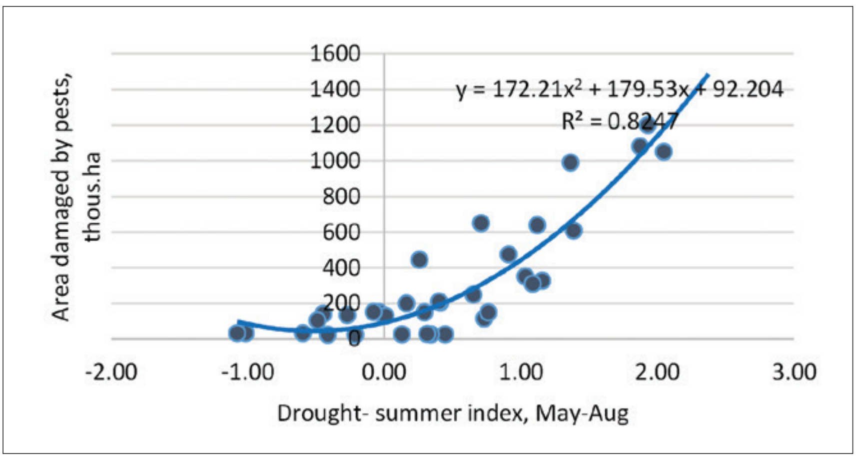



Figure 4.13 Correlation between the size of forest area affected by harmful insects and drought index (affected area 2003 and 2007 is excluded)

Many study results on annual growth of tree rings and assessment of forest resource per unit area (no consideration of saxaul forest) done by international and national researchers indicate some decreasing trend of accumulation of biomass of Mongolian forest year to year. However, due to the melting of long-term permafrost, a heat supply for vegetation and moisture supply to the soil may increase in Altai mountain region. Moreover, there is some trend of increase of precipitation in the region. Therefore, some bioproduction of forest increased in the western region (MNET, 2013). In the Figure 4.14 illustrates a long-term variation of annual growth index of larch sampled in Kharkhiraa-Turgen river basin (Lat: 49˚42' and Lon: 91˚32', an elevation of 1570 m).

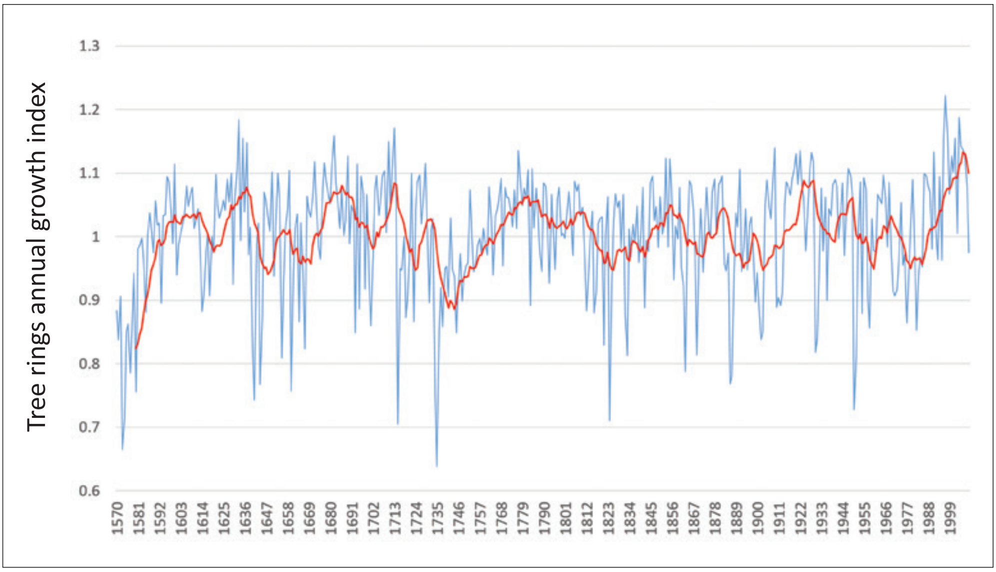



Figure 4.14 Long-term variation of the annual growth rate of tree rings of larch sampled in the Kharkhiraa-Turgen river basin (black line is moving average of 11 years and linear trend constructed by data since 1940)

If compare the above mentioned annual tree growth trend of larch in western Mongolia with Northern Khentii case, there is opposite pattern. This indicates different of climatic factors, which limits of tree growth in the mentioned regions. Although therein have not yet done more detailed studies, heat supply might be deciding factors for trees in high and cold mountain area while moisture would be a key factor for tree growth in the forest-steppe region. In contrast, intermediate regions, an appropriate combination of precipitation and temperature might be an important factor in forest growth. Such pattern also can be observed in the classification of the bio-c climate of the forest belts (Natsagdorj L, Khaulenbek A, 2012).

Long-term variation of the annual index of the tree rings from the Kharkhiraa-Turgen river basin correlate to different climatic elements of the region and the study provide sufficient result with a correlation coefficient of 0.47-0.49 between the sum of air temperature exceeding 10°C at Ulaangom meteorological station and tree ring indexes.

Climate warming, an increase of accumulation of carbon in the air mass, has certainly impacted positively on forest growth in Mongolia during growing season. However, soil deficit still will be predominate over all positive factors and probably will continue decreasing trend of the forest resource. The further intensity of warming in the whole atmosphere may facilitate the growth of forest in the tundra belts of the high mountains and expected some lifting up forest boundary. However, due to storms, avalanche and landslide, fallen trees, windfalls may increase in upper belts of mountains.



The intensity of climate warming much increased in last 70 years on a global scale. At the same time, several short cycles with relatively humid and cold climate occur over Mongolia in the mentioned period. This situation provides quite a favorable condition for forest recovery and growth in several regions of Mongolia such as East and Western Khentii, Central part of Khangai Mountain and also south-east and east Khangai. For instance, there is observed growth of young larch with age of about 35-40 years within 50-100 m strips around the forest edge at Zamtiin Hill in the upper Tuul River basin (an elevation of 1574 m, Lat. 43°01.197', Lon. 107°43.478').

*Assesement of impact on the forest ecosystem.* Based on the estimation of biome distribution (natural zones and belts) using different indexes which expresses humid/dry conditions of climate, Mongolian scientists stated that generally, area of forest-steppe and high mountain tundra is expected to reduce and on the other hand, steppe and desert steppe area will expand in the northern direction in Mongolia.

Under UNDP project "Ecosystem-based adaptation approach to maintaining water security in the critical river basins in Mongolia" MON/12/301, impact assessment results using Global climate model in the Kharkhiraa-Turgen and Ulz river basins show that forest boundary will be retreat up to 2050 and furthermore it will shift to the steppe in the Kharkhiraa-Turgen basin while larch and birch forest area will be reduced and pine and poplar forest is expected to increase slightly (MNET, 2013).

Statistical correlation study under RCP4.5 scenario indicates that occurrence of forest fire will be increased by 34-51 cases for periods of the beginning of the century (2016-2035), mid of century (2046-2065) and at the end century (2081-2100). Also, study results show that area of forest affected by wildfire and harmful insects is to increase in given periods by 175-403 thou.ha and 450-872 thou.ha, respectively. Under the RCP8.5 scenario, this trend will be 2-9 times greater than baseline and intensity of changes much exceeds previous scenarios.

*Results of MaxEnt model:* Geographical distribution of predominating trees species of the Mongolian Forest such as Larix sibirica, Betula platyphylla, Pinus sibirica and Pinus sylvestris have been generated by the ecological niche model MaxEnt (Maximum entropy theory) (Berger A. L et al., 1996). Data of National Multipurpose Forest Inventory (MET, 2016) of Mongolia and downscaled outputs of regional climate change models (RegCM4-HadGEM2 and RegCM4-ECHAM5 models) is used are used as inputs for the model (Gomboluudev et al., 2017).

Geographic location of the four species above is collected in the plot-wise assessment of National Forest Inventory (MET 2016). Forest species distribution was developed applying MAXENT model, which operates by establishing a relationship between known species distribution and climatic and environmental variables within the region. This relationship is employed to identify another region, which the species may occur and project potential range shifts caused by future climate change. For each species, occurrence data was divided into two datasets such as 75% of sample plot data was used to generate species distribution model, while remaining 25% were employed to test the accuracy of each model.

Figure 4.15 shows the result of MAXENT as relative probability, which is the potential forest distribution. That was compared with current forest distribution, in order to evaluate how to select bio indices and environmental variables that reflect the species habitat.

Comparison of the model output confirmed relative probability higher than 0.5 (50%) current species distribution.

The model accuracy was assessed using the area under the curve (AUC) of receiver operating characteristics (ROC) curve. Both training (establish a relationship) and test (evaluation of inventory data) case AUC is higher than 0.84, which indicates that the model reasonably well simulated current tree species distribution in Mongolia.

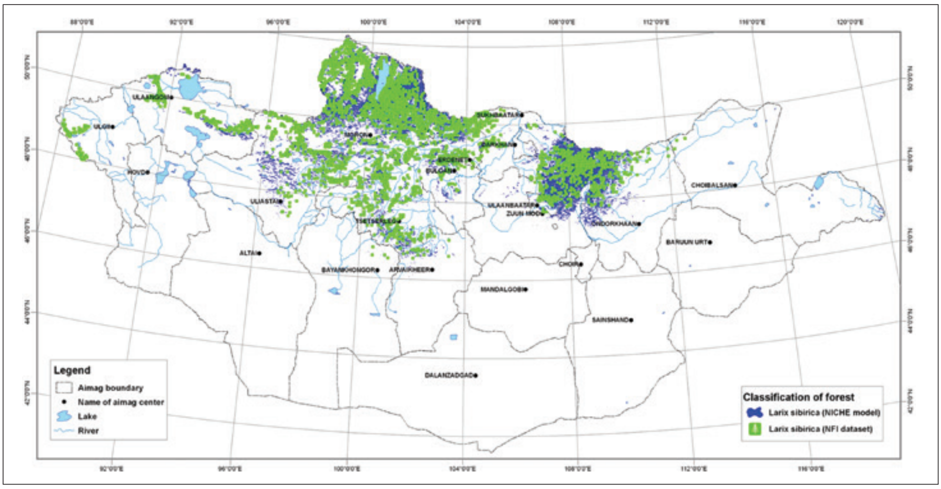
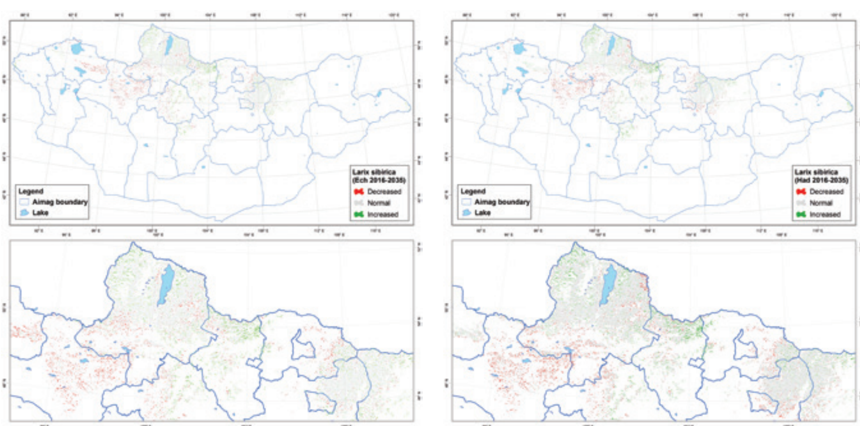



Figure 4.15 MaxEnt model output and forest inventory data (Larix sibirica)

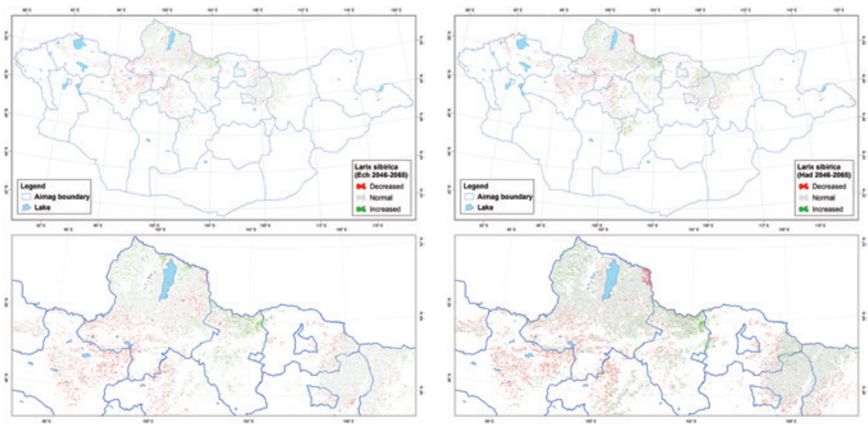
Dynamically downscaled climate change projection over Mongolia using Regional Climate Model (RegCM4) was applied to estimate future environmental variables (annual temperature, precipitation etc.) under RCP8.5 (Representative Concentration Pathway) GHG (Greenhouse Gas) emission scenarios.

Figure 4.16 shows the distribution in different future time intervals for Larix sibirica forest species under climate change projection of RegCM4-ECHAM5 and RegCM4-HadGEM2 models. A distribution change could clearly be recognized, where decrease is showing in red and increase in green (no-change=grey color) for Larix species presence. Same generation and projection like Larix sibirica were done for the other three species Betula platyphylla, Pinus sibirica, and Pinus sylvestris.

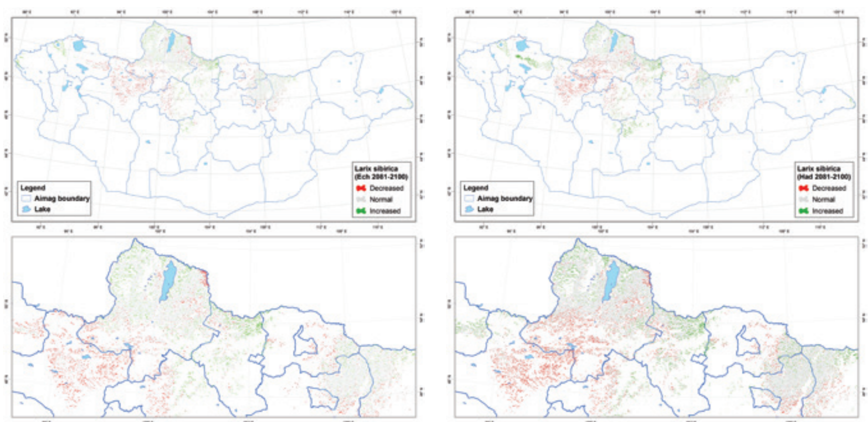
2016-2035



2046-2065




2081-2100




4.16 Potential Larix sibirica distribution in Mongolia under climate change RegCM4-ECHAM5 and RegCM4-HadGEM2 model

The potential distribution changes due to climate change for all species are shown in Figure 4.17 compared to current distribution. In average the spatial distribution will decrease by up to 4% for RegCM4-ECHAM5 and up to 6% for RegCM4-HadGEM2 climate change projections during this century. Only Pinus sylvestris will increase by 4% near future and Betula platyphylla and Pinus sylvestris by 2% in far future with projection RegCM4-HadGEM2.

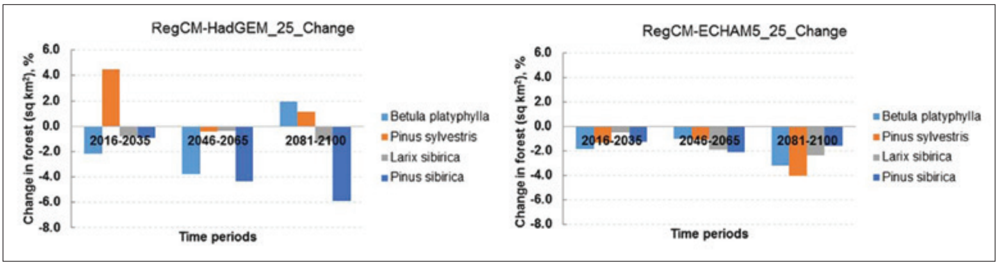



Figure 4.17 Potential forest distribution changes in Mongolia under climate change

Tables 4.4-4.5 present assessment results of expected future changes of selected tree species under change of future changes.

According to the RegCM4-ECHAM5, area of predominating tree species of Mongolian forest will be reduced by 0.5-1.8% (5.6-57.5 thou.ha, total area 95 thou.ha) in 2016-2035 and the area expected to reduce by 1.0-2.1% (5.4-136.6 thou.ha, total area 190 thou.ha) and 1.6-3.2% (5.4-136.6 thou. ha, total area 294 thou.ha) in 2046-2065 and in 2081-2100, respectively.

On the other hand, results of the RegCM4-HadGEM2 model shows that area of pine of Mongolian forest expected to increase by 4.5% (by 21.9 thou. ha) in 2016-2035 and this increase of pine area will be continued in 2046-2065 by 1.2% (5.8 thou.ha). As for other trees species, their area expected to decrease, but decreasing rate by the RegCM4-HadGEM2 model will be slightly lower than the RegCM4-ECHAM5 model. This is because the Hadley model provides higher temperature and higher precipitation compared to other models.

Table 4.4 Expected changes in the area of distribution of predominating trees species in Mongolia, %

| Species | 2016-2035 | | 2046-2065 | | 2081-2100 | |
|---|---|---|---|---|---|---|
| | RegCM4 - HadGEM | RegCM4 - ECHAM5 | RegCM4 - Had-GEM | RegCM4 - ECHAM5 | RegCM4 - Had-GEM | RegCM4 - ECHAM5 |
| Platyphylla | -2.1 | -1.8 | -3.8 | -1 | 1.9 | -3.2 |
| Pinus sibrica | -0.9 | -1.2 | -4.3 | -2.1 | -5.9 | -1.6 |
| Pinus sylvestris | 4.5 | -1.3 | -0.4 | -1.1 | 1.2 | -4.1 |
| Larix sibrica | -0.8 | -0.5 | -0.3 | -1.9 | -1.2 | -2.3 |
| Average | -2 | -1 | -2.4 | -2 | -2.3 | -3.1 |

Table 4.5 Rate of change of growth area of dominating forest species of Mongolian forest, $km^2$

| Species | Present area (2016), $km^2$ | 2016-2035 | | 2046-2065 | | 2081-2100 | |
|---|---|---|---|---|---|---|---|
| | | RegCM4 - HadGEM | RegCM4 - ECHAM5 | RegCM4 - HadGEM | RegCM4 - ECHAM5 | RegCM4 - HadGEM | RegCM4 - ECHAM5 |
| Platyphylla | 1198199 | -25162 | -21568 | -45532 | -11982 | 22766 | -38342 |
| Pinus sibrica | 626490 | -5638 | -7518 | -26939 | -13156 | -36963 | -10024 |
| Pinus sylvestris | 487317 | 21929 | -6335 | -1949 | -5360 | 5848 | -19980 |
| Larix sibrica | 7187356 | -57499 | -35937 | -21562 | -136560 | -86248 | -165309 |
| Average | 9499362 | -189987 | -94994 | -227985 | -189987 | -218485 | -294480 |

Observed climate warming in Mongolia expected to cause retreat of forest boundary in the high mountain regions and tundra. There is a high probability of shrinkage of forest area in the low land area while in high mountains observe shifting up of the upper boundary of forest boundary due to the melting of permafrost, increase of heat accumulation with increasing of phenology period and intensifying of the photosynthesis process.

### 4.1.3. Permafrost

***Permafrost distribution in Mongolia.*** The montane permafrost in Mongolia delineates the southern outskirts of the East Siberian region of permafrost. Thus, the permafrost of Mongolia is characterized by arid land and mountain permafrost with a temperature of about or below 0°C. This permafrost is either thawing or disappearing with the current warming of the climate (Jambaljav Ya et al., 2013).

The northern and high mountainous regions of Mongolia have continuous and discontinuous permafrost, while sporadic and isolated permafrost distributes in the foothills and slopes of Altai, Khangai, Khuvsgul and Khentii mountain ranges, as well as along small river valleys and in depressions (Jambaljav Ya, 2016).

Before 1970s, a southern limit of permafrost in Mongolia has been drawn differently and it is determined more precisely and became clear with increasing of research data and study materials. As shown on the geocryological map of Mongolia, established in 1971, the permafrost is found in approximately 63% of the land surface in a continuous and discontinuous form (Gravis et al., 1974).

Recently, scientist Ya.Jambaljav et al. created latest permafrost map of Mongolia with the scale of 1:1000 000 using permafrost distribution model of TTOP in 2014-2015 (Jambaljav Ya et al., 2016). As shown in the Figure 4.18, Mongolian permafrost is classified into continuous, discontinuous, rare patchy, occasional and seasonal categories.

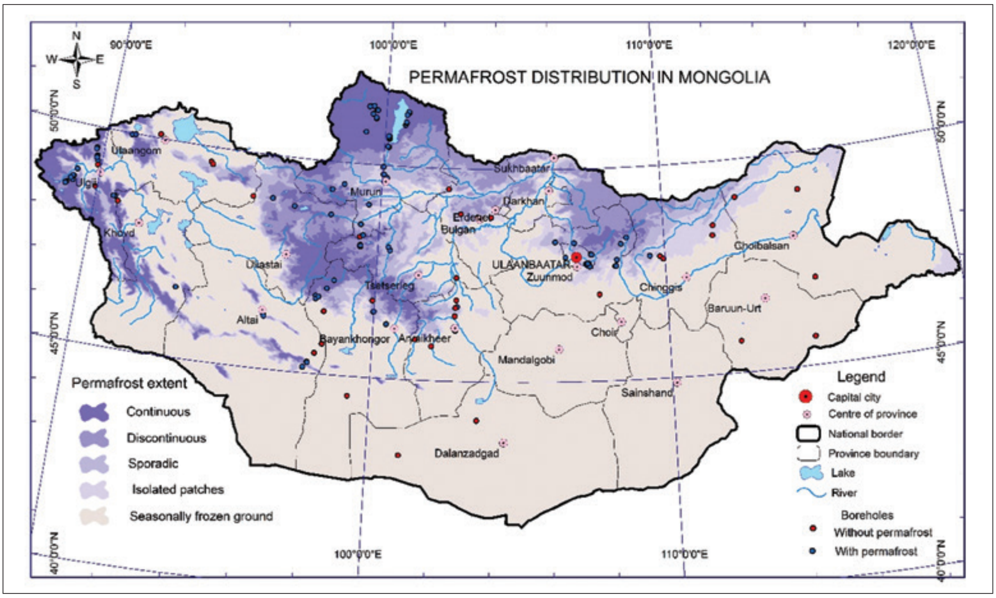



Figure 4.18 Permafrost distribution in Mongolia, 2016 (points represents borehole observation for permafrost)

In Mongolia, as shown on the new map of permafrost, the permafrost occupies about 29.3% of the country's area from isolated to a continuous distribution. Using the mean annual ground temperature (MAGT) at the bottom of seasonal thawing (at the top of the permafrost) and / or the mean annual ground temperature at the bottom of a seasonally frozen layer (where there is no permafrost), the country's area was divided by continuous (MAGT <-2°C), discontinuous (-2°C <MAGT <-1°C), sporadic (-1°C <MAGT <0°C), isolated (from 0°C <MAGT <± 1°C) and seasonal frozen ground (+ 1°C <MAGT), respectively.

*Current change of permafrost.* According to monitoring data, permafrost temperature at 10 and 15 m depths has been increased by 0.57-0.85˚C in Darkhad depression over the past 25-29 years. Permafrost temperature in Shargyn valley of northern-slope of the Bulnai Mountain and in Terkhiin river valley, where permafrost monitoring had been conducted in 1968-1969, has increased by 0.83˚C in last 45 years (Figure 4.19A). Permafrost temperature increased by 0.60-0.75˚C at 2400-2500 m above sea level on the southern side of Khangai mountain for the last 33 years (Figure 4.19A). In the old location of Erdene soum of Govi-Altai province, the temperature has a slight change of only around 0.12°C at a depth of 8 m over the past 34 years. The ground material is characterized by moist clay and silt at this location. However, recent measurement shows that the thickness of an active layer is around 8m (Jambaljav Ya et al., 2013). In 1968, earliest temperature measurement was measured in monitoring borehole of Tsagaannuur, Darkhad depression. However, systematic measurements began in the 1980s and early 2000s. Since that time, permafrost temperature has been increased by 0.04-0.29°C for every ten years (Figure 4.19B).

Temperature measurements show that the ground temperature rose by 0.04°C every 10 years in the intermountain valley of Gichgeny Mount, one of the branches of Govi-Altai Mountain. Once soil temperature exceeds 0° further, ground temperature accelerates too quickly (Figure 4.19A, B). For example, in the boreholes of Bayan soum, Tov province and Omnodelger soum, Khentii province, the ground temperatures were close to zero degrees or around -0.1°C during 1970-1980s. However, recent measurement indicated the temperature in the above-mentioned boreholes increased by up to 1.3°C (Jambaljav Ya et al., 2013).

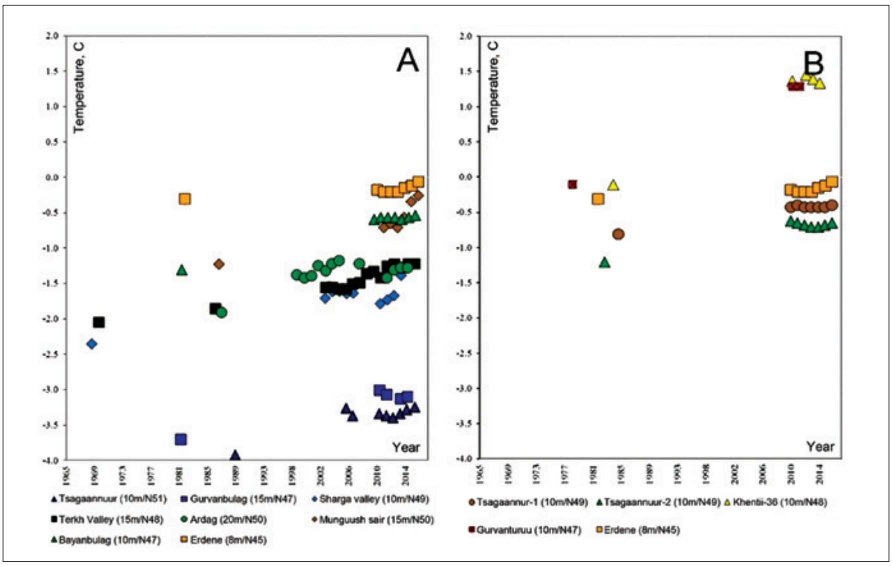



Figure 4.19 Permafrost temperature change in Mongolia, A-Part: Tsagaannuur soum, Khuvsgul province, Valley of Terkh river, Bayanbulag soum of Bayankhongor province, Gurvanbulag soum of Bayankhongor, Ardag mountain of Western shore of Huvsgul lake, Munguush in Darhad depression, Erdene soum of Govi-Altai province, B-Part: Tsagaannuur village, Bayan- Ulgii province (Tsagaannuur-1, Tsagaannuur-2), Umnudelger soum of Khentii province, Gurvanturuu-Bayan soum Tov province, Erdene soum Govi-Altai province

The temperature of permafrost in all boreholes involved in this study shows increasing trend by 0.15-0.22°C in every 10 years, while the temperature of the borehole located in the bank of Monguush dry bed in the Darkhad depression has increased by 0.29°C in every decade (Figure 4.19A). Ground materials are alluvial sediments consisting of gravel with sand and low in ice in Mongoosh dry riverbed. These materials have a high thermal conductivity.

The measurement carried out by scientist D.Tumurbaatar in the borehole near Nogoon Lake in Ulaanbaatar on 18th of January of 1970 showed that permafrost thickness was around 7m while another measurement conducted in 2012 showed the intensive degradation of permafrost in this point.

***Impact assessment of permafrost.*** Future change and impact of permafrost change have been estimated by TTOP (Temperature on Top of Permafrost) model. Inputs of the model are an annual mean temperature selected from outputs of future climate change models such as RegCM4-HadGEM2, RegCM4-ECHAM5 and snow cover and vegetation cover, and soil thermal characteristics.



The permafrost distribution map of Mongolia shows that 11,8296.6 km$^2$ (7.5%) of the total territory occupied by continuous permafrost, 12,7351 km$^2$ (8.08%) by discontinuous permafrost, 112,416 km$^2$ (7.12%) by sporadic permafrost, and 104,317.9 km$^2$ (6.62%) by isolated permafrost respectively. Totally, 29.32% of the total Mongolian territory is occupied by permafrost.

According to RegCM4 model simulation, permafrost distribution map produced in 1986-2005 using temperature inputs show that 117,155.37 km$^2$ area covered by continuous permafrost and 92,263.93, 106,315.55 and 121,737.1 km$^2$ belong to discontinuous, sporadic and isolated zones as respectively. Finally, modeling result shows that 28.01% of the territory of Mongolia is covered by permafrost (Table 4.6-4.7, Figure 4.1.23).

The spatial resolution of the permafrost map, generated in 2016 was 1 km, while the resolution of our modeling result is 30 km. In terms of area of permafrost distribution difference of the mentioned two permafrost maps of Mongolia is 1.31%.

*Future change of permafrost by Regional Climate Model:* Distribution of permafrost took 28.01% or 0.44 million of km$^2$ of the total territory of Mongolia during the period of 1986-2005, while permafrost area expected to cover 22.88% or 0.36 million km$^2$ of the area of Mongolia in 2016-2035. As shown RegCM4-HadGEM2 modeling results, permafrost area of Mongolia will continue to reduce, by occupying 10.88% or 0.17 million km$^2$ of the total area of the country in 2046-2065 and degradation of permafrost will continue and it is expected that permafrost area will occupy only 1.48% or 0.02 million km$^2$ of area of the territory of Mongolia in 2080-2099 (Table 4.6, Figure 4.20).

Table 4.6 Degradation of permafrost, km$^2$ (%), by RegCM4-HadGEM2

| № | Permafrost distribution | By map of 2016 | Base year (1986-2005) | 2016-2035 | 2046-2065 | 2080-2099 |
|---|---|---|---|---|---|---|
| 1 | Continuous | 118296.6(7.5) | 117155.37(7.50) | 48302.49(3.10) | 72.60(0.005) | - |
| 2 | Discontinuous | 127351(8.08) | 92263.93(5.91) | 77477.98(4.96) | 11330.83(0.72) | - |
| 3 | Sporadic | 112416(7.12) | 106315.55(6.81) | 117491.96(7.52) | 70130.29(4.485) | 660.82(0.04) |
| 4 | Isolated | 104317.9(6.62) | 121737.10(7.79) | 114186.92(7.30) | 88357.32(5.65) | 22716.12(1.44) |
| 5 | Degradation zone of permafrost | | - | 80012.60(5.13) | 267580.91(17.15) | 414095.01(26.53) |

As shown in the model output that the area of degradation of permafrost is expected to be 5.13% in 2016-2035. However, it is not exactly degrading of permafrost in such scale; it means some possibility of degradation of permafrost and disappearing of thin permafrost area in the mentioned size. Therefore this area is called as permafrost degradation zone and identified by brown color in the map (Figure 4.20). As mentioned above, area of permafrost degradation is to be 5.13% in 2016-2035 and about 50 percent of them expected to occur in the continuous permafrost zone and region where distribute discontinues, sporadic and isolated permafrost will not be much affected by the climate warming. However, here need to note some percentage of the transformation process of continuous permafrost zone into other types of permafrost in the total area of changes of permafrost. Further projection of permafrost degradation shows that about 17.15% of permafrost area will be degraded in 2046-2065. The Continuous (0.005%) and discontinuous (0.72%) permafrost are expected to nearly disappear in the mentioned project period and only sporadic and isolated zones remain.

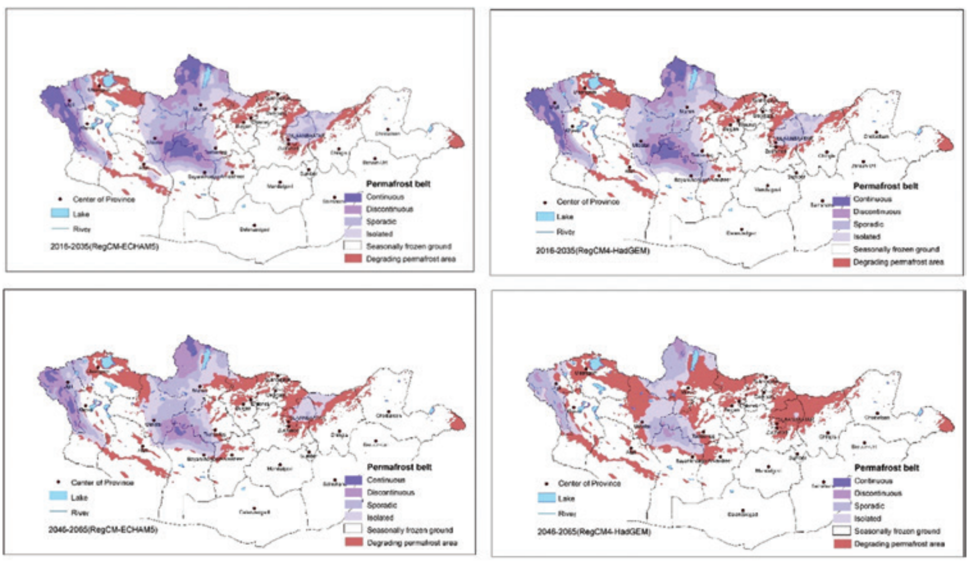
RegCM4-HadGEM2 model output results show that degradation of permafrost is projected to reach 26.53% of total permafrost area in the level of 2080-2099 and continuous and discontinuous permafrost zones will disappear completely and expected to remain a very small area with sporadic (0.04%) and isolated (1.44%) types of permafrost. In other words, heavy degradation process will occur and degradation level of permafrost will reach about 94.7% of total permafrost area.

The model output of RegCM4-ECHAM5 shows that permafrost degradation will take place in 4.61% of the total area within a period of 2016-2035 and about more than 50% of them will be regions with the continuous type of permafrost. In contrast, an area with discontinuous permafrost is even expected to increase by 0.63% (Table 4.7). However, the mentioned changes of permafrost is mainly explained by transformation or shift of permafrost zones from one to another type. The model results in 9.24% of degradation of permafrost area in 2046-2065. At this level, continuous (0.005%) permafrost will be lost much and other types of permafrost zones will be affected slightly. In 2080-2099 years, degradation of permafrost is projected to reach 20.73% of total permafrost area and continuous (0.003%), and discontinuous (0.03%) permafrost zones will nearly disappear and intensive degradation will take place in the regions where sporadic and isolated permafrost is distributed. Heavy degradation process and degradation level will reach about 74.0% of total permafrost area (Figure 4.20).



Table 4.7 Degradation of permafrost, $km^2$ by percentage (%), (by the RegCM4-ECHAM5 models)

| No | Types of permafrost | The base year (1986-2005) | 2016-2035 | 2046-2065 | 2080-2099 |
|---|---|---|---|---|---|
| 1 | Continuous | 117155.37(7.50) | 55681.46(3.57) | 14383.22(0.92) | 4.91(0.0003) |
| 2 | Discontinuous | 92263.93(5.91) | 78964.38(5.05) | 66478.74(4.26) | 405.67(0.03) |
| 3 | Sporadic | 106315.55(6.81) | 116178.19(7.44) | 93296.4(5.97) | 41516.4(2.66) |
| 4 | Isolated | 121737.10(7.79) | 114620.06(7.34) | 118963.61(7.62) | 71627.98(4.59) |
| 5 | Permafrost degradation zone | - | 72027.86(4.61) | 144349.98(9.24) | 323916.99(20.73) |



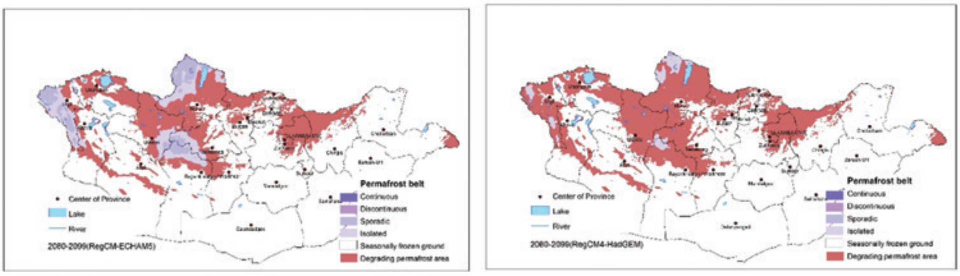



Figure 4.20 Future changes of permafrost of Mongolia, by RegCM4-ECHAM5 and RegCM4-HadGEM2

Finally, output results of the considering two models conclude that permafrost area of Mongolia is expected to reduce by 16.46-18.31% in 2016-2035 and such reduction of permafrost regions will be continued in 2046-2065 and 2080-2099 by 33-61.23% and 74-94.7% respectively.

### 4.1.4. Pasture, soil and land cover

***Changes observed in the pasture.*** About 82% of the territory of Mongolia is considered as natural pastureland as main source livestock grazing as well as only largest grassland ecosystem in the world which conserves unique native landscape. However, it is clearly indicated that process of degradation of soil and pasture is intensifying in Mongolia based on satellite images and ground measured observation due to negative human influences and climate change impacts.

Figure 4.21 and Table 4.8 present changes of landscape classification using satellite data from MODIS in 2000 and LANDSAT in 2015.

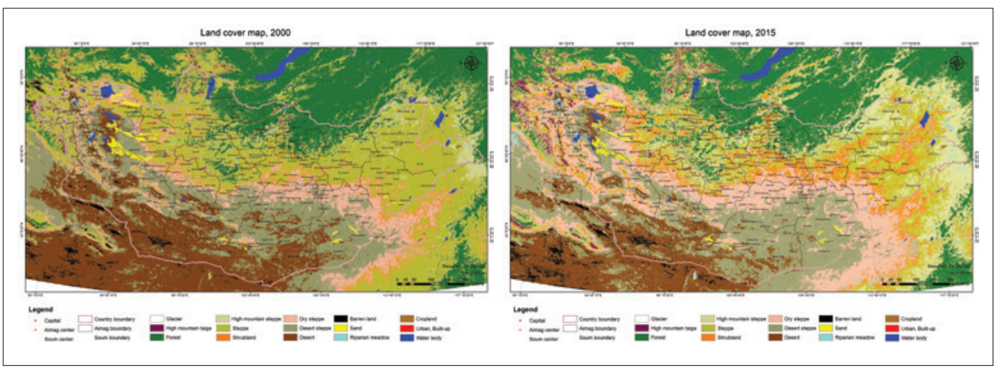



Figure 4.21 Land cover map of 2000 and 2015 years (S. Khudulmur)

Table 4.8 Area of landscape classes and their changes

| No | Landscape classes | The area in 2000 (ha) | The area in 2015 (ha) | Changes (%) |
|---|---|---|---|---|
| 1 | Glaciers | 256018 | 21946 | -91 |
| 2 | High mountain taiga, rocks | 530431 | 1122801 | 112 |
| 3 | Forest | 13305880 | 13230926 | -1 |
| 4 | Mountain steppe | 6767999 | 14949814 | 121 |
| 5 | Steppe | 45304217 | 22994836 | -49 |
| 6 | Shrub steppe | 3921752 | 14780259 | 277 |
| 7 | Dry steppe | 16371923 | 27833346 | 70 |
| 8 | Desert steppe | 36672774 | 39882033 | 9 |
| 9 | Gobi and desert | 26320212 | 13438685 | -49 |
| 10 | Bare land | 564664 | 550923 | -2 |
| 11 | Sand | 1908357 | 1737463 | -9 |
| 12 | Medow | 1351860 | 2436910 | 80 |
| 13 | Arable land | 1235101 | 1321767 | 7 |
| 14 | Urban area | 16459 | 47254 | 187 |
| 15 | Water bodies | 1284099 | 1462787 | 14 |

Hence, the area of Gobi desert and steppe region is decreased and area of the dry steppe, shrub-steppe, and mountain steppe regions is increased, especially rapid of increase of shrub-steppe region shows consequences of increasing pressure on pasture in last 15 years (Gunin P, 2001).

According to the results of the assessment of desertification and land degradation situation on 2015 done by specific factors of trends and changes of the Desertification Atlas of Mongolia (DAM, 2013), 76.8% of Mongolian territory has been affected by desertification and land degradation. Thereof, 22.9% of country's land is considered high and very highly degraded (Figure 4.22).

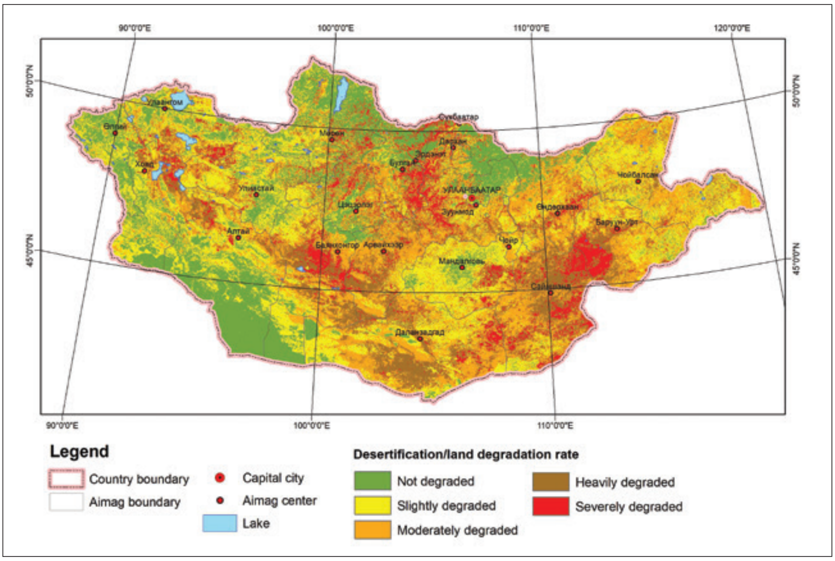



Figure 4.22 Desertification and land degradation in Mongolia, 2015 (N. Mandakh)

Along with Great Lake depression, Valley of Lakes, Southern and Eastern Gobi where desertification and land degradation previously already increased, land degradation processes also increased additionally in the regions such as Orkhon-Selenge river basin, Kherlen river basin and Eastern Mongolian steppe and Central Mongolian plateau. If this present situation is compared with previous study results then an increase of intensity of desertification and land degradation in last 15 years is clearly observed. Land area which belongs to the moderate and high degraded lands is increased by 3.9 and 10.2%, respectively (Figure 4.23).

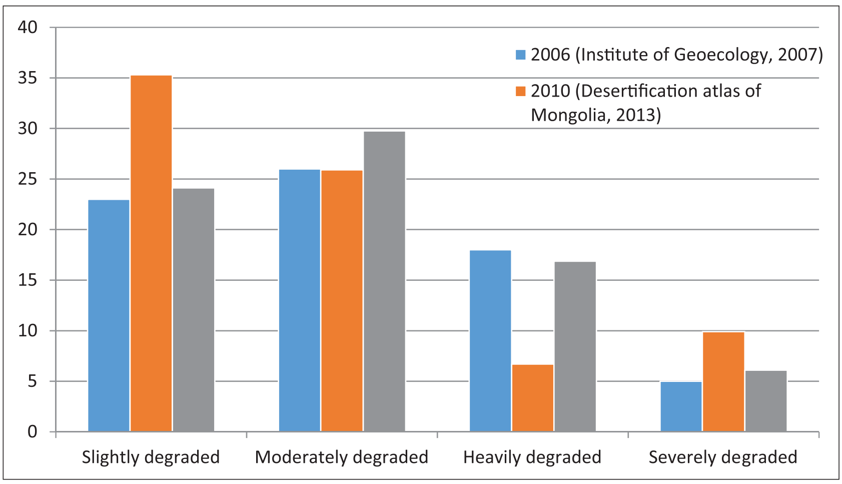



Figure 4.23 Dynamics of desertification and land degradation (N.Mandakh)

National report of pasture state of Mongolia (NRSMP, 2015) has issued in 2015 is considered one of the recent and significant study results on pasture condition. This report based on pasture national monitoring data of 1500 sites within state monitoring network of the National Agency for Meteorology and Environmental Monitoring (NAMEM). "State transition model" was used for data processing and analysis of the report; it is based on the ecological potential of pasture, commonly used in the countries with dry land ad pasture and it also utilizes "principles of classification of recovery of pasture plant community".

According to 2014's monitoring data, assessment results of pasture state for Mongolia using by above-mentioned methods and model, show that certain changes occurred in 65% of pasture plant community. Pasture area which urgently requires recovering and enhancing is already exceeding 40% and for the recovery, it is necessary to regulate grazing intensity of pasture with its pasture and recovery capacity and to change of present pasture use practice. These processes will take at least 3 years (Figure 4.24).



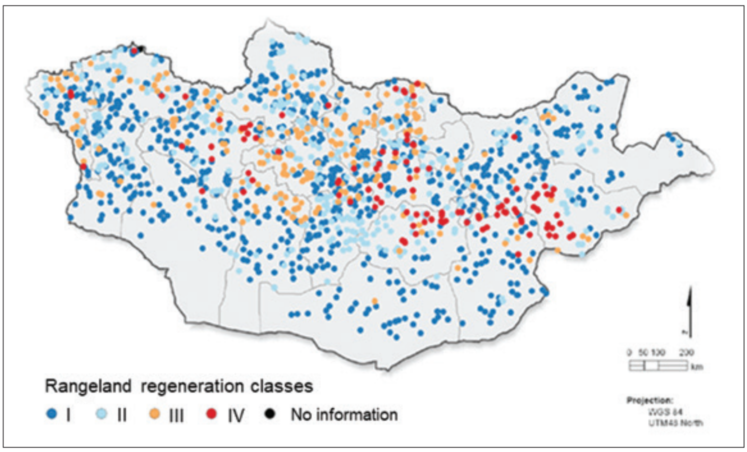



Figure 4.24 Classification of the capacity of pasture recovery

As shown in Figure 4.24, pasture land which belongs to recovery class of IV has most changes of the pasture plant community observed in the eastern part of the Zavkhan province, Arkhangai, margin area of Ovorkhangai and Tov provinces, Northern part of Dundgovi province, junction area of Khentii, Dornogovi and Sukhbaatar provinces. The class III of recovery capacity belongs to most of the territory of the Arkhangai, Bulgan, and Selenge, south-east of Khuvsgul and some part of Zavkhan, Uvs and Bayanolgii provinces. Soil fertility, harvesting from unit hectare in the mentioned region is high and also plant species is abundant. At the same time, human population and livestock numbers are also high and always occur exceeding of pasture capacity in these soums and provinces.

Therefore, it is needed to implement a proper pasture management including control and regulation of pasture capacity and pasture stress. Moreover, these regions, which are subject to land degradation, are very vulnerable to the climate change. About 10% percent of pasture land can be considered as an area which lost pasture quality and any more cannot be used as pasture due to a high degree of degradation and also which cannot be recovered naturally.

Assessment of state and capacity of pasture is concluded that about half of Mongolian pasture area still have not yet lost essential characteristics as pasture ecosystem if present improper utilization practice is changed successfully and from then within 10 years Mongolian pasture can recover or improve the situation. The pasture degradation situation is very clearly revealed from the satellite data using the Normalized Difference Vegetation Index (NDVI) data from 2001 to 2015 (Figure 4.25).

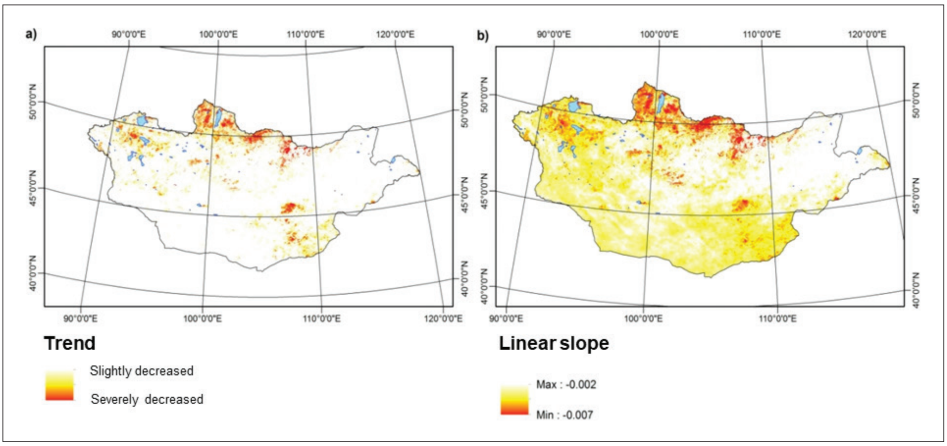



Figure 4.25 Changes on pasture NDVI occurred during the period of 2001-2015 a) trend; b) change rate (N.Mandakh)

Above NDVI map shows that NDVI values decreased by -0.007~-0.002 unit/year in last 15 years, which is clear evidence of pasture degradation. Key reasons for pasture degradation are excessive overgrazing, which is caused by exceeding the pasture capacity due to a large number of livestock and increasing intensity of droughts and dryness.

The total number of livestock of Mongolia estimates on basis of unit forage per sheep units (equivalent to sheep heads) (NSO, 2013). Studies on changes of the livestock heads per unit grazing area show that number of livestock per 100 ha pasture was 40-50 sheep unit (number of livestock equivalent to the sheep heads) in 1980-2000, then it increased to 60-70 sheep unit per unit area by 2000-2015 (Figure 4.26).

According to the scientist S.Tserendash's (Tserendash S, 2006) estimation, the capacity of Mongolian pasture is 80-90 millions of livestock equivalent to sheep heads or 50-60 sheep unit per unit ha of pasture. During the period of 1980-1990 number of livestock was persistent within the given capacity, however, since 1991 livestock heads steadily exceed pasture capacity even during several droughts and dzuds, when livestock numbers decrease.

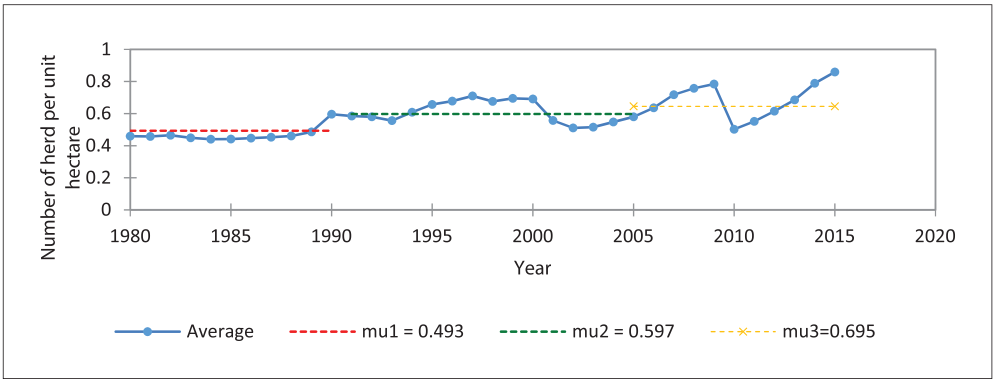



Figure 4.26 Change of livestock heads per unit hectare: a) average of the country in 1980-2005; b) average of 2000-2015 (N.Mandakh)

In terms of spatial distribution for livestock number, more increase of livestock is observed in Eastern and Central regions of Mongolia. Concerning numbers or density, the number of livestock per unit ha of pasture has been increased by 50-70 sheep heads per year in Darkhan, Orkhon, Tov, and Arkhangai provinces and around Ulaanbaatar city in last 15 years. Also in other regions, this increase was around 10-30 equivalent to sheep heads units and (Figure 4.27).

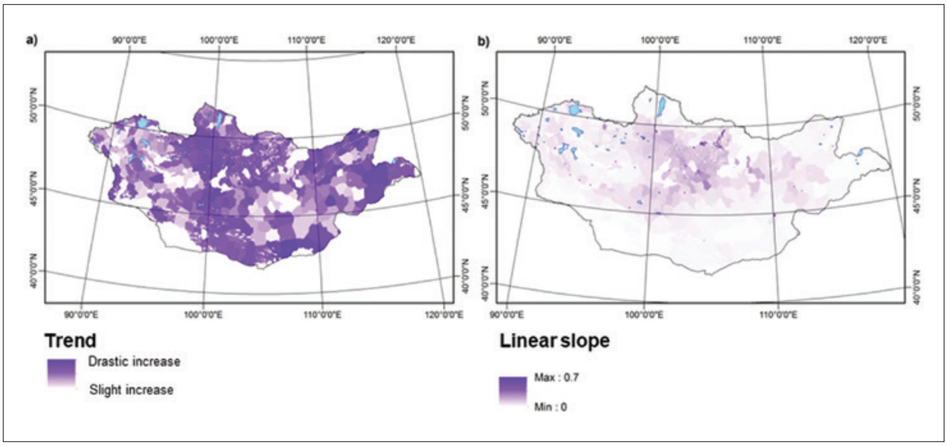



Figure 4.27 Trend of number of heads per unit hectare observed during the period of 2001-2015 a) monotonous change expressed by Zmk; mk ni index linear trend created by "a"-coefficient

***Soil fertility.*** Recently, ecosystem models are used for assessment of soil and pasture state and their changes and becoming more popular. Therefore the current content of some parameters of soil and pasture and their future changes are estimated by the Century model.

Table 4.9 presented current content of organic substances in the soils according to the natural zones. In the analysis, it has been applied outputs of regional climate model which uses NCEP analysis data, 1986-2015 (P.Gomboluudev, 2016). Here, level of pasture use or stress on pasture is taken as moderate.

Table 4.9 Present content of organic substance of soils, g/m$^2$

| Natural zones | Content, g/m2 | | | |
|---|---|---|---|---|
| | Organic carbon | Organic nitrogen | Aboveground biomass | Belowground biomass |
| High mountain | 2177.90 | 139.49 | 20.45 | 764.33 |
| Forest steppe | 4548.26 | 408.40 | 32.06 | 1461.57 |
| Steppe | 2657.81 | 220.16 | 29.41 | 1095.13 |
| Desert steppe/Desert | 1332.94 | 73.93 | 21.16 | 477.44 |

As shown in the table above, highest contents of organic carbon and organic nitrogen are observed in the upper layer of soil or at depth of 0-20 cm or 4,550 g/m$^2$ and 410 g/m$^2$, respectively. In high mountain regions, the content of organic carbon in the soils is 2,180 g/m$^2$ and 2,660 g/m$^2$ in the steppe region, while the lowest content of organic carbon, 1,330 g/m$^2$ in the soils is observed in desert steppe regions. As for nitrogen content, it is similar to carbon content or higher values in the soils of high mountain area (410 g/m$^2$) and it varies from 220 to 75 g/m$^2$ in the steppe and desert regions.

Plant root scatters not only along the depth but also many branches sidelong. This indicates soil moisture insufficient and combating soil moisture. Therefore ratio between aboveground and belowground biomass is relatively large (1:49-1:117).

In case of model outputs, aboveground biomass varies around 20-30 g/m$^2$ while belowground biomass is 480-1,460 g/m$^2$ which are 22-45 times greater than the aboveground biomass. The amount of an aboveground biomass is around 30 g/m$^2$ and a below ground biomass is 1,100-1,460 g/m$^2$ in the forest-steppe and steppe region. These values also somehow express soil fertility of the region.



***Impact assessment of soil fertility and pasture yield.*** The future state of soil and pasture of Mongolia have been estimated by Century model using outputs of future climate change projection data by REGCM4-ECHAM5 and RegCM4-HadGEM2 models. This estimation differs from previous one due to the level of stress on pasture use is taken into the model as moderate and high scenarios. Because of connection with an increase of the quantity of livestock and traditional pasture use practice which already broken down and pasture degradation became a common way of pasture use. From the variety of Century model outputs, contents of organic carbon (OC) and nitrogen (ON) in the soil layer of 0-20 cm and aboveground (AGB) and belowground biomasses (BGB) have been done in further analysis.

State of the pasture is projected in following three future periods as 2030 (2016-2035), 2065 (2050 2065) and 2080 (2081-2100) under a moderate scenario of stress on pasture use. Estimated results show that except aboveground biomass is expected to reduce, especially more intensive reduction in 2080 (Figure 4.28).

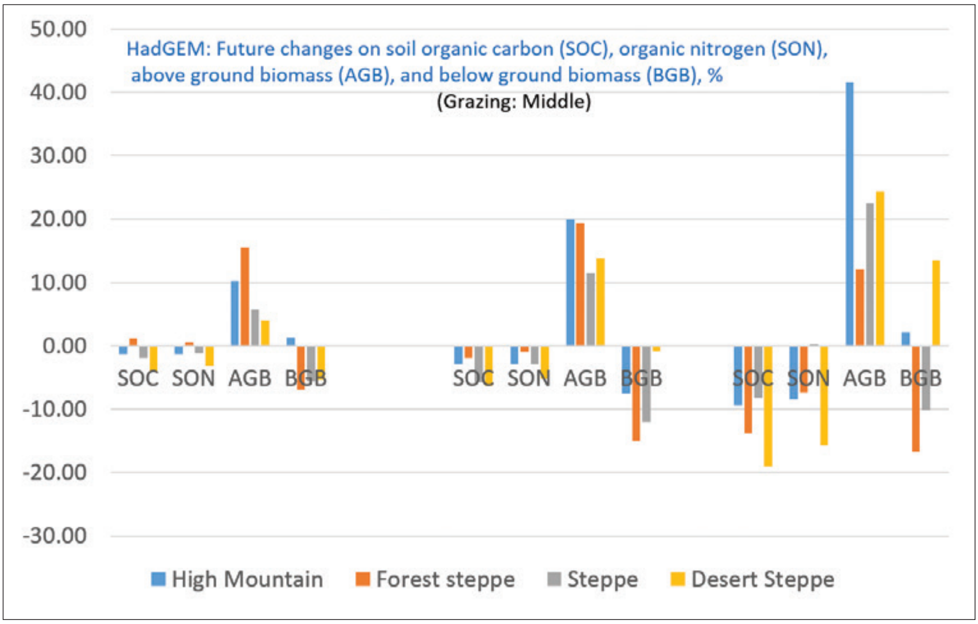



Figure 4.28 Future changes of some parameters and plants, % (outputs of RegCM4-HadGEM2 models for 2030, 2050, 2080, pasture use level-under moderate scenario)

Aboveground biomass is projected to slightly increase and it is connected with the lengthening of the growing season and maximum harvest expected to be collected in September. Another reason for such increase also may relate to the increased projection of rainfall in May as well. On the other hand, in case of high level of pasture stress scenario, all parameters of the pasture including organic carbon and nitrogen, and also above and below ground biomasses will be reduced significantly (Figure 4.29). This proves that excessive pressure has drastic negative impacts on soil and plant productivity. Therefore, it is urgently required to implement pasture management which needs to include pasture rotation, relieve and protection measures against pasture degradation.

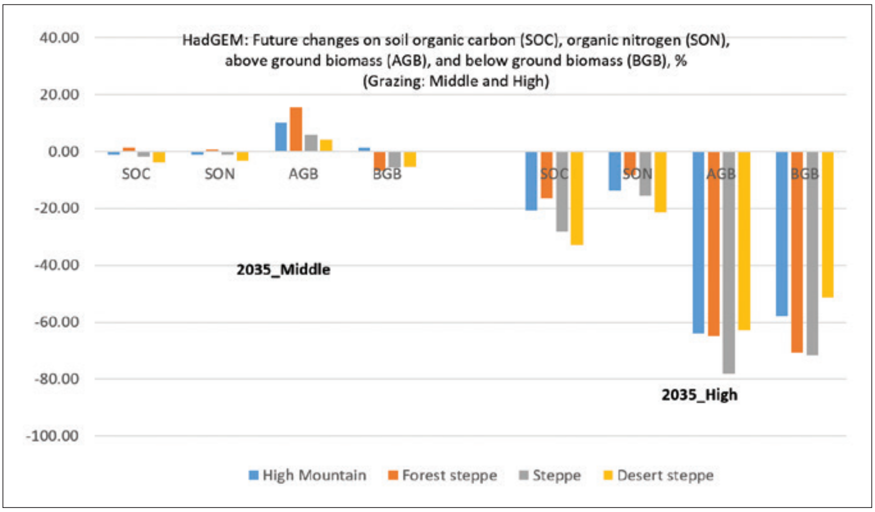



Figure 4.29 Expected changes of some parameters of soil and plants, % (by RegCM4-HadGEM2 models for 2035, 2050 and 2080, pasture use level-under high scenario)

Projection result for the year 2035 under the moderate and high level of pasture use scenarios shows a rapid decrease of all basic parameters of soil and pasture (Figure 4.30). Particularly, a sharp reduction of above and belowground biomass by about 50-80% is expected. Again this model result demonstrates how harmful excessive use of pasture is on soil and pasture productivity.

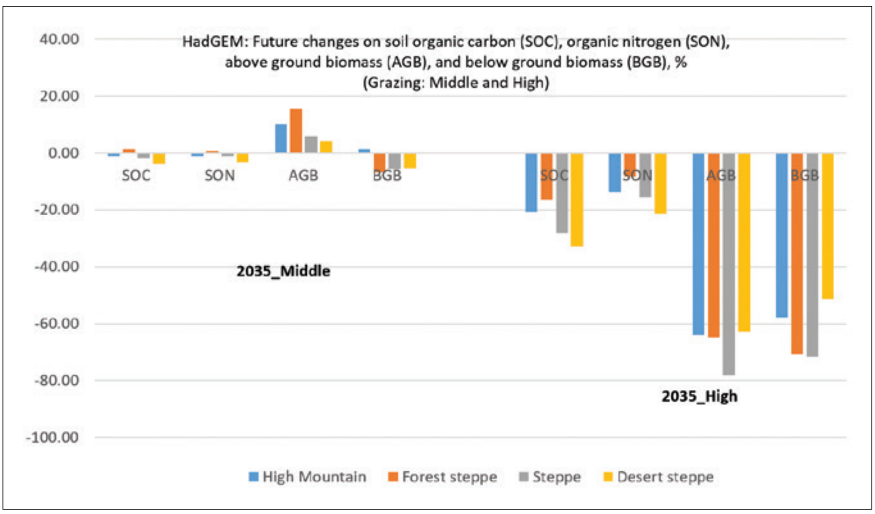



Figure 4.30 Future changes of some parameters of soil and plants, % (outputs of RegCM4-HadGEM2 models for 2035, pasture use level-under moderate and high scenarios)

A similar estimation also applied to the use of REGCM4-ECHAM5 models under a moderate scenario of pasture use. Model results show that future increasing rate of aboveground biomass or decreasing rate of other parameters will be less in comparison to previous models (Figure 4.31).

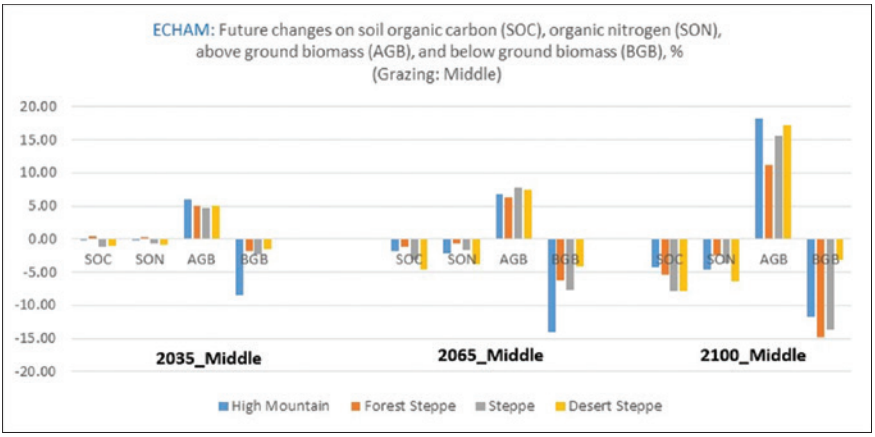



Figure 4.31 Future changes of some parameters of soil and plants, % (outputs of RegCM4- ECHAM5 models for 2035, 2065 and 2100, pasture use level-under moderate scenario)

The content of organic carbon and nitrogen expected to decrease by 10-20% in 2030 and 2050 years under a high level of pasture use scenario (Figure 4.32). In case of the RegCM4-HadGEM2 model, the reduction rate of mentioned organic substances will be slightly greater than above results or will be around 15-30%.

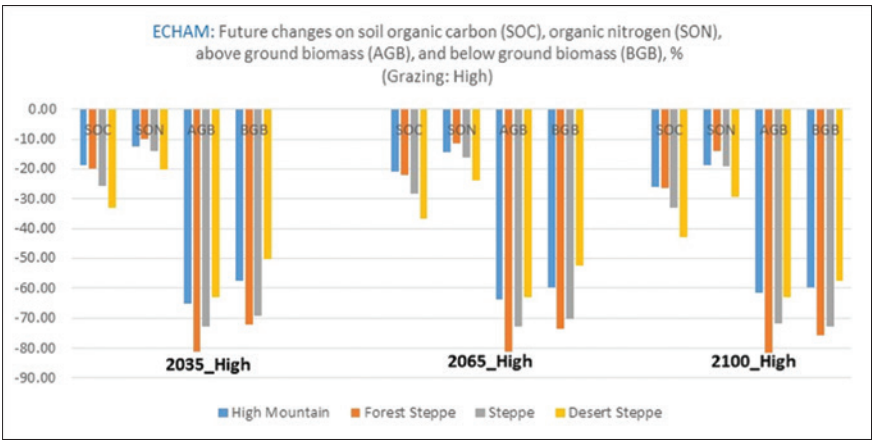



Figure 4.32 Future changes of some parameters of soil and plants, % (outputs of RegCM4- ECHAM5 models for 2030, 2050 and 2080, pasture use level-under moderate scenario)

If take a moderate level of pasture stress in the REGCM4-ECHAM5 models then decreasing rate of organic carbon and nitrogen also will be less compared to REGCM4-ECHAM5 model results (Figure 4.33).

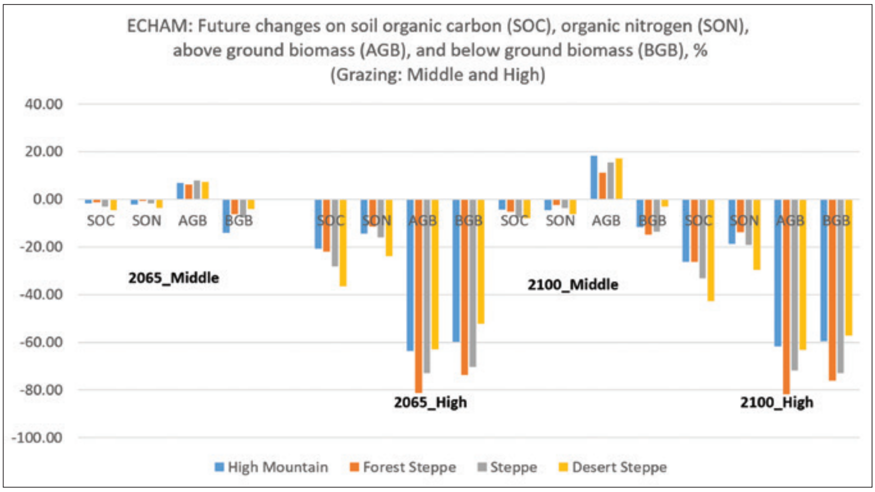



Figure 4.33 Future changes of some parameters of soil and plants, % (outputs of RegCM4- ECHAM5 models for 2030 and 2080, pasture use level-under moderate and high scenario)

Modeling results demonstrated that under the high-stress condition on pasture use, all characteristics of pasture expected to decrease which limits growing, yielding capability of plants and further weakening root systems. All mentioned situation cause soil and pasture degradation and intensified conditions for further desertification. More intensive reduction of soil and plant productivity is related to excessive overgrazing of pasture land, wherein the forest-steppe and steppe regions.

***Pasture fatality caused by rodents.*** Recently, areal propagation of some harmful insects and rodents was clearly observed with the increase of the occurrence of drought and climate change intensity. For example, propagation of Brandt's vole (gerbil) and grasshopper occurred in steppe region and caused huge damage to the pasture during the drought of 2000-2002. Moreover, propagation of this harmful insects spread in arable farming land and caused much loss of harvest, crop yield and vegetable during these years.

Besides, it is difficult to relate spread and propagation of harmful insects and rodents of pasture and arable farming land with climate and weather outputs since monitoring and observation network on the country scale have not



Chapter 4

been established yet. Recently, monitoring for harmful insects and rodents of pasture and arable land has started in Mongolian hydrometeorological system and observation network since 2001. Monitoring data and some studies allow determining pasture damage scale caused by these harmful insects and rodents, their numbers per unit area, its absolute density and areal distribution and relic area of the insect and rodents.

*Brandt's vole (Laciopodomus brandtii.R.1861):* Propagation of Brandt's vole might be caused by climate warming and pasture degradation due to increasing of livestock numbers. Since 1921, propagation of Brandt's vole was observed in 1941-1943, 1956-1957, 1963-1963, 1971-1973, 1981-1986, 1990-1991 and 1998-2002. It shows some 10-12 years cycle of vole spread out. Most likely, relic or focal area is expected to increase several times although the areal distribution of Brandt's vole has been increased by 2-3 millions of ha since 1940s of last century (Figure 4.34) (Avirmed D., 1989).

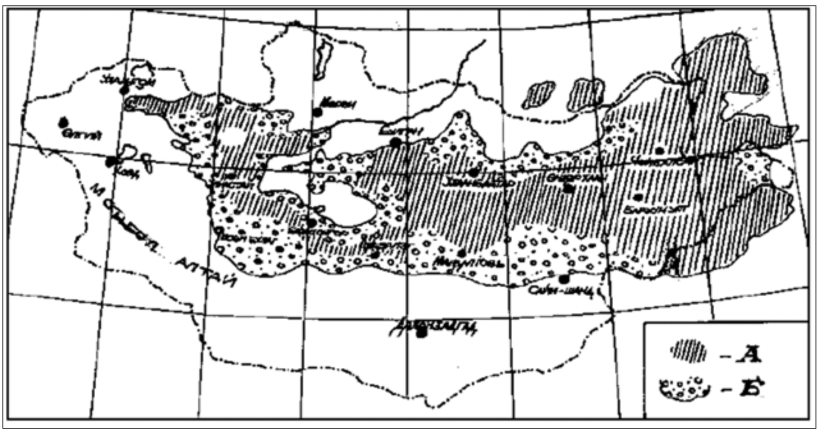



Figure 4.34 Areal distribution of Brandt's vole. A-by G.Bannikov from 1954 (Bannikov, 1954), B-by Avirmed, 1997-2000

According to regular monitoring data conducted since 2002, the highest number of rodents found from one single hole as well as the highest areal distribution of Brandt's vole were in 2002 and 2007, when severe droughts occurred. Rodent's distribution increased areas, the pasture yield is reduced by 1.2 centner/ha on average during the period of 1999-2002, when 4 years of consecutive droughts occurred. During that time, rodents spread out over 59 soums of 16 provinces in 2002. It was accounted nearly by 1-35 rodents over most of the territory in 2002. At the time, 1-35 rodents from a single hole in Bayan soum of Tov province, 120 in Galuut soum of Bayankhongor and 299 were recorded in Kherlen-Bayan Ulaan, Khentii province (Figure 4.35).

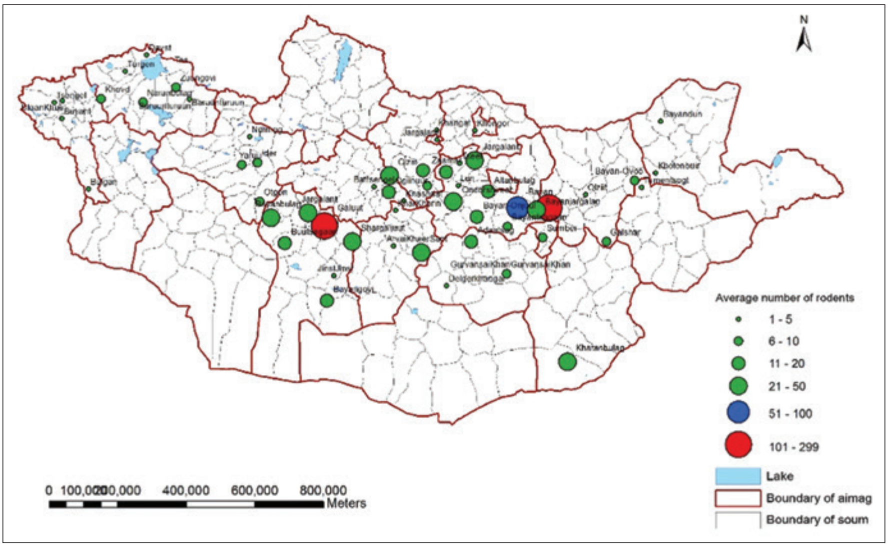



Figure 4.35 Number of rodents in one single hole
(second decade of August 2002)

In a relatively wet summer situation, for example in the second decade of August 2014, a number of rodents in one hole was about nearly 1-53 and around 96-121 in case of Tsakhir and Tsetserleg soums of Arkhangai province (Figure 4.36) respectively.

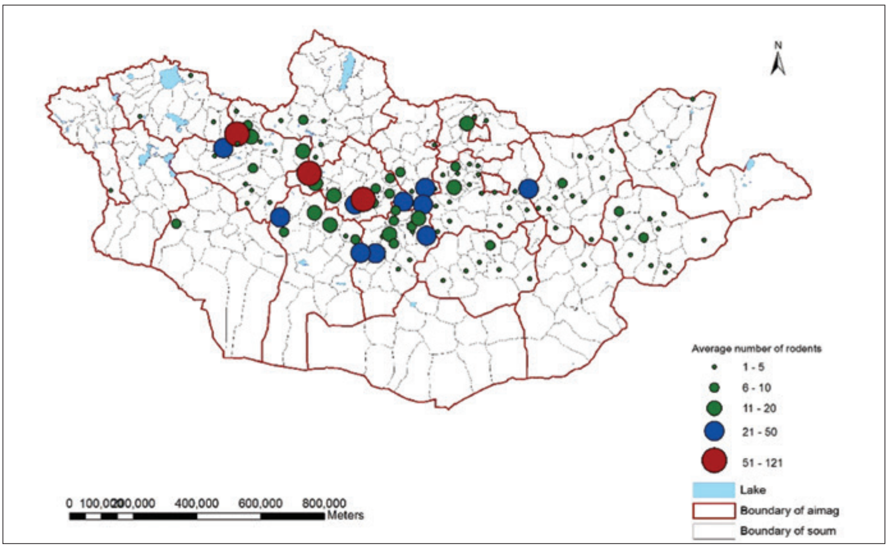



Figure 4.36 Number of Brandt's vole (second decade of August 2014)

The comparison of above maps of the areal distribution of Brandt's vole shows that its propagation is shifting to the north side of the country. Compared to results of a study done by scientist D.Avirmed, it indicates that Brandt's vole propagation has been extended in most of the soums territory of Selenge province, southern soums of Bulgan province, north-west parts of Bayanolgii and Uvs provinces and in northern soums of Dornod province.

Field survey results were done by Mongolian researcher D.Tseveendorj (Tseveendorj D., 2015), size of area spread of Brandt's vole and its numbers in hole per unit hectare area (relative density) are increasing since 2005 (Figure 4.37).

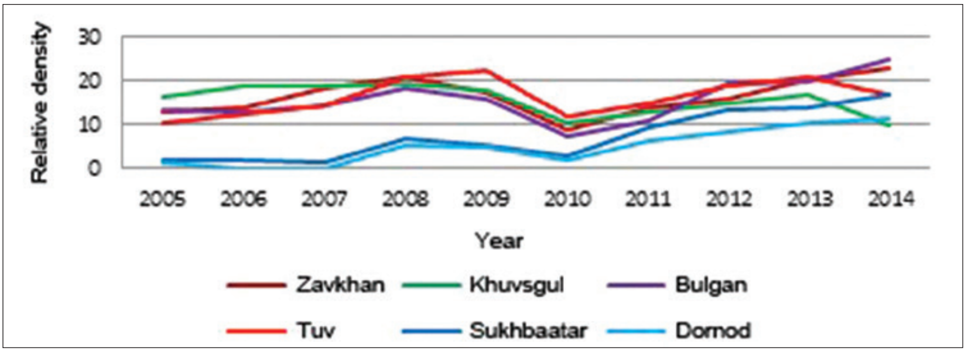



Figure 4.37 Relative density of distribution of Brandt's vole's (by D.Tseveendorj)

<u>*Grasshopper:*</u> There are about 140 species of grasshoppers widespread over Mongolia and 20 of them cause harmful damage to pasture and agricultural crops. Since 2001, monitoring for distribution and propagation of grasshopper is carried out by Mongolian Hydrometeorological service at monitoring network (meteorological stations).

This report only considered the case of Barabensis grasshopper (Angaracris barabensis, Pallas) from many species of grasshoppers in a situation of 1972. Figure 4.38 illustrates the current geographical distribution of this species.

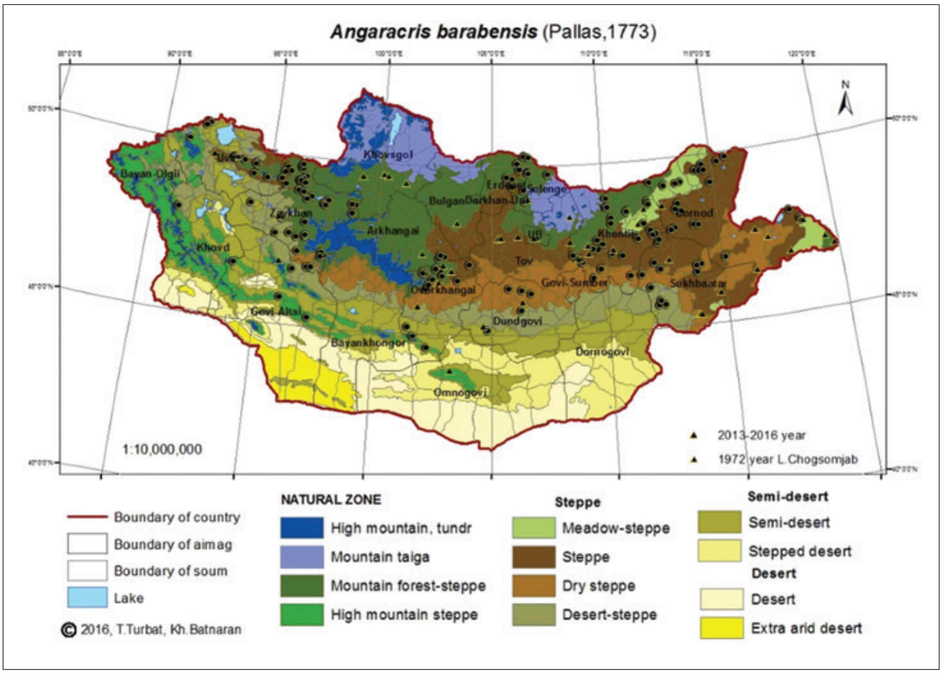



Figure 4.38 Geographical distribution of Barabensis grasshopper, 1972 (2013-2016)

*Future distribution of Barabensis grasshopper:* A present situation and future changes of distribution of grasshopper are estimated using MaxEnt model. For the model, inputs were used from climate data from 1986-2005. In the estimation of the distribution of grasshopper, the following criteria is used: if distribution probability >0.2 then no spread, if probability in between of 0.2-0.4 then less spread, 0.4-0.6 to be moderate and the probability is above 0.6< then propagation of grasshopper is considered to be high (Sunil Kumar and Thomas J. Stohlgre, 2009).

The current distribution of grasshopper produced by the MaxEnt model is shown in Figure 4.39 Barabensis grasshopper types of grasshopper predominantly distributes in southern edge of Khangai mountains, Khankhokhii, Darvy, Khantaishir, Tarvagatai, Bulnai, Ereen Hill, Jargalt Khairkhan, Bumbat Khairkhan Mountain, valleys of Ider, Tes, Khovd, Orkhon, Tuul, Kherlen, Onon, Ulz and Khalkhgol rivers and in the Daryganga plateau. From the comparison of observed and estimated distribution (Figure 4.39), we can see that the MaxEnt model consistently simulates the distribution of grasshopper in the spread areas.

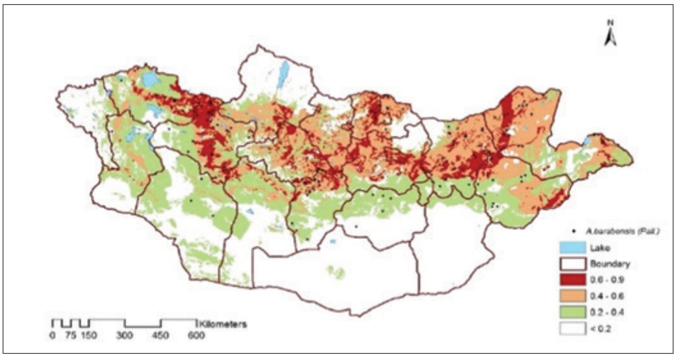



Figure 4.39 Distribution map of grasshopper produced by the MaxEnt model, 1986-2005

For the assessment of future impacts under climate change, grasshopper distribution is estimated by REGCM4-ECHAM5 and RegCM4-HadGEM2 model outputs. The assessment shows that high propagation of Barabensis grasshopper can be reduced slightly at the beginning of the century and further propagation tendency of grasshopper is expected to increase with climate change intensity. The Figure 4.40 shows the future change of distribution of grasshopper in the mid of this century under both models scenarios.

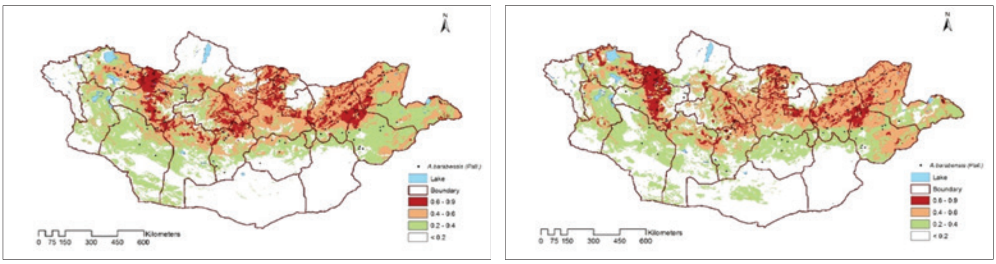


Figure 4.40 Future change of distribution of grasshopper: a) by REGCM4-ECHAM5 model b) by RegCM4-HadGEM2 model, 2046-2065

According to MaxEnt model simulation, Barabensis grasshopper is distributed in 4,473 thou.ha over Mongolia. This area of distribution is extending to change as slightly decrease by 1.4% in 2016-2035, increase by 5.2% 2046-2065 and by 4.6% in 2081-2100 according to RegCM4-ECHAM5 model output.

### 4.1.5. Biological diversity

Certain changes occur in biological diversity due to natural, environmental and climate changes. At the same time, the direct and indirect human influences have impacted the change of biological diversity. This could be seen as evidence such as the dramatic reduction of a number of heads of Mongolian marmot and some steppe rodents, change of areal habitat of Mongolian gazelle and deer, and shrinkage of their distribution area.

The study covers some species of 3 classes of the animal kingdom of Mongolia. The selection of animal species considers distribution ranges, such as widely and commonly distributed across the Mongolian territory and natural zones as well as distributed within unique limited spread area. Such selection allowed to improve the evidence of study and to make results of the study more realistic and accurate. MaxEnt model was used to assess the impact of climate change on the living environment, habitat area of the some selected animal species.

The survey is included the following species. Where:

- **Mammals**: Mountain wild sheep (*Ovis ammon),* Mongolian gazelle (*Procapra gutturosa),* goitered gazelle (*Gazella subgutturosa*), Deer (*Cervus elaphus),* Mongolian saiga (*Saiga Borealis*)
- **Birds**: falcon (Falco Cherrug), great bustard (*Otis tarda),* Henderson's ground jay (*Podoces hendersoni),* field lark (*Erempphila alpestris)*
- **Insect**: some mosquitos *from Phlebotominae* family, the spread of virus of hoof-and-mouth disease, a beetle from *Carabidae* family

Future projection of Climate Change (by RegCM4-HadGEM2, RegCM4-ECHAM5 model) shows that impacts of climate change are contrasted to effect to mountain ungulates species such as mountain wild sheep which spread widely in the regions of Mongolian Altai and Govi-Altai and Khangai Mountains and Central low land area compared to the steppe region or regions with smooth and uniform elevation and where there is relatively less diversity of habitat. Grassland, mountain, forest, forest steppe, desert steppes ungulates are selected as target species from mammals and made a comparison of changes of present and future of relic and distribution area by the size of the area ($km^2$) and demonstrate in graphic form. Although there are certain differences between relic and distribution area, it is hard to distinguish such small percentage in the graphic presentation. Therefore, results of comparison relic and habitat area of selected species are expressed by numbers and presented in the Table 4.10-4.11.

Change of present (1986-2005) and future relic and distribution area of some selected key species and some diseases such as foot-and-mouth disease is estimated using regional climate models.

Table 4.10 Change of habitat environment, the distribution area of some species of animals and foot-and-mouth disease estimated by climate change model of REGCM4-HadGEM2

| Name species | Habitat environment | 1986-2005 | 2016-2035 | Difference (%) | 2045-2065 | Difference %) | 2080-2100 | Difference %) |
|---|---|---|---|---|---|---|---|---|
| Mammals | | | | | | | | |
| Wild mountain sheep | Relic area | 58429.65 | 47725.53 | -18.3 | 54866.15 | -6.1 | 55448.27 | -5.1 |
| | Distribution area | 547289.63 | 337257.14 | -38.4 | 382178.49 | -30.2 | 355331.17 | -35.1 |
| Mongolian gazelle | Relic area | 218489.75 | 241749.95 | 10.6 | 214640.87 | -1.8 | 206554.57 | -5.5 |
| | Distribution area | 549334.41 | 469673.28 | -14.5 | 462214.6 | -15.9 | 451498.76 | -17.8 |
| Goitered gazelle | Relic area | 85724.33 | 70546.93 | -17.7 | 76240.62 | -11.1 | 70036.83 | -18.3 |
| | Distribution area | 340488.92 | 262412.41 | -22.9 | 243233.68 | -28.6 | 253464.89 | -25.6 |
| Deer | Relic area | 131575.64 | 103287.37 | -21.5 | 99639.68 | -24.3 | 95836.23 | -27.2 |
| | Distribution area | 504589.23 | 430920.57 | -14.6 | 437704.31 | -13.3 | 449087.79 | -11.0 |
| Saiga antelope | Relic area | 30597.91 | 23272.64 | -23.9 | 24699.14 | -19.3 | 22871.42 | -25.3 |
| | Distribution area | 45978.78 | 36475.83 | -20.7 | 39973.85 | -13.1 | 37778.36 | -17.8 |
| Birds | | | | | | | | |
| Field lark | Relic area | 130070.2 | 112385.92 | -13.6 | 98256.84 | -24.5 | 145190.87 | 11.6 |
| | Distribution area | 873871.0 | 675056.29 | -22.8 | 691024.09 | -20.9 | 748316.26 | -14.4 |
| Great bustard | Relic area | 93804.7 | 69743.61 | -25.7 | 77607.41 | -17.3 | 76097.61 | -18.9 |
| | Distribution area | 447395.9 | 336496.55 | -24.8 | 375596.53 | -16.0 | 375905.71 | -16.0 |
| Henderson's ground jay | Relic area | 100114.3 | 63245.8 | -36.8 | 51946.71 | -48.1 | 52798.03 | -47.3 |
| | Distribution area | 413399.0 | 277066.34 | -33.0 | 263995.51 | -36.1 | 490030.8 | 18.5 |
| Falcon | Relic area | 193178.9 | 169987.06 | -12.0 | 152775.05 | -20.9 | 155370.8 | -19.6 |
| | Distribution area | 804397.9 | 668558.54 | -16.9 | 672875.55 | -16.4 | 673037.84 | -16.3 |
| Insects | | | | | | | | |
| Beetle Harpalus | Relic area | 173246.12 | 111845.9 | -35.4 | 112297.3 | -35.2 | 145281.24 | -16.1 |
| | Distribution area | 837547.19 | 686399.41 | -18.0 | 627512.97 | -25.1 | 755456.66 | -9.8 |
| Mosquito Phlebotominae | Relic area | 113901.61 | 98117.76 | -13.9 | 99285.66 | -12.8 | 82406.6 | -27.7 |
| | Distribution area | 608858.39 | 462597.42 | -24.0 | 507911.36 | -16.6 | 470916.12 | -22.7 |
| Foot-and-mouth disease FMD | Relic area | 90002.21 | 57556.06 | -36.1 | 57391.5 | -36.2 | 59398.79 | -34.0 |
| | Distribution area | 348843.14 | 220342.49 | -36.8 | 246053.36 | -29.5 | 264490.92 | -24.2 |

Table 4.11 Change of habitat environment, the distribution area of some species of animals and foot-and-mouth disease estimated by Climate change models of REGCM4-ECHAM5

| Name species | Habitat environment | 1986-2005 | 2016-2035 | Difference (%) | 2045-2065 | Difference %) | 2080-2100 | Difference %) |
|---|---|---|---|---|---|---|---|---|
| Mammals | | | | | | | | |
| Wild mountain sheep | Relic area | 58429.65 | 56233.64 | -3.8 | 66477.49 | 13.8 | 55945.79 | -4.3 |
| | Distribution area | 547289.63 | 369259.76 | -32.5 | 378272.7 | -30.9 | 371294.73 | -32.2 |
| Mongolian gazelle | Relic area | 218489.75 | 206419.93 | -5.5 | 226515.01 | 3.7 | 263823.69 | 20.7 |
| | Distribution area | 549334.41 | 476887.74 | -13.2 | 498171.8 | -9.3 | 493080.34 | -10.2 |
| Goitered gazelle | Relic area | 85724.33 | 74717.8 | -12.8 | 75524.01 | -11.9 | 80865.51 | -5.7 |
| | Distribution area | 340488.92 | 398266.51 | 17.0 | 264181.17 | -22.4 | 269338.59 | -20.9 |
| Deer | Relic area | 131575.64 | 87714.66 | -33.3 | 96901.2 | -26.4 | 92710 | -29.5 |
| | Distribution area | 504589.23 | 433840.87 | -14.0 | 435828.62 | -13.6 | 444640.49 | -11.9 |
| Saiga antelope | Relic area | 30597.91 | 25354.46 | -17.1 | 21850.42 | -28.6 | 23793.41 | -22.2 |
| | Distribution area | 45978.78 | 40774.41 | -11.3 | 38677.78 | -15.9 | 37476.21 | -18.5 |
| Birds | | | | | | | | |
| Field lark | Relic area | 130070.16 | 90569 | -30.4 | 128403.14 | -1.3 | 112839.19 | -13.2 |
| | Distribution area | 873870.95 | 668126.56 | -23.5 | 731234.71 | -16.3 | 766029.65 | -12.3 |
| Great bustard | Relic area | 93804.74 | 83243.5 | -11.3 | 66821.57 | -28.8 | 73515.06 | -21.6 |
| | Distribution area | 447395.85 | 378130.19 | -15.5 | 326874.04 | -26.9 | 364492.54 | -18.5 |
| Henderson's ground jay | Relic area | 100114.34 | 54713.64 | -45.3 | 70037.67 | -30.0 | 57790.28 | -42.3 |
| | Distribution area | 413399 | 280408.16 | -32.2 | 284667.2 | -31.1 | 268488.18 | -35.1 |
| Falcon | Relic area | 193178.94 | 169561.35 | -12.2 | 157710.1 | -18.4 | 181774.63 | -5.9 |
| | Distribution area | 804397.86 | 698115.05 | -13.2 | 643057.67 | -20.1 | 735177.25 | -8.6 |
| Insects | | | | | | | | |
| Beetle Harpalus | Relic area | 173246.12 | 153333.79 | -11.5 | 140083.6 | -19.1 | 130751.65 | -24.5 |
| | Distribution area | 837547.19 | 755160.84 | -9.8 | 734279.29 | -12.3 | 692157.78 | -17.4 |
| Mosquito Phlebotominae | Relic area | 113901.61 | 81448.19 | -28.5 | 102882.25 | -9.7 | 67540.79 | -40.7 |
| | Distribution area | 608858.39 | 413725.12 | -32.0 | 459433.62 | -24.5 | 369363.93 | -39.3 |
| Foot-and-mouth disease FMD | Relic area | 90002.21 | 64473.15 | -28.4 | 61672.21 | -31.5 | 47103.85 | -47.7 |
| | Distribution area | 348843.14 | 259435.35 | -25.6 | 240326.32 | -31.1 | 217328.71 | -37.7 |

The average size of relic area of five species of mammals for baseline (1986-2005) period is *108040±31276* km$^2$ (n=5) and while for distribution area, the average size of distribution area is to be 3944460±98686 km$^2$ (n=5). If compare these baseline areas with areas projected by the regional climate change models then relic area will be decreased by 95023±22875 km$^2$, 97263±21888 km$^2$ and 98279±24290 km$^2$ in 2016-2035, 2046-2065 and 2080-2100, respectively. In case of the distribution area of selected mammals, reduction of distribution area projected by the models will be 324257±522734 km$^2$, 316516±53927 km$^2$, and 314808±53557 km$^2$, in 2016-2035, 2046-2065 and 2080-2100, respectively. To illustrate how habitat area of animals will project under climate change, as an example, change of distribution area of goitered gazelle estimated by climate model is shown in Figure 4.41.

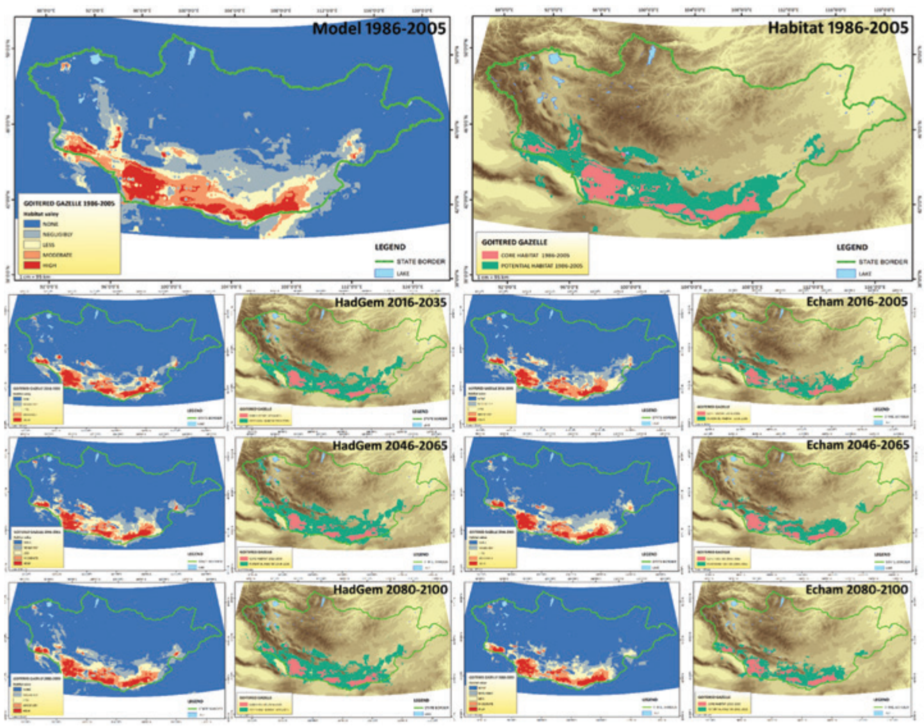



Figure 4.41 Change of habitat environment and distribution area (1986-2005) of goitered gazelle (Gazella subgutturosa) of Mongolia estimated by climate change models of RegCM4-HadGEM2; RegCM4-ECHAM5 for future periods (2016-2035, 2046-2065 and 2081-2100)

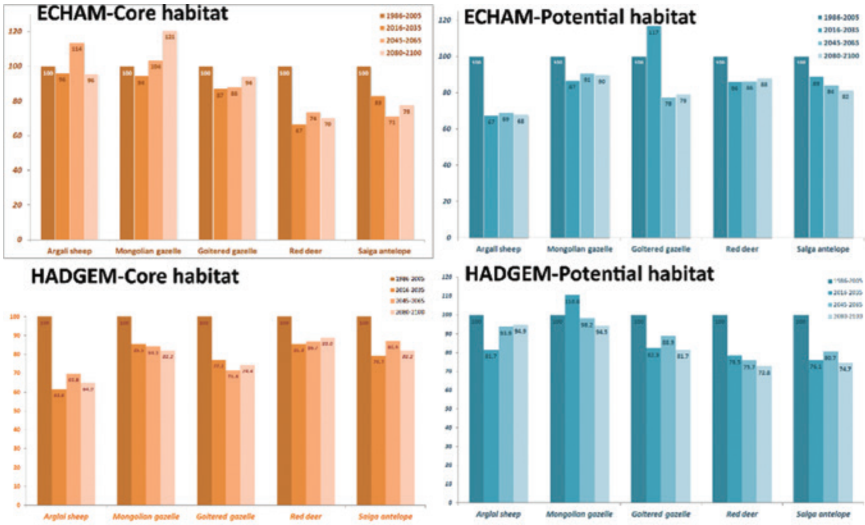



Figure 4.42 Change of relic and distribution areas of selected five species of ungulates by the RegCM4-HadGEM2 climate models. During climate baseline period (1986-2005) area size has taken 100 %

Climate change (RegCM4-HadGEM2) projection also show various ways of climate change impacts on habitat area of bird species. In case of some of the widespread birds, especially field lark and falcon which are spread across the vast steppe and through different natural zones, show some distinct impacts and changes caused by climate change. These differences can be seen from projection results in the future 3 projection periods. For example, the distribution area of the two selected bird's species is expected to increase in different ways in the three projection periods. On the other hand, relic area of falcon will be reduced while for field lark is expected a huge increase of relic area at the end of this century.

As for Henderson's ground jay which is spread in the Gobi desert regions, model projection show also results in sharp increase of its distribution area at the end of this century and in case of great bustard which is spread in the steppe regions, distribution area expected to increase gradually or constant increase in the last two projection periods. In case of the RegCM4-HadGEM4 model, relic area is expected to decrease for all selected bird species. But, relic area of field lark is expected to increase sharply at the end of the period. Although the size of relic area of selected bird species is expected to reduce in 2016-2035. This trend will continue further, the distribution area of the target birds will increase except Henderson's ground jay. However, as mentioned the distribution area of selected birds is stable or even has some increasing trend, the reduction area of the species might have serious impacts on the population of the birds because mostly the relic area is the nesting and laying area for the birds.

The study also shows a correlation between relic area and distribution area in terms of the changes of their baseline and model outputs. For example, there is certainly a correlation between relic and distribution areas of field lark ($r=0.6$; $p=0.155$) and on the other hand, this relationship for the great bustard was reverse with $r=-0.844$ and $p=0.017$. As for Henderson's ground jay species, have yet observed a clear correlation between relic and distribution areas ($r=0.289$; $p=0.5$) while in case of Falcon, there is quite a strong relationship between relic and distribution areas ($r=0.903$; $p=0.005$). A quite wide range of variation in size and changes of baseline and future relic and distribution areas of targeted bird's species indicates a difference of impacts of climate change on habitat environment of animals in Mongolia.

The average size of relic area of 4 targeted birds during the baseline period of 1986-2005 is 129292±22717 $km^2$ (n=4) and for distribution area, 634766±119044 $km^2$ (n=4). If compare these baseline areas with projected areas in different projection periods then relic area will be decreased by 101681±16122 $km^2$ (n=8) in 2016-2035 and 100445±14475 $km^2$ (n=8) and 106922±17351 $km^2$ (n=8) in 2046-2065 and 2080-2100, respectively. As for distribution area of selected birds, it is expected to decrease by 497745±68925 $km^2$ (n=8) in 2016-2035 and at the level of 2046-2065 reduction of the area will be around 498666±71690 $km^2$ (n=8) and finally, at the level of 2080-2100, 552685±71080 $km^2$ (n=8) etc.

Projection of future climate change (RegCM4-HadGEM4) model for a selected class of insects' species, such as some mosquitos *from Phlebotominae* family, the spread of virus of hoof-and-mouth disease, a beetle from *Carabidae* family are quite distinctive and at the same time, quite specific results are produced. For example, distribution and relic areas of beetle (Carabidae family) species are expected to reduce on the vast steppe regions of the country. But at the end of the century, might observe some increases in the mentioned areas.

For mosquito which only distributes in the Gobi regions, relic area is expected to decrease constantly while future distribution area is kept stable. Propagation of the foot-and-mouth disease will continue to increase from baseline in the future, but relic or focal remains unchanged. Therefore, impacts of climate change are to be varied for different species distributed in the vast territory or in some particular regions. Relic area of the all selected insects is expected to decrease in future. Such decreasing trend is likely to be positive especially in case of the harmful hoof-and-mouth disease in terms of socio-economic condition.

Finally, we have been estimated a size of relic area and distribution area of totally, 12 species of mammals, birds, and insects of our country using baseline data of 1986-2005 and outputs of climate models of RegCM4-HadGEM2 and RegCM4-ECHAM5 for particular future periods as 2016-2035; 2046-2065 and 2080-2100.

An average relic area of the baseline of 1986-2005 and model outputs of 12 species was 119543±15222 $km^2$ (n=12). At the same time, an average of model outputs for three mentioned periods (24 changes of two different models) have been decreased by 97102±11108 (n=24), 97908±10415 (n=24) and 298777±11974 $km^2$ in 2016-2035, 2046-2065 and 2080-2100, respectively. In case distribution area, mean of 12 species was 525551±69303 $km^2$ (n=12) and average of projected distribution area by models for three mentioned future periods (24 changes of two different models) will be decreased by 417591±40535 $km^2$ (n=24), 415417±40809 $km^2$ (n=24) and 430803±43547 $km^2$, 2016-2035, 2046-2065 and 2080-2100, respectively.

Biodiversity of our country, namely within some selected animal species, their mean values change and projected reduction for relic and distribution area are consistent with regional climate model results. It can be concluded that overall impact assessment has a certain confidence.

## 4.2. Climate change impacts on some socio-economic sectors

### 4.2.1. Arable farming

The main crop production regions of Mongolia include a Central region, especially Selenge, Darkhan-Uul, Bulgan, Uvurkhangai, and Arkhangai provinces. History of modern agricultural production began since 1959 when started a campaign to hold the prairie land and in order to ensure food demand of the county. A large area has been cultivated and its maximum area reached 828-838 thou.ha during 1988-1989. For example, wheat crops area reached 526-532 thou.ha in the 1989-1992 periods and potato cultivation had reached 15.4-16.8 thousand hectares in 2011-2013.

But since the mid-1990s until 2008-2009, cultivation area and harvest much decreased and the agricultural sector is nearly collapsed. For example, by 2007 harvested only 109 thousand tonnes of wheat, 114 thousand tonne of potatoes, 76.4 thousand tonnes of vegetable and 14 thousand tonne of feed and this harvest provide only 27.5%, 88.7% and 48.8% of the country's total needs, respectively. In case of fruits and berries, only 1% is provided from domestic cultivation and harvest. There are a number of factors which affected in such situation and however, the most important are related to climatic factors (successive years of drought, extreme hot events, etc.), quality of sowing seeds worsened, outdated techniques, lost technological regime and almost no use of fertilizer and herbicide.

Although agricultural production has increased substantially, harvest per unit area remains very little (harvest per unit area for crops 0.56 tonnes/ha and for potatoes 12.8 tonnes/ha by 2015) and harvest per unit area is almost 2 times less than compared to the Asian countries with similar conditions without irrigation. The main reason is that more than 90% of total crops, 60% of the potato and 70% of feed crops are cultivating in conditions without irrigation and therefore harvest rate directly depends on climate situation.

If considering the case of historical cultivation experiences for wheat without irrigation then harvest of 1961, 1969, 1980, 2002, 2005 and 2015, were very small 0.4-0.6 tonnes/ha and which is nearly 2 times less than country's average (0.95 tonnes/ha). The reason for such small yield was drought, extremely hot days and late planting in the mentioned years (Figure 4.43).

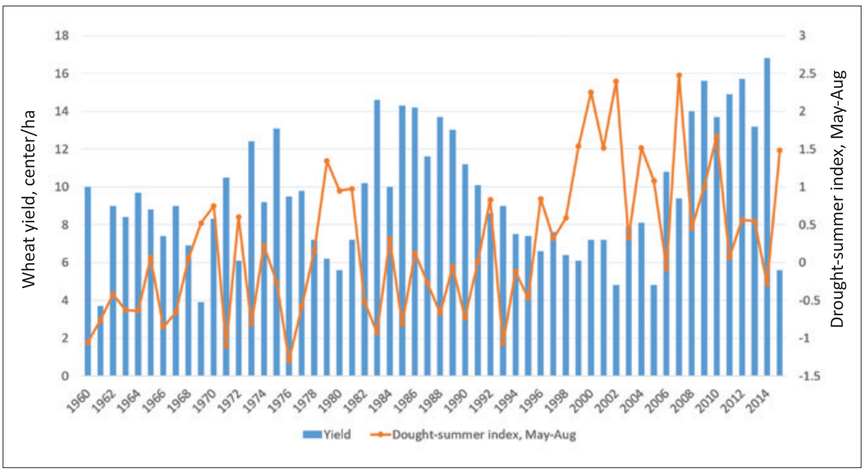



Figure 4.43 Long-term course of country's average harvest of wheat production per 1 ha unit and long-term variation of drought index as considering May-July in the Central region (L.Natsagdorj, 2015)

The harvest from none-irrigated area mainly depends on the climatic condition of growing season and therefore relationship between the general condition of drought-summer condition and harvest certainly exists. For this reason, drought index of May-July in the Central region have been shown additionally in Figure 4.43. The relationship is established separately for the period before the collapse of agricultural production which cover 1960-1992 years and 2007-2015 periods, where "Third Campaign for Reclamation" is implemented (Figure 4.44).The figure shows that correlation of about last ten years has improved because of significant improvement of cultivation culture.

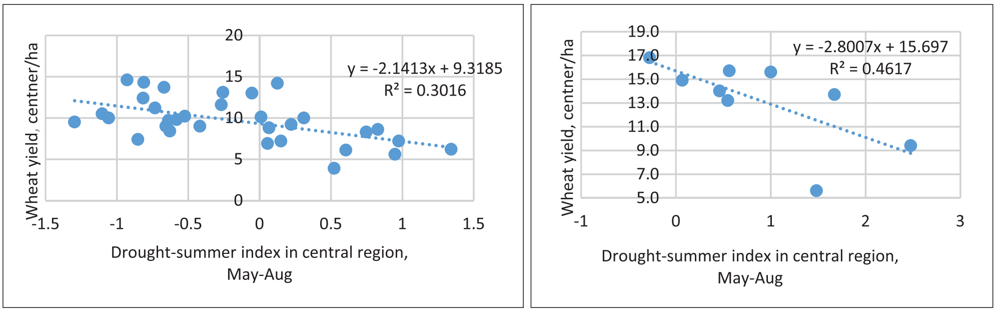



Figure 4.44 Relation of the drought-summer index and wheat yield (estimated by L.Natsagdorj, 2016). 1961 data were excluded, a) 1960-1992 b) 2007-2015

Harvest of the wheat crop depends on many factors such as a number of hot days, heat capacity during pollination and flowering phenological stage, and severe sudden cold in the spring season. The relationship between yields wheat crop and duration of hot days where daily mean air temperature exceeds 26°C in June and July months of growing season in crop agriculture regions (Figure 4.45). The figure shows that correlation between the number hot days above 26 degrees and wheat harvest was high in Darkhan, Bindert while nearly no correlation in the Baruunturuun sum of the western region as considering 1961-2015. But time series of 1961-2005, the correlation coefficient was 0.29 ($R^2$ = 0.29) which is likely to be associated with quality data for last year's wheat crop.

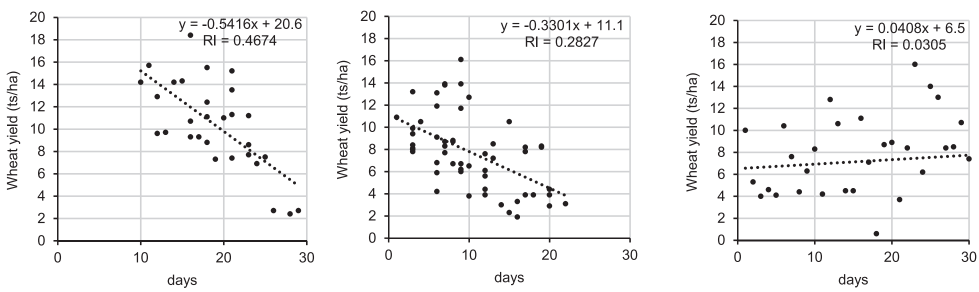



Figure 4.45 Relationship between wheat harvest and duration of days, where daily mean air temperature exceed 26°C in July month
(a) in Darkhan (b) Binder (c) Baruunturuun



Chapter 4

***Impact of wheat yield.*** Future wheat harvest pattern has been estimated by DSSAT v4.6 model which is based on the outputs of regional climate models by RegCM4-HadGEM2 and RegCM4-ECHAM5 under the RCP8.5 scenario. Changes in the future wheat yield estimated at 2025(2016- 2035), 2050(2046-2065) and 2080(2080-2099) which tailored for twenty-year average precipitation and temperature changes from the baseline climate, 1986-2005 (Table 4.12).

Changes in wheat yield are estimated by comparing wheat yield in baseline climate calculated by the models with an average yield of wheat estimated for 2020, 2050 and 2080 time slices under the emission scenarios.

Table 4.12 Future change of wheat yields, %

| No | Station name | RegCM4-ECHAM5 | | | RegCM4-HadGEM2 | | |
|---|---|---|---|---|---|---|---|
| | | 2020 | 2050 | 2080 | 2020 | 2050 | 2080 |
| 1 | Darkhan | -5 | -22 | -43 | -20 | -31 | -44 |
| 2 | Baruunkharaa | -21 | -20 | -49 | -10 | -30 | -47 |
| 3 | Baruunturuun | -5 | -9 | -22 | -4 | -30 | -39 |
| 4 | Erdenesant | -3 | -15 | -31 | -2 | -17 | -35 |
| 5 | Eroo | -10 | -2 | -44 | -5 | -29 | -47 |
| 6 | Khalkh gol | -11 | -10 | -21 | -15 | -5 | -29 |
| 7 | Orkhon | -9 | -20 | -39 | 0 | -23 | -44 |
| 8 | Tarialan | -6 | -14 | -42 | -11 | -20 | -35 |
| 9 | Tsagaannuur | -19 | -3 | -32 | 14 | -11 | -31 |
| 10 | Ugtaal | -5 | -7 | -32 | -6 | -19 | -34 |
| 11 | Khutag | -9 | -23 | -30 | -17 | -32 | -46 |
| 12 | Orkhon tuul | -7 | -23 | -50 | -24 | -35 | -56 |
| 13 | Binder | -5 | -10 | -36 | -18 | -23 | -36 |
| 14 | Dadal | -12 | -10 | -24 | 3 | -14 | -28 |

It shows that wheat yield changes estimated by DSSAT v4.6 model, which projected by two mentioned regional climate models, is expected to decrease by 9%, 18% and 37% under RCP8.5 emission scenarios according to the ensemble mean of models in 2020, 2050 and 2080, respectively. This estimation is done under a condition which is seeding time (15$^{th}$ May) as mean of current period (1986-2005) and also wheat variety and soil fertility remained and unchanged. In Figure 4.46 is shown the spatial distribution of changes of wheat crop yield estimated for the central farming region of Mongolia in 2020, 2050 and 2080 periods. The figure shows the REGCM4-ECHAM5 model results in some decline of harvest in the western part of the central farming region in 2020 when have not taken any adaptation actions. But expected decrease will be less than other regions. Most high reduction (more than 16%) of wheat yield level will be projected in 2050 in the western region and high decline is expected in 2080 while in the eastern part.

But under RegCM4-HadGEM2 result, there will be some slight increase in yield in 2020 in the northern agricultural part of the central region. Generally, the wheat yield will decrease to 30-61% during 2050 and 2080.

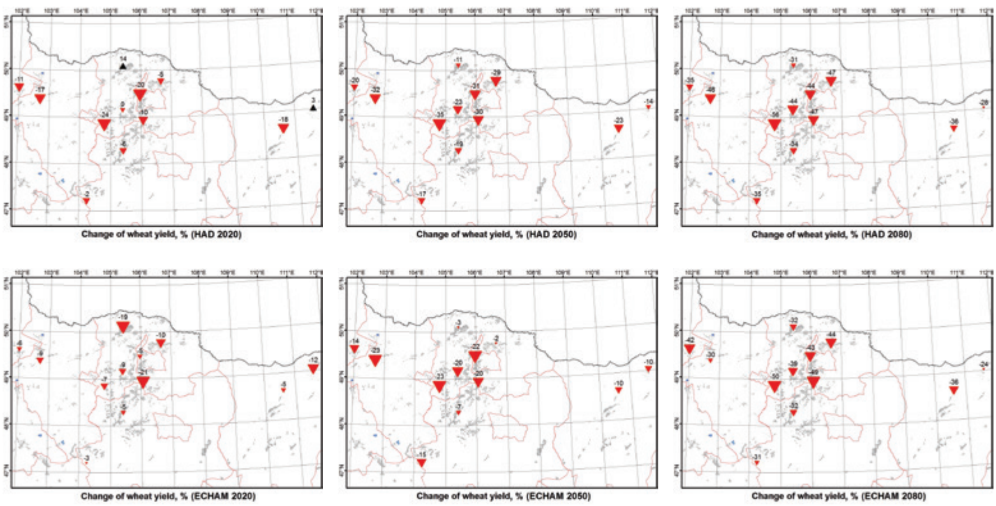



Figure 4.46 Spatial distribution of future changes in wheat yields in the Central region for arable farming

### 4.2.2. Animal husbandry

Climate change effects on pastoral cattle breeding in two ways: in direct and indirect forms. At first: extremely hot, wind and snow storms are direct affecting factors and cause difficulties and delays in the breeding of animals thus animals could not take proper condition during the summer and autumn seasons. It will have difficulties to overcome hardness of the winter-spring time. Secondly: indirect impacts or through pasture can be determined to fatten livestock and mortality.

***Changes in livestock head numbers and herd structure.*** The number of livestock was quite stable between 20-25 million during the old socialist period since 1940s of the last century. Then since mid-1990s, after privatization of livestock sector, it sharply has increased and reached to 61.5 million at the end of 2016, which previously has never been achieved (Figure 4.47).

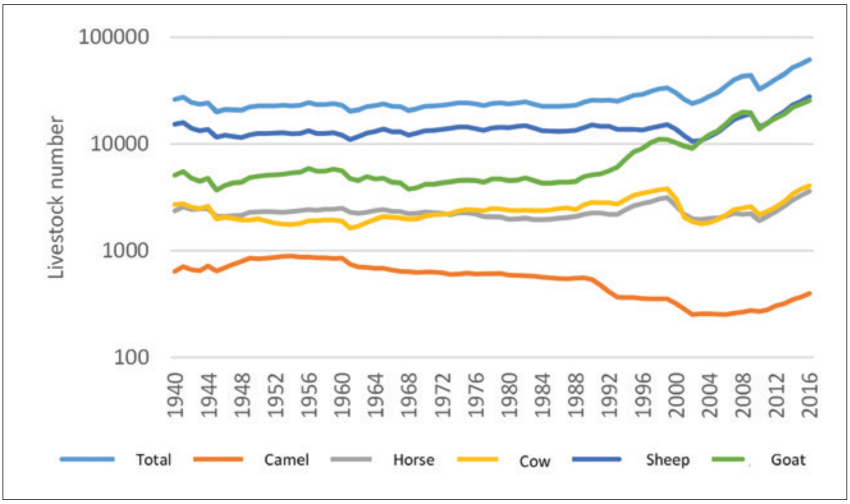



Figure 4.47 Dynamics of livestock head numbers (N ordinates – numbers of livestock in logarithmic units) Source: NSO, 2016

As can be seen from Figure 4.2.5, the number of camels almost constantly decreased since 1960s of the last century. The number of cattle which is the most productive herd among five domestic animals have increased also since 1960s, then after 3 years of consecutive drought and dzud (harsh winter) of the 2000s, and its number years of the has tendency to decrease. But a number of goats emerged to increase constantly after 1990s. Nowadays (in 2016) goat number accounts for 41.6% of the total livestock herds. The traditional structure of livestock herds was significantly broken in the last 20 years.

A number of the cattle herd, which is used to graze pasture with tall grass due to specific biological characteristics, accounts for 9.7% of the total number of livestock during the period of 1960-1990, while its percentage is reduced till 6.6% after dzuds of 1999-2000. At the same time, the percentage of goats during the period of 1961-1990 was 19.5% and the number of goats already reached 41-46% of the total herds since 2008 and is becoming close to the number of sheep. It is clear that increased goat number is increased due to demand of cashmere market, which is made up a significant portion of herder's income. But, the weight reduction of percentage for camel number is attributed mainly to needs for meat demand.

***Drought and dzud risk, their related change and fluctuation of livestock numbers.*** The precipitation amount almost is not changed during plant growth season under climate change in Mongolia over past 70 years. But summer drought and warming of winter season significantly have increased due to a rapid increase in temperature. The winter season is becoming harsher because of increase of winter precipitation in the form of snow and frequency and intensity of dzud have much increased due to the above mentioned two factors, and consequently and negatively impacted to animal husbandry.

Correlation studies between drought and dzud index and a loss of mature animal were done by L.Natsagdorj et al. show a relatively high correlation between two variables (Batima P et al., 2007). However, recent studies indicate some decline of the mentioned correlation and reason of such change might be a loss of traditional herd structure. For example, the correlation coefficient between dzud index and mature animal loss was 0.86 in 1942-2001, while for data series which cover a period of 1942-2014, the correlation coefficient reduced to 0.76. This means non-natural mortality rates of animals become high (Natsagdorj L, 2014) in relatively mild and favorable conditions compared to conditions of 1940-1980, where weather and climate situation were harsh and cold (Figure 4.48).



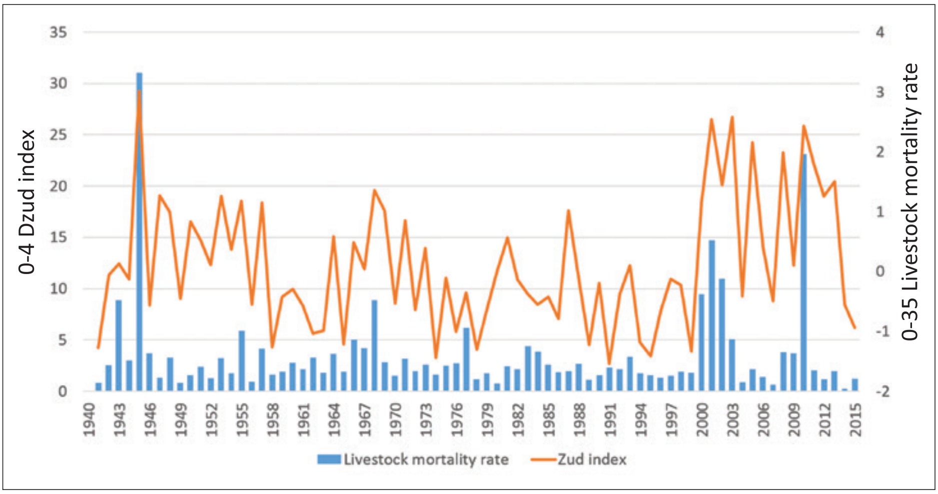



Figure 4.48 Comparison of mature animal loss of a year to the number of livestock at beginning of the year, in percentage. Source: L.Natsagdorj, Impacts of climate change to the forest, water resource and agricultural sectors and their detailed vulnerability and risk assessments, 2012

The compared ratio between non-natural loss of mature animals and number of livestock at the beginning of the year was 4.5% during the period of 1940-1960, when herders lived as individual families and wintering condition was mostly harsh. Then this ratio has reduced to 2.8% during the period of 1940-1960 when herders already united into cooperatives. Finally, after privatization of livestock, this ratio again increased up to 4.0% in the period of 1991-2015.

According to the future climate change projections, the intensity of drought and harsh winter (dzud) is expected to increase in Mongolia.

The percentage of possible animal losses in near future under moderate GHG emissions scenario, RCP4.5 is estimated by relationship of future intensity of drought, wintering, and dzud indexes (See Chapter 4.2.3), and animal loss which is based on the results of 10 global climate models (ensemble mean) which provide best simulation of the past climate of Mongolia. The estimation shows that about 5.5% of the livestock which counted at the beginning of a year, will be lost in mid of this century and this percentage will reach to 7.6% at the end of this century. Thus, livestock loss is expected to increase by about 50% in the mid of this century compared to the present situation and loss will be doubled by end of the century compared to the present loss rate. A significant increase of livestock losses certainly will affect negatively on the reproduction of livestock which directly relates to the livelihood of herders and food supply to the population. At the same time, migration of rural people to the cities caused by the decline of herder's livelihood will bring rapid mechanic growth in the urban population and all the mentioned processes and phenomena will lead to aggravating economic problems. and social constraints in the country's scale.

*Changes in livestock productivity.* Due to climate change, plant productivity and yields much weakened in last twenty years in most parts of Mongolia. Especially in the central part of the country as well as in western part of the eastern region, the plant productivity has decreased by 5-13% in 1961-1990.

Observation and survey made since 1980s in the forest-steppe region show that, in addition to decreasing of pasture yields, the number of extremely hot days (Natsagdorj L, 2008) which is considered as an unfavorable condition for animal grazing has been increased during summer seasons and eventually animals could not get enough fat in summer season and size of animals is becoming small and light.

Figure 4.49 shows long-term measurement results (since the 1980s) of live weight mature cow in spring (a period with the lowest weight) and in autumn seasons (a period where live weight is more) observed at the zoo-meteorological station located in the forest-steppe region or in the Orkhon soum of Bulgan province.

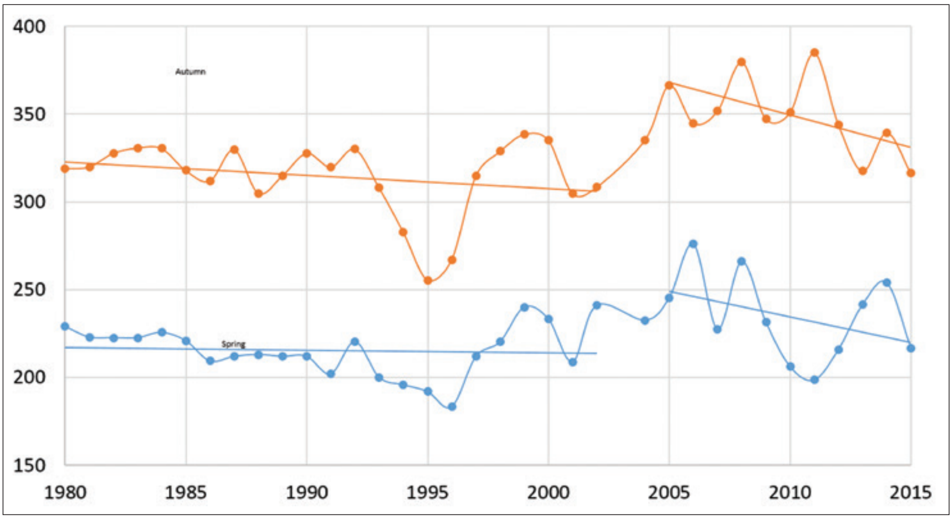



Figure 4.49 Dynamics of live weight of mature cows, in Orkhon soum, Bulgan province. Source: Data from zoo-climate observation of Institute of Meteorology, Hydrology, and Environment

Live weight of mature Mongolian Cow generally has a tendency to decrease from 1980 to 2015. In the last 7-8 years, live weight of animals decreased instead of dead animals during dzud period (2002-2004). Measurement results also show that fluctuations of live weight of animals increased significantly in recent years. It seems to be live weight decreasing of winter-spring is higher than live weight decreasing of summer-autumn. Also increasing of live weight fluctuation is indicating that increasing of herd's vulnerability due to its environmental change. Decreasing tendency of live weight of mature cow was also observed in the steppe regions (data from the zoo-meteorological station of Bayanonjuul soum of the Central province).

The meat and wool yields of animals also have a decreasing trend in connection with a summer-autumn decrease of live weight of cattle. Similar trends also to appear in sheep and goat's measurements cases. As an example, Figure 4.50 shows multi-year fluctuations of sheep wool yields measured in the Orkhon zoo-meteorological station of Bulgan province.

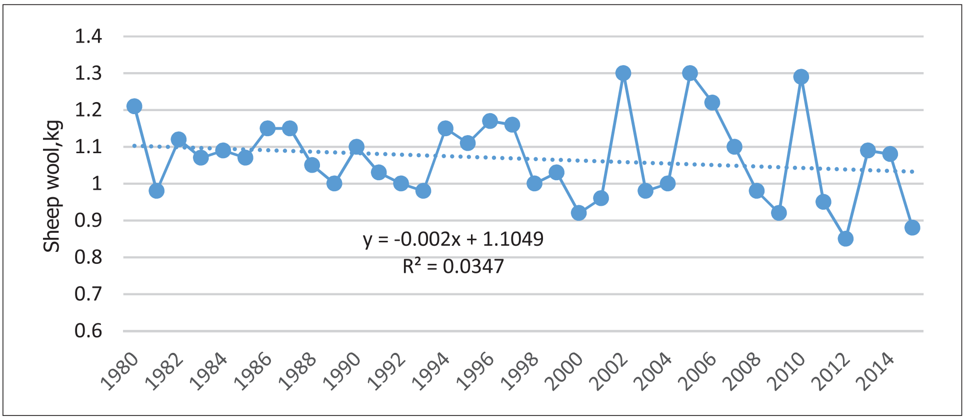



Figure 4.50 Sheep wool yield (by kg) in Orkhon soum, Bulgan aimag (Source: Zoo meteorological measurements at Institute of Meteorology, Hydrology, and Environment)

Spring starts earlier, while goat cashmere combing and sheep wool shearing time are also becoming earlier (Figure 4.51).

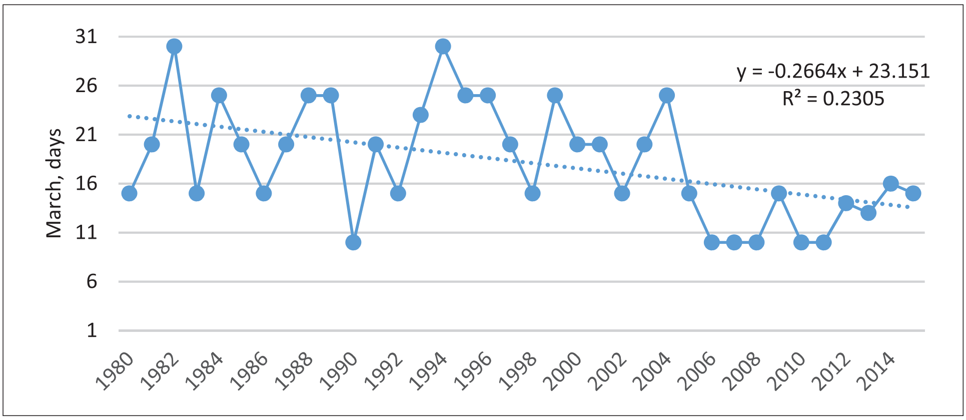



Figure 4.51 Goat combing time, (by date in March), Orkhon, Bulgan aimag (Source: Zoo meteorological measurements at Institute of Meteorology, Hydrology, and Environment)

***Animal Diseases.*** Impacts of climate change on distribution and propagation of livestock disease is not much studied and only outlined the very general way on a global scale. It appears that climate change can influence the ecology or environment and in the way of animal disease infection. Detailed research evidence and data on animal disease are very limited in Mongolian case. However, it is possible to face the following risks. This includes:

- further outbreaks of infectious diseases due to climate change-induced natural disasters,
- entering through the border, new and re-emerged diseases, regardless of near and far distance,
- risk of not decreasing outbreaks of diseases, spread area and regions and focal or relic area of infectious diseases,
- types (items) of new and re-emerged diseases are expected to further increase,
- pathogenic evolution of infectious disease has become faster and appears new strains resistant to environmental changes).

Studies constitute that there are 26 new animal diseases, 8 re-emerged diseases and 6 animals are diseases spreading out in Mongolia the recent years (Orgil D, 2014). But, a study which identifies a link to the mentioned diseases to climate change is very rare. Here is shown as an example of a few years trend of animal losses due to anthrax and animal madness diseases (Figure 4.52).

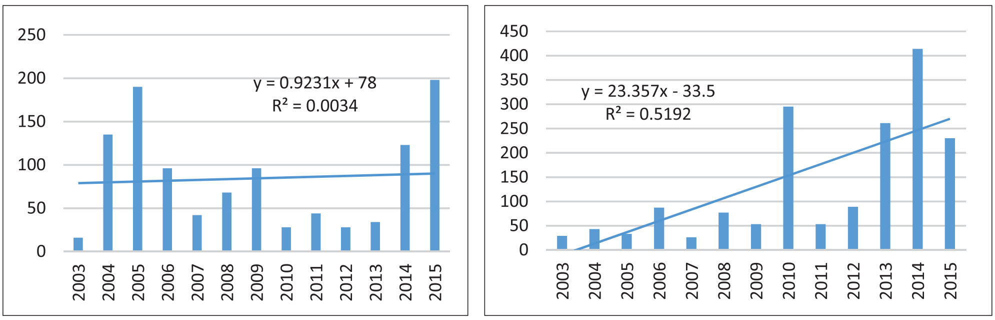



Figure 4.52. Animal losses caused by some extreme infectious diseases: anthrax and animal madness respectively (Source: National Emergency Management Agency)

***Livestock water supplies.*** Pasture water supply is a critical issue for improvement of pasture use. Before the 1990s, about 60% of pasture already has been supplied with water sources and there are totally more than 40 thousand of different types of wells exist in Mongolian pasture and 20 thousands of them engineering designed wells and remaining wells are just dug wells of herders (Nergui D, 2011).

According to the studies on the impact of climate change to water use and water resources, area and volume of glaciers and number of small lakes and ponds in high-mountains are much reduced.

Warming of the water temperature due to future climate warming would provide an improvement of ecosystem productivity and positively impact on livestock water supply in the cool and high mountain regions of the country. However, increasing trend of evaporation predicts entirely dry conditions for Mongolia. Therefore, above conditions show that water resource is expected to be one of a crucial challenge for Mongolia. Consequently, it will likely affect the water supply of pasture to a certain degree.

### 4.2.3. Natural disaster

**Types of natural disaster and their characteristics of the distribution.** Concerning natural disasters in the country, the following various disasters may occur in the territory of Mongolia. At first, atmospheric originated or hydrometeorological disasters such as drought and dzud, flash and river floods, heavy snow and rain storms, mesoscale phenomena or events associated with convection (thunder and lightning, heavy thunderstorms and squall), snow and dust storms, strong winds, heat and cold waves, and then geological (earthquakes) and biological born disasters including human and animal disease epidemics, pasture and forest insect and rodent outbreaks, etc. But due to the country's geographical location, nomadic living style of people and country-specific socio-economic condition, only some of the mentioned natural disasters could cause socio-economic and environmental damages.

Among the natural disasters, forest and wildfires which may spread and activate due to natural dryness and droughts, but mostly caused by anthropogenic activities take important contribution.

In practice, increasing intensity pasture degradation which caused by the combined impacts of human activity and climate change is considered to be very serious types of natural disaster for Mongolian people who mainly involved in livestock farming.

According to the Special report of IPCC (IPCC-SREX, 2012) on natural disasters, the frequency of hydrometeorological disasters and magnitudes of climate extremes events have been increased much more since the 1950s, and similar trends also have been observed in the territory of Mongolia.

About 10 different types of natural disasters occur in our country, which causes significant damage to the socio-economy of the country. Most of them are originated from atmospheric phenomena. If natural disasters are ranked according to socio-economic risk, drought, dzud, forest and steppe fires, snow storms, floods and extreme cold are considered to be major disastrous events in the country.

In last 10 years, natural disasters bring damages, which costs around 50-70 billion MNT to the country's socio-economy in every year. This damage is almost 10-14 times higher than in the previous 10 year's statistics. Figure 4.53 shows frequency of hydrometeorological extreme and disastrous events, which have occurred in Mongolia during 1989-2015.

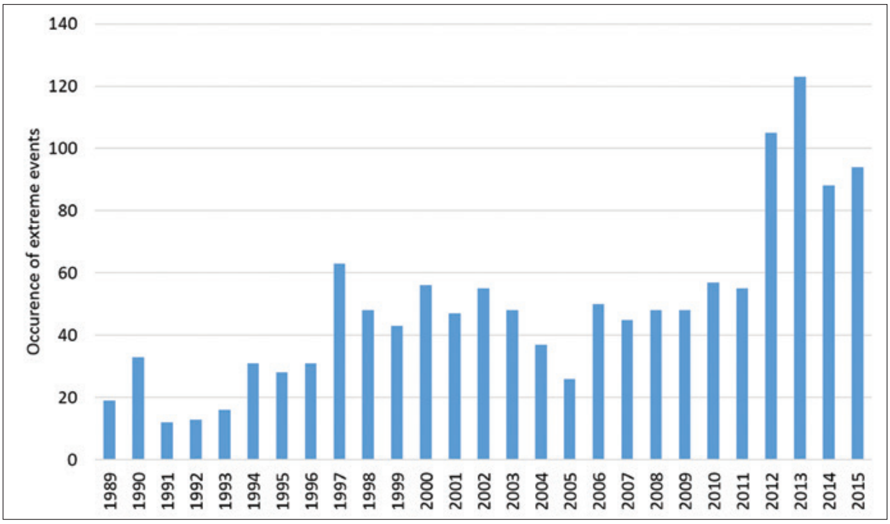



Figure 4.53 Frequency of hydrometeorological extreme and disastrous events in Mongolia (drought and dzud are not included)

Some statistics registered since 1989, show that about 49 extreme and disastrous events related to the atmospheric phenomena occur in Mongolia in every year. Considering their occurrence in 2 decades of the last 20 years, then it shows that around 30 extreme and disastrous events were observed in the first decade, while these statistics have increased by 2 times in the second decade.

Figure 4.54 shows a long-term variation of atmospheric related extreme events, which was occurred in Mongolia (forest fire is not included). It is taken in 2 classifications according to the duration of event's development as short and long lasting (Doljinsuren M, Chandima Gomes, 2015).

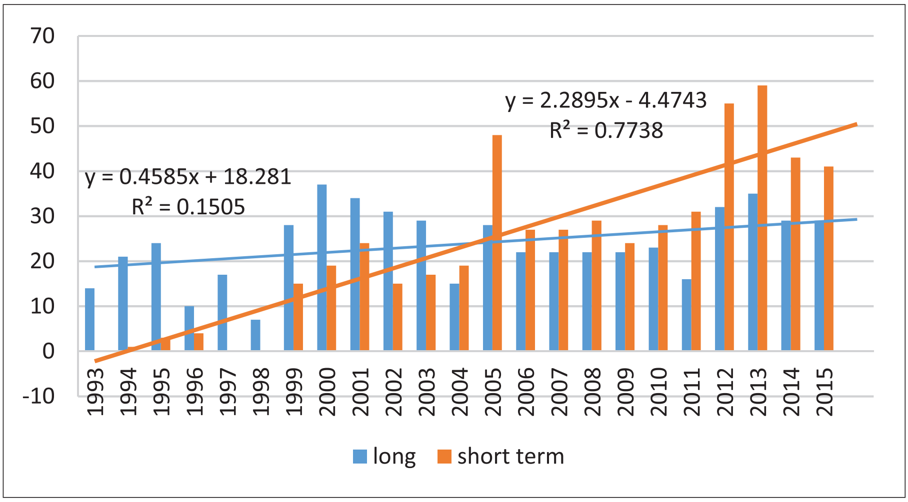



Figure 4.54 Long-term variations of short and long lasting atmospheric related extreme events in Mongolia

These could be explained by the increase of population settlements and on the other hand, relates to the increase of weight or ratio of heavy storms (Natsagdorj L, Kh.Altantsetseg, 2008) in summer precipitation due to climate warming. Table 4.13 is shown the annual occurrence of extreme events related to atmospheric phenomena in Mongolia.

Table 4.13 Occurrence of hydrometeorological extreme events over the territory of Mongolia, 2001-2015

| Extreme events | Windstorm | Heavy snow | Heavy rain | Wind squall | Shower, rain and flash flood | Hail | Thunderstorm and lightning | Frost | Cold rain | Wet snow | Spring Flood | Avalanche | Forest and steppe fire |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Occurrence in year (average in year) | 15 | 3 | 3 | 8 | 15 | 4 | 10 | 3 | 1 | 2 | 2 | 1 | 181 |

Among the disastrous and extreme events, which occur in Mongolia, strong winds, flash floods, thunderstorms, and squall are appeared to be the most frequent disasters and take 22.4%, 22.4% and 15% of the total disasters, as respectively. In total, 308 people were killed due to extreme and disastrous events in a period of 2004-2015 and 40.0% of them caused by strong wind storms, 24.0%, and 16% are due to flash floods and lightning, as accordingly.

Extreme and disastrous events such as strong winds, snow and dust storms, heavy snowfall and rain, severe cold (frost) and wet snow cover a large area and last relatively long time. Therefore they bring significant damages to the agricultural production and account for about 39% total annual cases of extreme and disastrous events.

Heavy rain and flash flooding, squall winds, hail, and lightning are considered short-range (1-4 hours) events which cover a small area but cause much destruction and damages. About 57% of total extreme events and disasters belong to the short-range events and 40% of them belong to only flash flooding. The spring floods and snow slide take 4% of extreme events and disasters which occur within a year.

The frequency of heavy rain and flash flooding, squall winds, hail, and lightning is increased sharply in Mongolia and cases which lead danger and damages have been increased by 2 times in last 20 years. These statistics are consistent with survey results which show an increase of daily rainfall amount and an increase of the percentage of heavy rainfall events among the total rainfall cases (Natsagdorj L, Kh.Altantsetseg, 2008).

The relationship between the frequency of disastrous events related to atmospheric phenomena occurring in Mongolia and annual mean air temperature shows that correlations coefficient was r=0.36 (Figure 4.55).

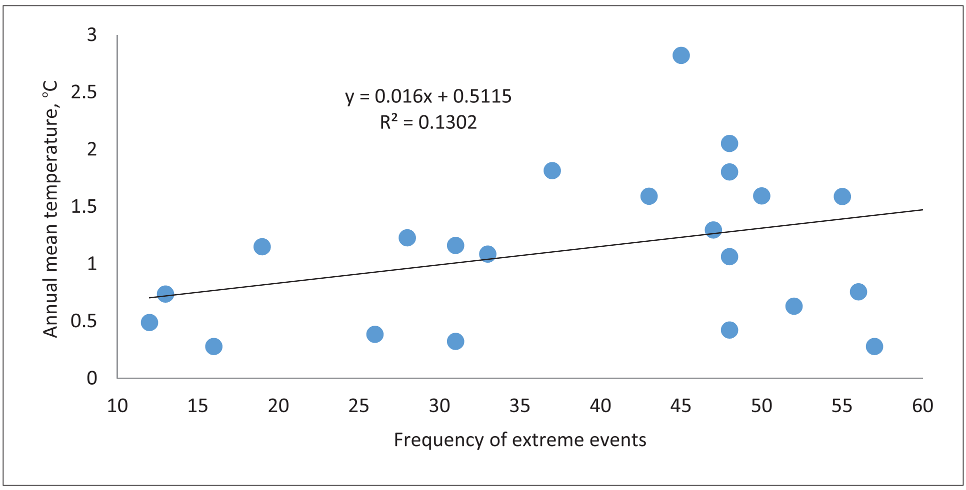



Figure 4.55 Relationship between the frequency of disastrous and extreme events and annual mean air temperature in Mongolia

In another word, above relationship consistent with the world and international study results, which is indicated an acceleration of warming intensity bring an increase of the frequency of-of extreme weather events (Natsagdorj L, 2012).

It is estimated that frequency of disastrous events related to the atmospheric phenomenon is expected to increase by almost 23-60% by the middle of this century in any climate change scenario.

*A feature of disaster damage.* The damage caused by natural disasters include not only direct losses caused by disasters but also cost for combating and elimination of disaster's consequences. In Mongolian case, so far we could not fully estimate and assess the direct damage caused by the disaster and only do some partial estimate of few limited types of disasters such as severe storms, floods and steppe fire in the form of loss of private properties, livestock losses, crop hail struck and livestock losses due harsh winter (dzud).

Concerning damages of some organizations and community is generally only considered the damage caused to schools, hospitals, and public institutions which funded by central and local government budgets. But, the costs of coping with disasters and elimination cost of the consequences which funded from the state budget, somehow estimates relatively accurate.

Cost of damages such as reduction of crop and pasture yields, loss of livestock weight caused by drought (none-irrigated arable farming, mainly crops, livestock forage, etc.) cannot assess as completely. Cost of damages due to forest fire is estimated by ecological and economic damage estimation method of forestry. In another word, economic damage of disasters is mixed with environmental damages. Once economic damage of the disaster could not be assessed sufficiently and consequently disaster risk assessment is becoming much complex and its estimation concerns only some quality forms of assessments such as high or low etc.

In the report of the project named as "Case study on national data collection and the state implemented follow-up disaster measures and compensations for the disaster" implemented by The World Bank in 2015, have been done analysis of data from natural disasters occurred in 2004-2013 collected and accumulated by Mongolian National Emergency Management Agency (NEMA) (Munkhtseren Sh et al., 2015).

The number of natural disasters occurring each year highlighted in above study is slightly differs from atmospheric related disaster data collected by hydrometeorological services. But the content of collected data on disaster damage was quite informative (Table 4.14).

Table 4.14 Occurrence of disastrous events and related information of damages (2004-2013 year)

| Type and name disasters | Total number of occurrences | Geographical impacts: affected soums and districts | Impacts on a human being | | | Destroyed /damaged infrastructure and objects | | | | | | Agriculture | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of affected people | Death toll | Number of injured people | Number of affected schools | Number of affected apartments and gers | Length of damaged roads | Destroyed and damaged bridges | Number of affected hospitals | Number of affected state organizations | affected or damaged area of, ha | Number of lost or dead animals |
| Fires | 1507 | 1564.0 | 140 | 26 | 28 | - | 355 | - | - | - | 64 | - | 6282 |
| Thunder and lightning and hails | 124 | 127.0 | 85 | 41 | 30 | 1 | 37 | - | - | 9 | 62 | 303 | 11903 |
| Earthquake | 161 | 177.0 | - | - | - | - | - | - | - | - | - | - | - |
| Gust winds | 116 | 198.0 | 65 | 2 | 45 | 6 | 3158 | 462 | - | 2 | 593 | 3 | 554 |
| Floods | 344 | 383.0 | 12.395 | 96 | 38 | 12 | 3163 | 520 | 43 | 6 | 291 | 5117 | 34980 |
| Harsh winter (dzud) | 7 | 909.0 | 760993 | 1 | - | - | 8 | - | - | - | - | - | 10770565 |
| Dust and snow storms | 174 | - | 7708 | 149 | 124 | 35 | 3330 | - | - | 9 | 2727 | 170812 | 987539 |
| Total | 2433 | 3358.0 | 781386.0 | 315.0 | 265 | 54 | 10051 | 982 | 43 | 26 | 737 | 176234.9 | 11811823 |

*Note: it is not clear that which phenomena are considered as hurricane and flood, and also earthquake has no damages.*

If consider damages caused by natural disasters in terms of human fatality (death toll) or a number of injured people then floods (mostly flash floods), gusty winds and forest and steppe fires occupy the first ranking places among the natural disasters.

One of the clear forms of impacts of natural disasters on people and community is the huge migration of rural people to the urban area due to loss of livestock during the harsh winter (dzud) and consequently loss of the living source of livelihood of herders. For example, during the harsh winter of 2009-2010, nearly ten million animals are lost and about 8 thousands of herders' families are left without livestock and source of livelihood, the poverty level in rural areas much increased and thus intensified migration to urban centers and caused irreversible damages to the country's economy in a few years.

In terms of economic damages and losses, dust and snow storms, forest and steppe fires and river floods are biggest threatening natural disasters in

Mongolia. Percentage of damage caused by disasters in the gross domestic product is reached 7.5 – 11.5% during the years of 2000 and 2001, where country's economy was weak. In 2010, when almost 23% of the total livestock has been lost due to dzud, the percentage of damage caused by natural disasters took 6.22% of the GDP (from a percentage of GDP of the previous year) (Figure 4.56).

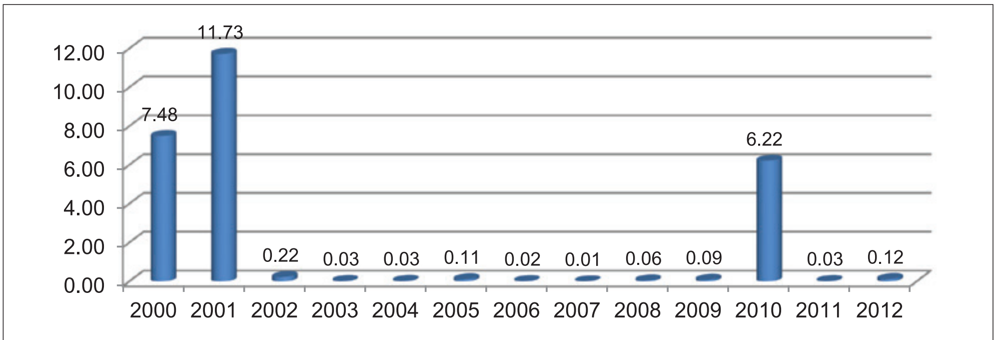



Figure 4.56 Percentage of damages caused by disastrous events related to atmospheric phenomena in the nation's GDP (ecological damage caused by forest and steppe fires is not included)

About 91% non-natural animal mortality is caused by dzud (by the average of 2004-2013), about 8.4% animal death is due to snow and dust storms, and remaining percent is related to another type of disaster events.

Due to disastrous events, damages often happen, for example, damage to building roofs, breaking of window glass, destruction and damage to the roads and bridges, damage to the power and communication lines, falling of lighting poles, blockage of roads and passes, and the collapse of boiler chimney in rural areas, breaking fences. Among them, living houses as traditional gers for Mongolian people are incurred to fall and break down.

If consider damages caused by disasters in the infrastructure then snow and dust storms, floods, and gusty winds are main reasons for such damages in this sector. In term of infrastructure damage caused by disasters, it accounted for 54-73% alone of the total disastrous events occurred in 2008 and 2009.

***Cost expenses for the rescue operation and reduction of disaster consequence.*** In 2003-2004, a total of 5.4 billion MNT has spent for rescue and recovery measures of the natural disasters. The majority of these expenses were funded by provincial governor's reserve fund, fund of emergency departments, road maintenance companies and frontier garrisons. Around 21% of cost expenses for the rescue operation and reduction of harmful consequences of disasters has spent for the case of floods, 33% for dzud case and 37% for wildfire case during or totally, 91% of total expenses have spent only for 3 disaster situations.

If compare spent expenses with the cost of damages then in case of wildfire and dzud only 5% of the cost of the damage has spent for recovery measures or for reduction of harmful consequences of the mentioned disasters. Expenditure of disaster mitigation costs by the year shows that 56% of total cost spent in 2008-2010, while 33% of total cost spent for recovery measures in 2011-2013 years.

*Future projection of drought and dzud.* The assessment of future projection for drought and dzud have been done by estimating index, which represents summer and winter conditions defined by monthly air temperature and precipitation data used in the assessment of future climate change of Mongolia (Gomboluudev P, 2014) by Global Climate Models.

To express summer conditions have been selected Ped Drought Index (PDI) (Ped D.A, 1975) and also winter and dzud condition selected as (WI) and (ZI) (Natsagdorj, 2001) indexes, as respectively. The temporal (a) variation of the mean value of indexes expresses their intensity conditions, while frequency (b) is estimated by the change of a number of occurrences in space within certain climate period.

Figure 4.57 shows temporal variations of various indices PDI, WI and ZI under different scenarios of greenhouse gas (GHG).

The numerical value of the PDI will be increased compared to baseline climate condition of 1986-2005 under all scenarios of GHG (Figure 4.57a). Its value will be increased until 1.08 in 2020, 2.60 in 2050, and 4.61 in 2080 under high emission scenario (RCP8.5) of GHG. In case of moderate emission scenario (RCP4.5), PDI index is expected to increase between 0.98 and 2.28 (Table 4.15). Thus the further intensity of drought is expected to increase constantly compare to present condition (1986-2005) in Mongolia.

As for WI index which expresses winter conditions, there is small change till 2050, but at the level of 2080 under high emission scenario of GHG the value will be 1.30 and under moderate emission scenario will be around 0.59 (Figure 4.57b) (Table 4.15). These relatively small changes of index relate to the increase of winter temperature and winter precipitation. It can be explained by the relatively mild winter and an increase of winter snow. Figure 4.57c shows a temporal change of ZI index. The numerical value of ZI index will be lower than 1.0 until 2020 under all scenarios but will be increased until 1.28-1.81 in 2050 and 1.67-3.31 in 2080 under both high and moderate emission scenario (Table 4.15). It shows also an increase of intensity of dzud as dominantly dependent on summer drought condition.

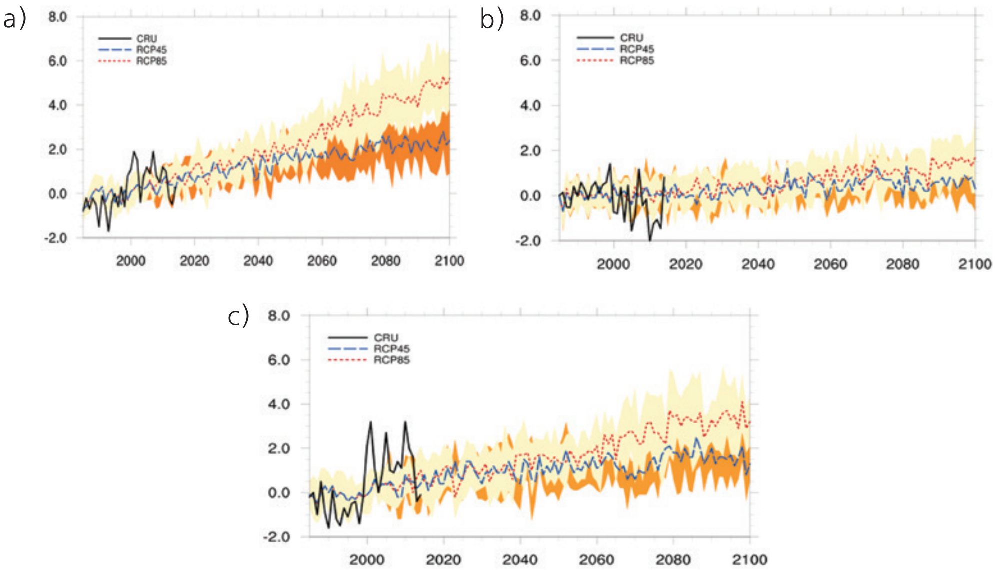



Figure 4.57 Interannual variations of PDI WI and ZI indices compared to climate period, 1986-2005

Table 4.15 Climate extreme events and their representative indices (ensemble mean of a global climate model, compared with climate baseline, 1986-2005)

| № | Change of indices | The RCP4.5 scenario of GHG | | | The RCP8.5 scenario of GHG | | |
|---|---|---|---|---|---|---|---|
| | | 2016-2035 | 2046-2065 | 2081-2100 | 2016-2035 | 2046-2065 | 2081-2100 |
| 1 | Drought-Summering | 0.98 | 1.77 | 2.28 | 1.08 | 2.60 | 4.61 |
| 2 | Winter-harsh winter | 0.14 | 0.62 | 0.59 | 0.27 | 0.98 | 1.30 |
| 3 | Dzud | 0.82 | 1.28 | 1.67 | 0.84 | 1.81 | 3.31 |

A change of drought frequency compare to baseline climate, 1986-2005 is estimated by ensemble mean of models under average GHG emission scenarios is shown in Figure 4.58. Drought frequency is expected to increase by 5-15% under moderate scenarios of GHG (Figure 4.58a) and by 5-15% under high emission scenario (Figure 4.58b).

Relatively intensive increase (15%) is expected to observe in the southern part of the country by 2020 and 2050 under average scenarios of GHG and in the central part of the country by 2080 (Figure 4.58a). In case of high emission scenarios of GHG, about 15% increase is expected to observe in 2020 level in western and eastern parts of the country. Furthermore, increases are expected to observe until 20-25% and 30-45% in 2050 and 2080, respectively (Figure 4.58b).

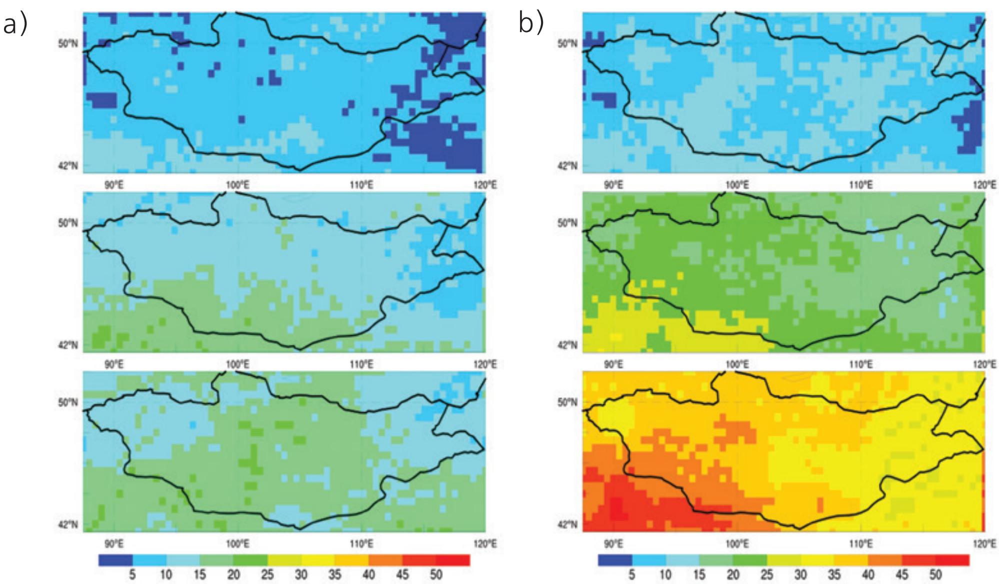



Figure 4.58 Frequency changes of drought index, PDI estimated by ensemble mean of Global climate models in different periods (2020, 2050 and 2080) a) by the RCP4.5 emission scenario b) by the RCP8.5 scenario

The frequency of winter indexes estimated by different GHG emission scenarios is shown in Figure 4.59.

A changing rate is expected to decrease by 5-10% in any case of GHG emission scenarios. Therefore, in most regions of Mongolia a reduction of the index value is expected and only at some points might observe 5% some increase (Figure 4.59a, b). It means that there is some tendency of weakening harsh winter condition under influences of global warming. However, with an expected increase of winter precipitation, harsh winter condition remains same as in the northern and eastern parts of the country. The pattern of spatial distributions of changes is expected to be similar in both cases of GHG scenarios (Figure 4.59a, b).

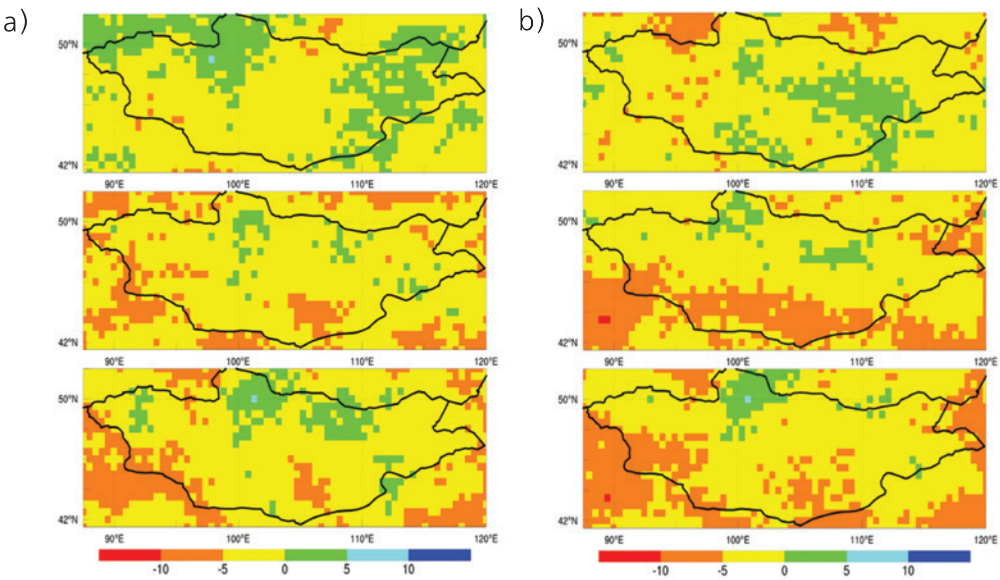



Figure 4.59 Frequency changes of winter index, WI estimated by ensemble mean of Global climate models in different periods (2020, 2050 and 2080) a) by the RCP4.5 emission scenario b) by the RCP8.5 scenario

Figure 4.60 shows the change of frequency of dzud under different GHG emission scenarios. Dzud's frequency is expected to increase by 5-20% under moderate scenario (Figure 4.60a) and in case of high emission scenario; the increase will be around 5-40% (Figure 4.60b).

Relatively intensive increase (15%) is expected to observe in south-east and northern parts of the country at the end of this century or at the level of 2080 under moderate scenarios (Figure 4.60a), while 40-45% increase is expected to observe in the north of Mongolia (Figure 4.60b).

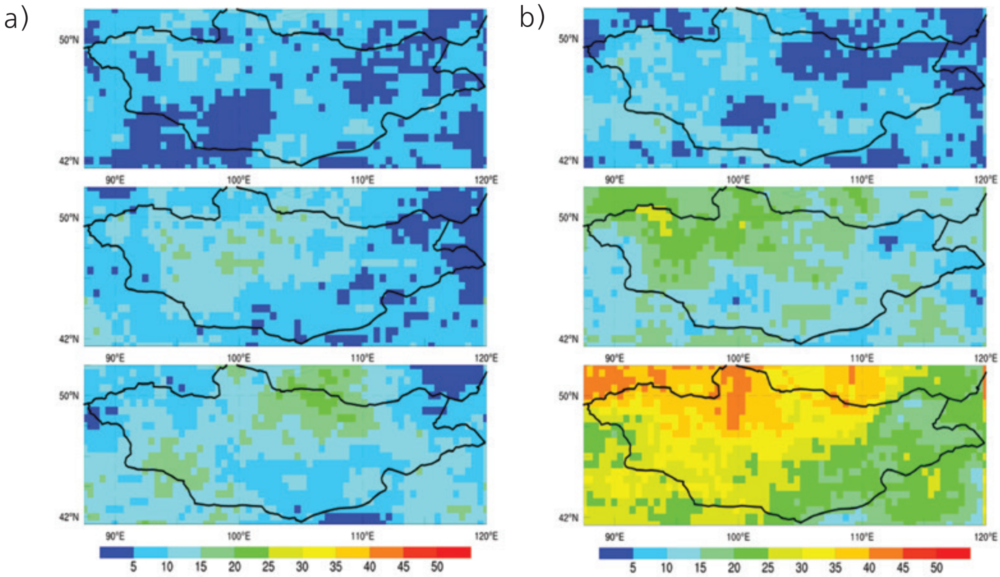



Figure 4.60 Frequency changes of winter index, WI estimated by ensemble mean of Global climate models in different periods (2020, 2050 and 2080) a) by the RCP4.5 emission scenario b) by the RCP8.5 scenario

### 4.2.4. Public health

Climate change-related heat waves, air pollution, flooding, drought, water shortages and pollution and impacts of climate on agriculture are likely to affect the health of our country's population in direct and indirect ways. Due to mentioned impacts of climate change, cardiovascular and respiratory diseases, including asthma, diarrhea, and malnutrition, may spread and transmission of infectious diseases and other infectious diseases may increase among the population, especially among children. Even emerging and re-emerging infectious diseases may potentially increase.

In addition, an increase in the frequency of natural disasters such as floods, heavy rains, severe winter, and storms results in risks of death of citizens, mental stress, loss of shelters and delays of medical care and services.

***The survey results.*** Climate change and health (2009) study attempts to identify long-term trends of some diseases among the population and its relationship to some parameters of weather and climate, and have achieved certain results. In last 34 years of climate warming, respiratory disease is may decrease while cardiovascular has increased (Figure 4.61).

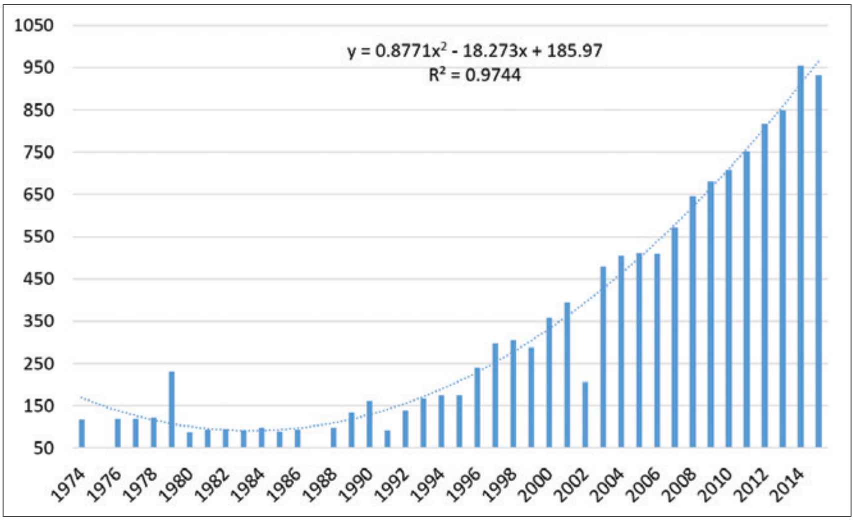



Figure 4.61 Morbidity of cardiovascular diseases among the population in Mongolia

Increasing of cardiovascular diseases is possible to increase the frequency of heat waves. The frequency of heat wave has a direct correlation with the mean air temperature of the summer season (Natsagdorj L, 2008).

There is some evidence of an increase of infection of tick-borne encephalitis caused by forest ticks (Figure 4.62). According to survey and data of the National Center for zoonotic disease, have died 7 people due to above-mentioned infection during 2005-2015.

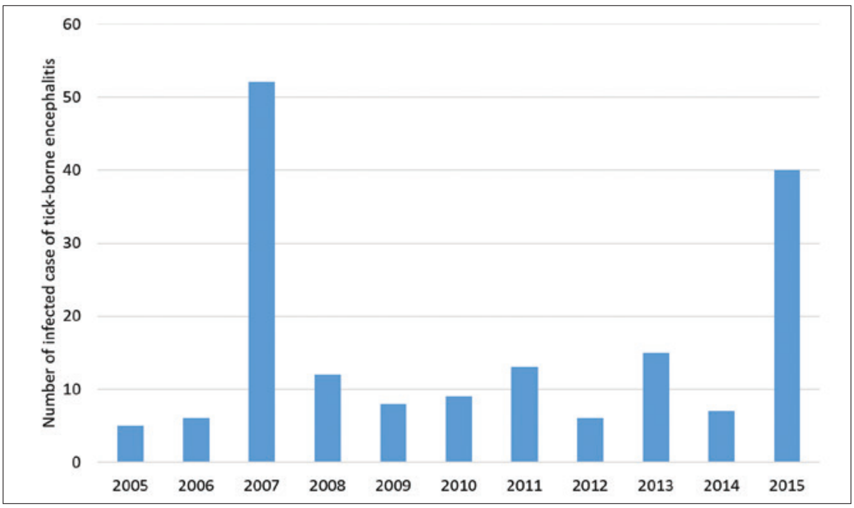



Figure 4.62 Number of tick-borne encephalitis infected cases (by NCZD data, B.Burmaajav and B.Uyanga)

Increasing cases of tick-borne infection had previously not paid attention, but it is likely to be related to climate change to some extent. Figure 4.63 shows, the relationship between a number of occurrences of tick-borne encephalitis and drought index of early summer period (May-July) in the central region of the country where dominant part of the Mongolian forest is located.

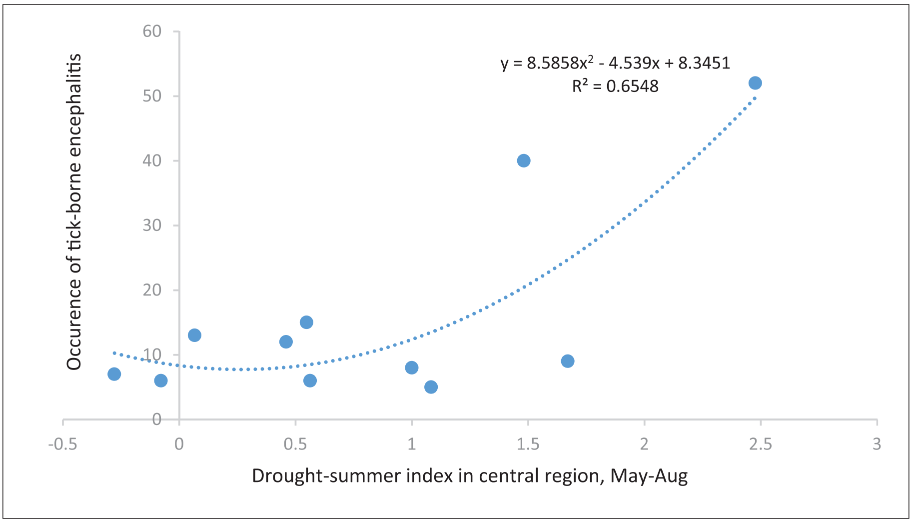



Figure 4.63 Relationship between the frequency of tick-borne encephalitis and drought index (by L. Natsagdorj and B.Burmaajav)

According to this relationship, there is a high probability that the morbidity of tick-borne diseases is caused by forest tick under climate warming. The estimation done by above relationship shows that number of victims of tick-borne encephalitis expected to increase by 80% by mid of this century and even may increase up to two times at the end of the century.

Box 4.1:

The following conclusions are made after comparative studies [13-14] between survey conducted in the Ugalz mountain of Tonkhil soum of the Gobi Altai province in 1987-1990 and results of the project named as "climate change and improvement of control and monitoring on transmitting infectious diseases":

- The vegetation cover of the Ugalz mountain has changed due to climate change compared to 1987-1990 and plants which



Chapter 4

express desert-steppe types shift up by 100 meter along the vertical belts

- Warming has contributed to increase of size of area representing desert-steppe types and create favorable habitation conditions for ground squirrels (S.erythrogenus), yellow rodent (E.luteuse), spreading their distribution area
- Negative changes in the marmot's habitat range cause shrinking of its distribution area and finally reflected d on reduction of number of marmots in combination with hunting impacts
- Survey results conducted in Ugalz mountain of Tonkhil soums in 1987-1989 show that totally 32 species of lice flea, 7 species of ticks and 2 species of flea are registered in the study area
- Mean temperature of the April-September months has negative correlation (r = -0.9) with the marmot population
- It shows that sharply reduced number of ectoparasites due to increasing of air temperature, reducing of humidity and increasing of drought

### 4.3. Integrated vulnerability and risk assessment of climate change

According to vulnerability and risk assessment of the organization named as German watch, which was used to release an assessment of climate risk induced by natural disasters and hazards at global scale since 1990s, Mongolia always is considered as a country with high risk of climate change among the other countries in the world. For example, Mongolia is ranked in 8$^{th}$ position among more than countries by an average of assessment of 1993-2012 (Global Climate Risk Index 2014).This is a relatively high indicator for the country such as Mongolia which is located in the center of the continent without a hurricane, ocean tidal wave (tsunami) and with less seismic hazards. That is why we are saying that Mongolia is particularly vulnerable to climate change in terms of geographic location, fragile ecosystems and people's lifestyles and economic systems.

The first concrete vulnerability and risk assessment to climate change (or exposure)for the environmental and socio-economic sectors of Mongolia have been done in 2012 using multi-criteria analysis method which based on methods of "Risk assessment of climate change" of Environment, Food and Rural Affairs (DEFRA) of the Government of the Kingdom of Great Britain and Northern Ireland.

The quantitative assessment of climate change for the basic natural components of the ecosystem such as water resources, forests, permafrost, wildlife, pasture-soil and natural disasters and key socio-economic sectors such as arable farming, animal husbandry, and human health have been done using results and outputs of the global and regional climate change dynamic models. The quantitative impacts of the mentioned components and sectors appear in different dimensions and units. Therefore, it is certainly needed to integrate results of impacts by the different sectors and carry out vulnerability and risk assessment of climate change.

For this purposes, we determined indices, which are expressed the current and future risks. Parameters of the particular sectors which most closely related to climate change are selected as indicators for the assessment. These indicators are determined at provinces and regional levels and converted into one dimension using normalization method of the UN's human development index (HDI, UNDP, 2006). Finally, the current average value of the normalized indicator is considered a **vulnerability index**, while future mean values are to be considered as **risk index**.



Theoretically, the risk is a function of damage and probability. Therefore, we considered future impact assessment could be shown as risk index. It has been estimated by climate change projection under future GHG emission scenarios with a certain probability. For example, change of future harvest per unit hectare can be considered as damage and it is possible to express in terms money, on the other hand, it is estimated by certain emission scenario (RCP8.5, high) of climate change and therefore contains certain terms of probability.

Present and future indicators of ecosystems, environmental and socio-economic sectors were selected as shown below.

1. Climate
    a. The annual mean air temperature, ˚C
    b. The annual sum of precipitation, mm
    c. Drought frequency, %
    d. Dzud frequency, %
    e. Their future changes
2. Water resource and permafrost
    a. Index of dryness,
    b. Permafrost distribution area, thou.km$^2$

  c. Their future changes
3. Forest resource
   a. Current forest area (larch, cedar, birch, pine), thou. ha
   b. Future changes in forest area, thou. ha
4. Pasture and soil cover
   a. Recovery capacity of pasture, the degree of classification
   b. Organic content of soil (carbon, nitrogen), $g/m^2$
   c. Future changes of the organic content of the soil, $g/m^2$
   d. Above and below ground biomass, $g/m^2$
   e. Future changes of the organic content of the soil and biomass
5. Wildlife
   a. Relic and distribution area
   b. Future changes of areas, thou. ha
6. Agriculture/Arable farming
   a. Wheat yield per unit hectare, kg
   b. Future change of wheat yield per unit hectare, kg
7. Animal husbandry
   a. Livestock heads, in sheep unit
   b. Percentage of livestock loss, %
   c. Dzud frequency, %
   d. Future trend of Dzud frequency, %
8. Public health
   a. Occurrences of hot days, days
   b. Future change of occurrences of hot days, days

Indicators, as shown above, were normalized at province level and vulnerability and risk indexes transferred into one dimension so that each sector can take 0-1 values. We have divided into 5 classes of index values and the maximum value of the index represents a highly vulnerable and high-risk situation as respectively (Table 4.16).

Table 4.16 Threshold values used in the assessment of vulnerability and risk classification

| No | Lower threshold values | Classification Current/Future | Upper threshold values |
|---|---|---|---|
| 1 | 0.81< | Very much vulnerable/risky | <1.00 |
| 2 | 0.61< | Much vulnerable/ risky | <0.80 |
| 3 | 0.41< | Vulnerable/ risky | <0.60 |
| 4 | 0.21< | Less vulnerable/ risky | <0.40 |
| 5 | 0.00< | Not vulnerable/not risky | <0.20 |

In this assessment, quantitative impact assessment results of different sectors in a period of 2046-2065 have been used, which is based on climate change projection downscaled by the regional climate model RegCM4-ECHAM5 and RegCM4-HadGEM2.

Table 4.17-4.18 is shown as an example, the results of estimated risk index and climate vulnerable index. Table 4.17 is presented quantitative values of impact assessment indicators, while Table 4.18 provides normalized their values, and together with vulnerability and risk index in the provinces and regions. For example, according to the classification of a vulnerability index, Bulgan province fall in "not vulnerable" class, Uvs, Zavkhan and Dundgovi provinces belong to "much vulnerable" while other provinces are classified into "vulnerable and less vulnerable " class etc. At the same time, assessment of climate change future impacts and risk assessment shows that 6 provinces to be very risky and others belong to risky class as increasing of vulnerability index in the most of the provinces.

Table 4.17 Climate indicators value at province and regional level

| Region | Aimag | Assessment of vulnerability (Current climate, 1986-2005) | | | | Risk assessment, RegCM4-ECHAM5 ( Future climate, 2046-2065) | | | | Risk assessment, RegCM4-HadGEM2 (Future climate, 2046-2065) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% |
| Western | Bayan ulgii | 1.1 | 135.6 | 15.0 | 17.0 | 3.1 | 162.7 | 30.0 | 27.0 | 4.6 | 149.2 | 30.0 | 27.0 |
| | Uvs | -2.5 | 204.2 | 20.0 | 20.0 | -0.5 | 224.6 | 40.0 | 45.0 | 1.0 | 224.6 | 40.0 | 45.0 |
| | Khovd | 2.0 | 113.9 | 17.0 | 16.0 | 4.0 | 131.0 | 37.0 | 31.0 | 5.3 | 125.3 | 37.0 | 31.0 |
| | Gobi Altai | 2.4 | 129.0 | 18.0 | 20.0 | 4.4 | 148.4 | 43.0 | 30.0 | 5.7 | 141.9 | 43.0 | 30.0 |
| | Zavkhan | -2.0 | 193.2 | 20.0 | 19.0 | 0.0 | 212.5 | 40.0 | 39.0 | 1.3 | 212.5 | 40.0 | 39.0 |
| | Bayank-hongor | -1.8 | 205.3 | 15.0 | 22.0 | 1.2 | 225.8 | 40.0 | 32.0 | 1.5 | 236.1 | 40.0 | 32.0 |
| Central | Khuvsgul | -2.0 | 272.4 | 12.0 | 17.0 | 0.0 | 299.6 | 27.0 | 37.0 | 1.5 | 299.6 | 27.0 | 37.0 |
| | Bulgan | -0.3 | 314.7 | 11.0 | 15.0 | 1.7 | 346.2 | 26.0 | 30.0 | 3.2 | 339.9 | 26.0 | 30.0 |
| | Uvurkhan-gai | 0.4 | 256.3 | 17.0 | 25.0 | 2.4 | 281.9 | 32.0 | 35.0 | 3.7 | 281.9 | 32.0 | 35.0 |
| | Arkhangai | 0.5 | 297.9 | 15.0 | 20.0 | 2.5 | 327.7 | 30.0 | 35.0 | 3.8 | 321.7 | 30.0 | 35.0 |
| | Central | -0.6 | 242.4 | 14.0 | 14.0 | 1.4 | 266.6 | 29.0 | 29.0 | 2.9 | 266.6 | 29.0 | 29.0 |
| | Selenge | -0.6 | 276.0 | 14.0 | 13.0 | 1.4 | 303.6 | 29.0 | 23.0 | 2.9 | 298.1 | 29.0 | 23.0 |
| | Ulaan-baatar | -0.3 | 249.9 | 15.0 | 15.0 | 1.7 | 274.9 | 30.0 | 25.0 | 3.2 | 274.9 | 30.0 | 25.0 |
| Eastern | Sukhbaatar | 1.4 | 248.3 | 14.0 | 18.0 | 3.7 | 273.1 | 26.0 | 28.0 | 4.7 | 273.1 | 26.0 | 28.0 |
| | Dornod | 1.2 | 259.9 | 15.0 | 20.0 | 3.5 | 285.9 | 27.0 | 30.0 | 4.7 | 285.9 | 27.0 | 30.0 |
| | Khentii | 0.1 | 313.7 | 15.0 | 19.0 | 2.4 | 345.1 | 30.0 | 34.0 | 3.4 | 345.1 | 30.0 | 34.0 |
| Gobi | Dundgovi | 2.2 | 148.9 | 23.0 | 25.0 | 4.5 | 163.8 | 38.0 | 40.0 | 5.2 | 163.8 | 38.0 | 40.0 |
| | Dornogovi | 3.2 | 143.2 | 14.0 | 14.0 | 5.5 | 157.5 | 34.0 | 24.0 | 6.2 | 171.8 | 34.0 | 24.0 |
| | Umnugovi | 5.3 | 115.9 | 14.0 | 16.0 | 7.6 | 133.3 | 34.0 | 31.0 | 8.3 | 144.9 | 34.0 | 31.0 |

Table 4.18 Estimation of vulnerability and risk index based on normalized climate indicators at aimag and regional-level

| Region | Aimag | Assessment of vulnerability (Current climate, 1986-2005) | | | | Risk assessment, RegCM4/ECHAM5 ( Future climate, 2046-2065) | | | | Risk assessment, RegCM4/HadGEM2 (Future climate, 2046-2065) | | | | Current | Future | Trends |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% | Annual mean air temperature, °C | Annual sum of precipitation, mm | Drought frequency, % | Dzud frequency,% | Vulnerability index | Risk index | |
| Western | Bayan ulgii | 0.5 | 0.9 | 0.3 | 0.3 | 0.4 | 0.8 | 0.6 | 0.4 | 0.3 | 0.8 | 0.6 | 0.4 | 0.5 | 0.6 | ↑ |
| | Uvs | 1.0 | 0.6 | 0.8 | 0.6 | 0.8 | 0.5 | 0.9 | 1.0 | 0.7 | 0.5 | 0.9 | 1.0 | 0.7 | 0.8 | ↑ |
| | Khovd | 0.4 | 1.0 | 0.5 | 0.3 | 0.4 | 0.9 | 0.8 | 0.6 | 0.3 | 1.0 | 0.8 | 0.6 | 0.5 | 0.7 | ↑ |
| | Gobi Altai | 0.4 | 0.9 | 0.6 | 0.6 | 0.3 | 0.9 | 1.0 | 0.5 | 0.2 | 0.9 | 1.0 | 0.5 | 0.6 | 0.7 | ↑ |
| | Zavkhan | 0.9 | 0.6 | 0.8 | 0.5 | 0.8 | 0.6 | 0.9 | 0.8 | 0.7 | 0.6 | 0.9 | 0.8 | 0.7 | 0.7 | ↑ |
| | Bayankhon-gor | 0.9 | 0.5 | 0.3 | 0.8 | 0.6 | 0.5 | 0.9 | 0.6 | 0.6 | 0.5 | 0.9 | 0.6 | 0.6 | 0.7 | ↑ |
| Central | Khuvsgul | 0.9 | 0.2 | 0.1 | 0.3 | 0.8 | 0.2 | 0.5 | 0.8 | 0.6 | 0.2 | 0.5 | 0.8 | 0.4 | 0.5 | ↑ |
| | Bulgan | 0.7 | 0.0 | 0.0 | 0.2 | 0.6 | 0.0 | 0.5 | 0.5 | 0.5 | 0.0 | 0.5 | 0.5 | 0.2 | 0.4 | ↑ |
| | Uvurkhangai | 0.6 | 0.3 | 0.5 | 1.0 | 0.5 | 0.3 | 0.7 | 0.7 | 0.4 | 0.3 | 0.7 | 0.7 | 0.6 | 0.5 | ↓ |
| | Arkhangai | 0.6 | 0.1 | 0.3 | 0.6 | 0.5 | 0.1 | 0.6 | 0.7 | 0.4 | 0.1 | 0.6 | 0.7 | 0.4 | 0.5 | ↑ |
| | Central | 0.8 | 0.4 | 0.3 | 0.1 | 0.6 | 0.3 | 0.6 | 0.5 | 0.5 | 0.3 | 0.6 | 0.5 | 0.4 | 0.5 | ↑ |
| | Selenge | 0.8 | 0.2 | 0.3 | 0.0 | 0.6 | 0.2 | 0.6 | 0.3 | 0.5 | 0.2 | 0.6 | 0.3 | 0.3 | 0.4 | ↑ |
| | Ulaanbaatar | 0.7 | 0.3 | 0.3 | 0.2 | 0.6 | 0.3 | 0.6 | 0.4 | 0.5 | 0.3 | 0.6 | 0.4 | 0.4 | 0.5 | ↑ |
| Eastern | Sukhbaatar | 0.5 | 0.3 | 0.3 | 0.4 | 0.4 | 0.3 | 0.5 | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 | 0.4 | = |
| | Dornod | 0.5 | 0.3 | 0.3 | 0.6 | 0.4 | 0.3 | 0.5 | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 | 0.4 | = |
| | Khentii | 0.7 | 0.0 | 0.3 | 0.5 | 0.5 | 0.0 | 0.6 | 0.7 | 0.5 | 0.0 | 0.6 | 0.7 | 0.4 | 0.4 | = |
| Gobi | Dundgovi | 0.4 | 0.8 | 1.0 | 1.0 | 0.3 | 0.8 | 0.8 | 0.8 | 0.3 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | ↓ |
| | Dornogovi | 0.3 | 0.9 | 0.3 | 0.1 | 0.2 | 0.8 | 0.7 | 0.3 | 0.2 | 0.7 | 0.7 | 0.3 | 0.4 | 0.5 | ↑ |
| | Umnugovi | 0.0 | 1.0 | 0.3 | 0.3 | 0.0 | 0.9 | 0.7 | 0.6 | 0.0 | 0.9 | 0.7 | 0.6 | 0.4 | 0.5 | ↑ |

The assessment for above-mentioned sectors have done at the aimag level and the regional index is taken as mean of provinces in each region. Finally, index of whole Mongolia is calculated by averaging all provinces' index.

Figure 4.64 is shown the current vulnerable and risk indexes for all environmental and socio-economic sectors in Mongolia. In general, in the current situation of sectors belongs to the "vulnerable" classes and it is expected to become "much risky" class during the 2046-2065 period.

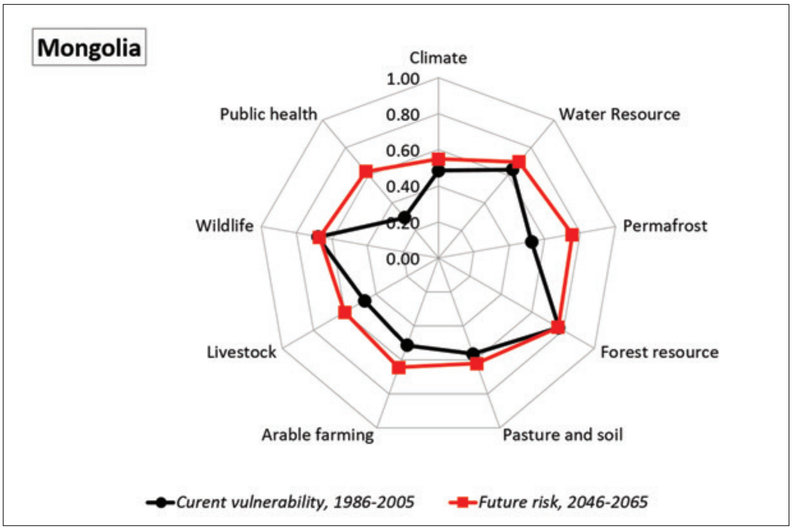
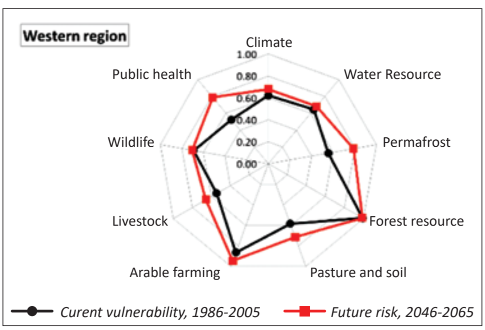
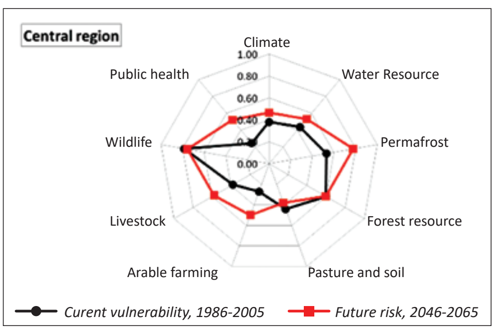



Figure 4.64 Climate change vulnerability and risk index for environmental and socio-economic sectors in Mongolia

Concerning situation at the regional level, depending on their specific condition it is to be different from regions to regions. For example, western regions to be "much vulnerable" to climate change while other regions are classified as "vulnerable" (Figure 4.65). The value of vulnerability index is to be relatively small in the Central region. However, index of the sectors is to be different within the regions. For example, the value of the index of agriculture, forestry sectors is high in the western region (Figure 4.65a) while the index of water resources and pasture sectors is expected to be high in the Gobi Desert region (Figure 4.65d). According to climate change projection, the vulnerability and risk index will be increased in all regions of Mongolia.



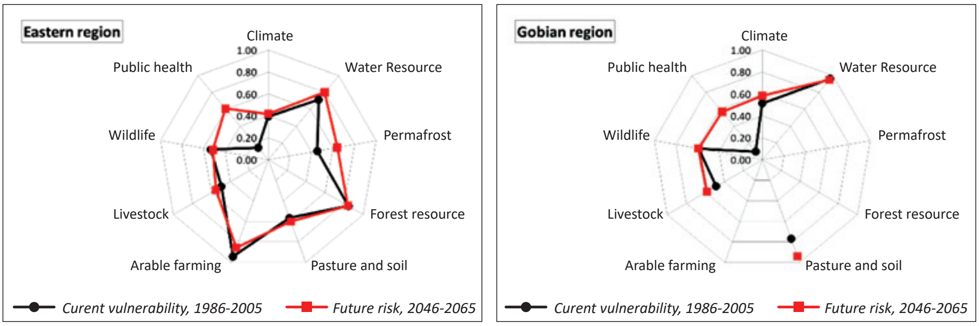



Figure 4.65 Climate change vulnerability and risk index for environmental and socio-economic sectors in the different region of Mongolia. a) Western b) Central c) Eastern and d) The Gobi

This analysis allows converting impacts assessment in the different sectors into one dimension and gives the opportunity to compare them each other. Thus, finally, we made adaptation assessment based on developed measures for reducing climate change vulnerability and risk particular sectors (environmental, social and economic) in the aimags and regions.

Climate change vulnerability and risk index is averaged by the territory of aimags and shown in Figure 4.66. Assessment results show that climate change risks will be increased in all aimags and their spatial distribution is presented in Figure 4.67.

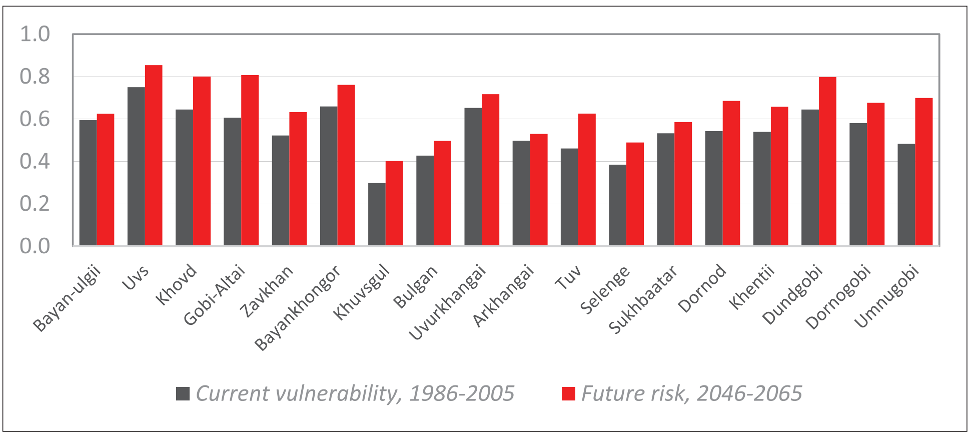



Figure 4.66 Climate change vulnerability and risk index in aimags, Mongolia

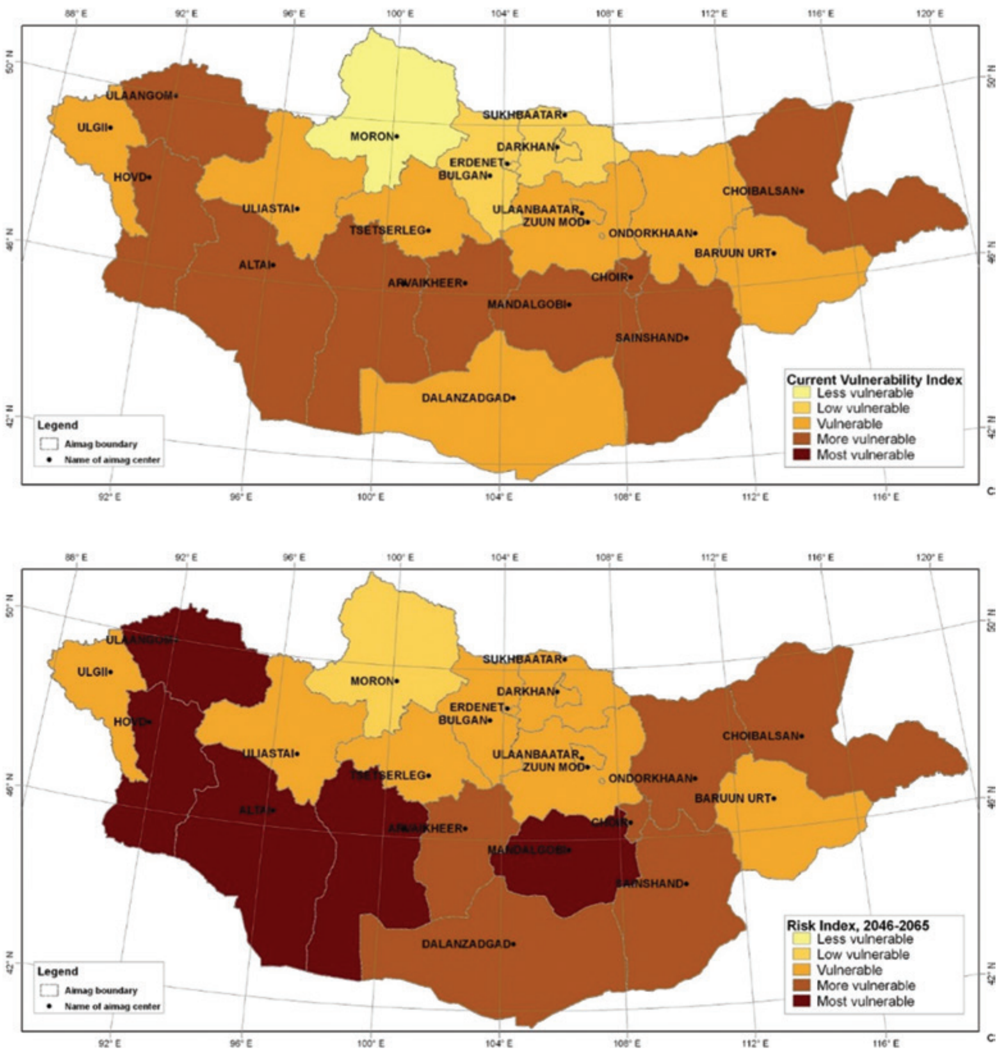



Figure 4.67 Spatial distributions of climate change vulnerability and risk index

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# Chapter 5

## CLIMATE CHANGE ADAPTATION POLICY AND STRATEGY

## 5. Climate change adaptation policy and strategy

*Needs to adapt climate change.* The future development of Mongolia faces numerous challenges and risks and the climate change has become one of the main risks. For the country in which lifestyle and enterprise of herders and farmers have much dependent on fragile ecosystems and natural climatic conditions, climate change is expected to have a strong influence not only the environment but also social and economic development. According to statistics, there are more than 1000 policy and strategic documents, projects, and programmes approved by legislative body and government. 177 national projects and programmes are implementing at the government level and 60 of them have social and economic development orientation.

Adaptation policies to climate change in certain degree has been reflected in legislative, policy and strategic documents such as National Action Program on Climate Change (NAPCC), Mongolian National Security Concept, 2010, Mongolia's Sustainable Development Vision 2030 adopted by parliament in 2016, Green development policies of Mongolia adopted by parliament in 2014 and its action plan for 2016 implementation.

For the first time, NAPCC has been developed in 2000 and later updated in 2011. Issues related to strategies, policies, and measures of adaptation to climate change are introduced in more general terms and quite broadly in the NAPCC.

The consequences of climate change reveal in the form change of flow regime and water resources, drying up lakes and ponds in regions without permafrost, dropping of groundwater levels, summer extreme heat, intensifying desertification due to drought, soil and pasture degradation, reduction of plant species, change of distribution area of wild animals and increase of frequency of wildfire and ultimately, degradation of the whole environment in our country. Although today we have not felt significantly the impacts of climate change in our lives, glaciers in the high mountains and permafrost which occupy about 60 percent of the country's territory already have melted to some extent from the top. So far, these changes have some positive effect on water resources of the region and some high-mountain ecosystems, in a few decades later, it is anticipated to bring unimaginable negative consequences in the region. One of the key main reasons of the increase of livestock losses, deterioration of country's economy and livelihood of rural people which account for nearly forty percent of the country's population and consequently an increase of poverty is an increase of frequency and intensity of natural disasters, especially droughts and dzuds caused by climate change.

Since 1990s several science based assessments have been done on how in near future or in XXI century, the climate of Mongolia will change on the of the background of global climate change and how these changes will impact the environmental and socio-economic condition of our country and updating of these impact assessments is continued up to now. This situation allows formulating long-term policy on adaptation to climate change.

The population of Mongolia has reached 3.1 million by end of 2016 and according to demographic forecast it is expected to reach 3.5 million in 2030 and by 2040 and 2050, the population of Mongolia will be 3.82 million and 4.1 million, respectively. About 63% of the population lives in urban areas. During the last twenty years, this indicator increased by 10 points. As the population increases, tension on healthy and safe food issues is also becoming critical. Currently, compared to rural people, urban people consume 1.5 times less meat and 3.9 times less milk and on the other hand, rural people consume potatoes and vegetables 2 times less than urban people and 9.5 times fewer eggs. Main indicators of nutritional quality of food such as baby's immature birth weight, delay of growth of children up to 5 years old, malnutrition, rickets, and anemia have not declined consistently in the country.



## 5.1. Potential alternative adaptation in particular sector

In order to achieve sustainable development of the country, it is urgently needed to mitigate climate change and carry out policies and measures of adaptation, which will be continued independently from us. Combating climate change requires a huge cost and significant time and enormous process that may even claim a change of traditional living style.

Most of the studies have shown that damage and costs associated with delay of measures to be taken against climate change will be much high. One of the lacks of state policy on climate change adaption is that so far, we have not yet properly estimated what kind of positive and negative impacts of climate change will be there and how these impacts will affect the country's socio-economy and environment with some economic calculation.

Therefore, we need to think very seriously and to make very careful and fundamental decision. Our present generation should not have any right to make irresponsible and rash resolution on behalf of future generations on these issues.

The conceptual basis of climate change adaptation can be defined as mitigation of risk to the vulnerable socio-economic sectors and compound environmentally friendly adapted basis for green development.

Following adaptation strategies are identified for particularly vulnerable sectors to the climate change for 2030.

### 5.1.1 Animal husbandry

***Strategical goal:*** Expanding the production of ecologically clean products and provide sustainable food security of citizenship and supply of raw materials for light and food industries through creating livestock sector with a capacity of overcoming risks and adaptive capacity to climate change.

*Strategic Objective 1.* To improve the production structure of the livestock and to raise productivity, quality, and efficiency:

To ensure this objective, following actions and measures are recommended to take:

- to establish and develop a legal and economic environment for the development of herders' group, cooperative and partnership based on herders' economic interest,
- to establish a legal framework and implement economic incentives from government to herders who are engaged in production in accordance with the effects of climate change,
- to improve the animal value of the region to establish selection farms and enterprises for breeding and resale of extensive productive animals at soum and aimag levels based on state and private sectors
- to create and implement government incentives and subsidies aimed at supporting of breeding of animals which suite to pasture capacity through the government policy,
- to compound appropriate ratio between animal types and herd structure by keeping the weight of herd dams at the certain scientifically based level,
- to develop intensive livestock farming with high productivity near urban and village areas where concentrate settlements of the population and to support their measures on strengthening their capacity-building through concessional loan and stimulus policies of the government to improve capacity building and increase investment of central and local professional organizations aimed at reduction of risk of climate change-induced animal diseases.

*Strategic Objective 2.* To reduce the vulnerability of pasture to climate change and to increase adaptation capacity:

- to make clear margins and boundaries of regions where to engage pastoral and intensive livestock farming,
- to produce and implement standards and integrated regulation on the use of certain percentage of the tax and compensation from mining for rehabilitation purposes of pasture damaged by mining and related road, infrastructure activities,.
- to provide ecosystem balance by ensuring the right to use, revitalization and protection of pasture land,
- to improve use and reduction of pressure on livestock summering area by ensuring conditions for biological and construction investment to pasture from herders,
- to establish "Fund for pasture risk" by creating payment systems for pasture use and spend it for the improvement of pasture watering, preparation of supplements resource of forage and ecological education of herders,
- to teach herders, local officials and administrative management staff about traditional and modern advanced methods and technologies of pasture management and to raise up their ecological education,
- to introduce into pasture utilization practice, pasture rotation and pasture relieve technologies during the warm season and to provide assessment and control on the realization of methods and technologies of the rotated and freed areas and pasture,
- to expand measures on improvement of hayfields and degraded pasture and conduct experimental studies in the improvement of pasture in main natural zones and regions,
- to carry out experiments on selection and sort of summering and wintering crops such as wheat, rye, and barley in some natural zones and regions and to produce planted pasture which provides a harvest in early spring and late autumn,
- to introduce and develop agrotechnic suitable for own condition by conducting experiments and testing on some sort of some perennial crops of sown (planted) forage with high yields and also wheat, peas, barley, sunflowers, corn, and soybeans etc.,
- to introduce technology for silage production and install gear for the feeding of milking cows by green silage,
- to respond to forage shortages for animals, fencing grasses in steppe, forest-steppe-meadow, and semi-desert regions is needed for reservation of forages,

- to ensure sustainability of pasture ecosystem by introduce environmentally friendly methods and technologies and to prevent the spread of harmful rodents and insect to pasture such as Brandt mice cicadas (grasshopper), to balance numbers and species of them,
- to explore and introduce best practices and advanced technology from other countries for protection and use of pasture land,
- to establish operational information network of pasture and "Information center on pasture and regional database" based on Geographic Information Systems,
- to establish schema on the protection of livestock against the risk of forage shortage, to develop management plans for pasture use by evaluating pasture condition of each soums and aimags based on the satellite data and ground measurement,
- to recover and maintain pasture condition by conducting by reducing the concentration of animals by constructing engineering designed wells in remote and unused areas, pastures due to lack of watering,
- to construct accumulation ponds of snow and rainwaters, protect runoff formation zone or upstream of rivers and to develop herders' initiatives to set dug wells and to support these activities with local and international projects,
- to promote herder's initiatives on reducing carbon from traditional livestock and to develop an integrated approach for estimation and realize it in the international market.

*Strategic Objective 3.* Improving animal feed supply during the winter and spring seasons by producing energetic forage consistent with the productivity of pastoral and intensified livestock farming:

- to increase the productivity per unit area of hay fields located in the mountain-steppe, floodplains meadows and steppe areas where moisture supply is high by fertilizing with organic and mineral fertilizers,
- to introduce substitute experiences and maintaining the stability of productivity, introducing of hayfields,
- to increase hay yield along the river, stream's floodplain by irrigating by snow melting water during spring flooding period,
- to increase hay yield and save the soil moisture by accumulating and fencing (blocking) snow cover,
- to develop agrotechnic for perennial forage crops with high harvest such as sunflowers, corn and some beans (plating fort silage) and to

introduce developed agrotechnic into practice,

- to carry out production experiment on the development of recipes and norms of granulated, mixed fodder production, strong and full of nutrient feed etc.,
- by installing small sized forage production units based on the local raw forage materials and to produce mixed and mineral nutrition forages in local scale,
- to develop a recipe for alternative products of forage and milk from plants and animal-born products and produce the forages,
- to plant green fodder from imported seeds and carry out selection and breeding experiment on sorts with high yields suitable for green fodder under Bogar and irrigation,
- to cultivate forage sown under irrigation and bring forage production close to the customer in Govi region,
- breeding of local and adapted sorts of forage crops,
- to establish rationally combined system (model) of livestock and crop production in regions with high possibility of forage production and also close to the markets.



*Strategic Objective 4.* Build the capacity to overcome livestock risk:

- to improve insurance systems for livestock and to create reinsurance system,
- to improve the quality and preservation condition of reserve fodder for livestock during the natural disaster situations at soum and aimag levels by optimally defining the amount and location of feedstock,
- to design warm shelters and fences for livestock and introduce best construction technologies suitable for the local condition in terms local raw materials and specifics and to develop projects scientific and technological projects in this field,
- Establish early warning system against drought and harsh winter (dzud).

### 5.1.2. Arable farming

***Strategical Goal:*** Ensuring domestic needs in farm-based food and animal feed through mitigation of risks related to potential negative impacts and full beneficial use of the positive impacts of climate change.

*Strategic Objective 1.* The increase of soil moisture snow by accumulating snow in the in the field:

- to carry out research studies on snow accumulation and retention of melted snow water in the soil (by different technologies such as recess, profiles and compacting snow to delay quick melting etc.) within Science-Technological projects in core agricultural areas and to import necessary technics and equipment to agricultural research centers as Khalkhgol, Darkhan and Uvs institutions,
- plantation of certain plants and forest strips for protecting of snow accumulation against soil windblown.

*Strategic Objective 2.* Cultivation of-of medium and late maturing plantation (sown) and sorts with high yields crops:

- breeding and testing of medium and late maturing wheat, potatoes, and vegetables.

*Strategic Objective 3.* Appropriate use of reserve of cultivation areas with the possibility of irrigation in the irrigated arable farming:

- to summarize size and location of areas that are possible to use in irrigated arable farming and develop a plan for utilization and inform to public,
- to develop feasibility studies of irrigation systems for the areas exceeding 500 hectares by the state budget and for an area with a size of 200-500 hectares by provincial budget.

*Strategic Objective 4.* Protection and sustainable use of water resources from glaciers:

- to conduct research studies on rivers and streams originating from glaciers that can be used for agricultural purposes.

*Strategic Objective 5.* Use of methods and technologies with lowest used water resource and labor allocation in the irrigated agriculture:

- to important supply to the farmers with drip irrigation device for irrigation of fruit trees, perennial bushes, potato and crop,
- to reduce water loss by the lining of irrigation channels (by a plastic film, cement, and stone),
- to support domestic production and import of black and translucent plastic films,
- to alternate irrigated lands by food plants such as soybeans, peas, beans and forage type plants such as Lucerne, sweet clover etc..

*Strategic Objective 6.* Introducing of methods and technologies on reduction of soil evaporation and increasing of soil moisture accumulation in un-irrigated areas:

- to introduce the technology on the reduction of mechanic cultivation of soils (to reduce the number of mechanic cultivation of soils and reduce the cultivation depth),
- to introduce the technology on discarding (give up) of mechanic cultivation of soils (using Raundapherbicide),
- to reduce evaporation of soil moisture by sheltering (sheeting) grain fields by straw mulch.

*Strategic Objective 7.* Selection and plantation of drought-resistant crop sort:

- to adapt (acclimate) and select drought and heat-resistant sorts of summering wheat.

### 5.1.3. Water resources

***Strategic goal:*** Reducing risks of water resources caused by climate change, protection of water quality and water resources, ensuring sustainable water supply to the population, industry and agriculture and prevention of flood hazards.

*Strategic Objective 1.* Improve the soil moisture by accumulating snow during the winter season and use of accumulated water for forestry and pasture watering and irrigation of arable land:

- to carry out research study and survey on snow accumulation in the forest, pasture, cultivated land and along the ravines to increase soil moisture and establish "Scientific-Production" Partnerships in the Orkhon, Tuul, Baruunturuun, Khovd, Khalkh river basins for introducing the research outputs into practice,
- to conduct research experiments on the accumulation of spring flood water in the side ponds and reservoir and increasing of recharge of groundwater from reservoirs seepage reservoirs and use the collected accumulated water for irrigation, pasture watering, industry and urban landscape settlements.

*Strategic Objective 2.* Conducting measures which support natural regulating capacity of river flow through the increase of forest resource using improvement of ecosystem productivity in the taiga, high mountains, mountain steppe regions in terms of increase of moisture and thermal conditions:

- 70 percent of the water resources of Mongolia form in the mountain ranges of Mongolian Altai, Khangai, Khentii, Khuvsgul and Khyangan Mountain which occupies 30 percent of Mongolian territory. Therefore it is necessary to take measures for the protection of these areas and include a special network of protected areas,

- to establish long-term monitoring stations on forest climate, hydrology, and ecosystems.

*Strategic Objective 3.* Supporting immunity of aquatic ecosystems through the development of breeding enterprises of native fish, useful aquatic plant, animals in accordance with environmental changes such as water temperature increase due to climate change in the rivers and lakes along the natural belts and zones:

- to develop breeding enterprises and farms of native fish, useful aquatic plant, animals in accordance with environmental changes such as water temperature increase due to climate change in the rivers and lakes along the natural belts and zones,
- to implement climate change adaptation projects which support immune system of aquatic ecosystems in vulnerable river basin such as rivers originated from the southern slope of Altai and Khangai mountains, upstream of Tuul and Orkhon rivers and Kherlen river basins and improve ecosystem of lakes located in floodplains and wetlands by constructing channels, facilities for water delivery to the lakes.

*Strategic Objective 4.* Establish capacity and early warning system against water shortage, flood hazards and ecosystem degradation and ensuring sustainable use of water resources:

- to introduce modern technics, technology and advanced system monitoring-modeling-warning scheme which include satellite data and information, monitoring network of hydrometeorology and environment and modeling, provide conditions for stable operation and effective use of the system in socio-economic and environmental protection sectors,
- to estimate environmental flow or river flow to sustain ecosystems of the rivers and determine available water resource for use in each river basins and groundwater aquifers based on the defined environmental flow rate,
- to introduce water saving and reuse modern technics and technologies and to control and monitor water usage,
- to reduce significantly water leakage and losses and to reduce water use.

*Strategic Objective 5.* Create the accumulation of water resources and increase lakes and groundwater resources:

- to carry out research studies on the possible use of water resources of high mountains and glaciers for power production, pasture watering, irrigation of arable land and water resource accumulation,
- to carry out research studies on water cycle and balance of groundwater and wetlands and their impact on evaporation.

*Strategic Objective 6.* Introducing of methods and technologies on climate change adaptation, rational use of water, increasing water use efficiency and ensuring of accessibility and provide sustainable consumption of water resources:

- to conduct optimization studies in the area of small-sized water accumulation ponds and reservoirs in order to reduce evaporation losses in different geographical belts and zones and use of reservoirs and water delivery systems and an increase of water resource of wetlands,
- to introduce drip irrigation technologies in arable farming and to reduce water loss by the lining of irrigation channels by plastic film and cement,
- to develop hydropower utilization practice and creation of reservoirs with long-term flow regulation options.

*Strategic objectives 7.* Including and updating issues related to the reduction of negative impacts of climate change to the water resources, application of positive impacts and support of immune system of ecosystems in the planning and implementation of Integrated Water Resource Management (IWRM) principles:

- to implement strategies, programmes and plans of Integrated Water Resource Management (IWRM) principles in 29 rivers basins of Mongolia,
- to implement and include actions and measures in supporting the immune system of ecosystems and climate change adaptation in the planning and implementation of Integrated Water Resource Management (IWRM) principles,
- to introduce payment system on ecosystem benefits in animal husbandry, arable farming, and some economic sectors.

*Strategic Objective 8.* Increase of density of surface and groundwater monitoring network and create a capacity building for operational service to ensure government, public with data, information based on capacity building to ensure efficient modern numerical models, technics, and technologies:

- to expand surface and groundwater water and soil moisture monitoring network and improve capacity building and introduce modern automatic observation equipment, instruments and tools in hydrometeorology and environment monitoring network,
- to establish modern and complex hydrological system with satellite data and information, radar network of precipitation, GIS application, a database of water-energy cycles and numerical simulation models and to provide operation information service.

### 5.1.4. Forest resources

*Strategic goal:* Build and strengthen the capacity of the forest sector to adapt to climate change by reducing the negative consequences of climate change and most effectively using the positive climate change impacts

*Strategic Objective 1.* Evaluate impacts of climate change on forest sector, vulnerability and adaptation possibilities forest ecosystem based on scientific research studies:

- to conduct research studies on negative and positive impacts of climate change on forest sector and Evaluate vulnerability of forest ecosystem and adaptation possibilities,
- to introduce advanced technologies in forest inventory with use of high-resolution satellite images and smooth (systematic) circle fields for sampling,
- to compose and implement forest management plan which includes adaptation measures, indicators of the diversity of species and conduct forest inventory,
- to determine capacity and possibilities of plants and soil to absorb carbon and develop and use improved remote sensing technologies for the creation of a map of forest area changes.

*Strategic Objective 2.* Carry out reforestation and forest breeding by tree seeds, plantation, and seedlings of genetic quality trees with high adaptive capacity under climate warming and dry conditions and recovery of afforested areas through natural regeneration capability of forest and increase forest-covered area:

- to select and regenerate trees, shrubs adapted to the harsh and dry climate of Mongolia,
- to improve the genetic quality of various trees species genetic in order to increase biomass productivity and absorption of greenhouse gases,

- to select elective forest and establish seed collecting group and build plantation from the selective tree and seedlings obtained by cloning micro breeding methods,
- to introduce advanced techniques and technologies of breeding of seedlings with high adaptability and growth capabilities and resistance to climate change, drought, unfavorable conditions,
- to expand measures on reforestation, forest plantation, protective forest strips and green groves and to increase the capacity of measures up to 15,000 hectares per year.

*Strategic Objective 3.* Protect forest ecosystems, forest biodiversity and forest resources against negative human impacts, forest fires, disease and harmful insects and reduce the intensity of forest depletion:

- to protect forest reserve by contracted ownership to forest communities, enterprises, and organizations,
- to organize the wide media awareness on prevention, damage, and consequences of wildfire, to create ground and dust and deciduous forest strip against fire and to take measures to set roads, forest boundaries and prevent the spread of fire,
- to increase public participation in forest fire prevention and fighting off with fire, to organize seasonal reward patrols in forest area and also to organize volunteer group for operational detection and extinction of fires and finally, to provide financial incentives for firefighters,
- to establish firefighting units in the extremely dangerous areas and provide finance from the state budget, to strengthen capacity building of fire-fighting work by providing firefighting aircraft, machinery, equipment, and substances,
- to take measure to combat harmful insects before propagation and growth of numbers and species by conducting constant monitoring
- to create a legal framework to implement measures to combat illegal exploitation of forest resource by the various forest units at different levels and improve technical machinery support and funding,
- to create incentive and bonus system for active participation of citizen, forest partnerships and different organizations in fighting against illegal logging.

*Strategic Objective 4.* Create forests adapted to climate change, increase the productivity by coordinating forest structure and density based on sustainable forest management including permanent maintenance for cultivated and natural trees:

- to develop guidelines, cutting technologies by establishing basic parameters of cutting and maintenance (tree selection methods, time selection, cutting intensity and frequency etc.) by each dominant tree species based on experiment and survey,
- to carry out care cutting in accordance with peculiarities of the region in order to improve forest growth and productivity and compose healthy forest environment.

*Strategic Objective 5.* Improve management of wood products and wood raw material utilization rate and sustainable use of forest resource through environmentally friendly and ecologically balanced technologies under specific local and Mongolian features conditions:

- to take measures to develop scientific bases and practical recommendation on sustainable forest management of Mongolia and to introduce the sustainable use of forest resource through environmentally friendly and ecologically balanced technologies,
- to develop and promote the production of biofuels and smokeless briquette production, use of solar and wind power to reduce the amount of wood used for fuel in nationwide scale,
- to adopt technologies of production of bioenergy by using forest products to replace fossil fuels,
- to increase wood utilization level-up to 80% from 1 $m^3$ of forest logging, to introduce modern wood processing technology such as deep processing, waste wood processing.

### 5.1.5. Public health

***Strategic Goal:*** Improve and strengthen the health systems capabilities in accordance with the protection of human health against adverse impacts of climate change and adaptation to climate change

*Strategic Objective 1.* To create awareness among the population about the impact and consequences of climate change and develop healthy habits and attitudes:

- to develop and implement training and awareness programmes on serious adverse impacts of climate change to human health and on information, knowledge, tools, techniques, technology to adapt to climate change,
- to elaborate manual, a handbook on "Management of protection of human health against climate change" manual processing,

- to develop guidelines for human reproductive and risky group of population (children and elderly) to prevent expected changes caused by climate change and environmental pollution,
- to celebrate the nationwide particular day in each year on "Adaptation and impact of climate change on human health".

*Strategic Objective 2.* Research support on impacts, adaptation and overcome the consequences of climate change to human health and provide evidence of impacts:

- to conduct survey and evaluation of knowledge and understanding and change of attitudes of climate change on human health among the population,
- to maintain websites and create databases on studies of impacts of climate change on human health and free exchange of available information on human health research related to climate change effect,
- to improve capabilities of technical equipment of scientific research researchers and workers and health science institutions,
- to involve doctors and researchers of medical and health sectors in the long term and organize international and local training in the field of development of research methodologies and policy development,
- to develop methodology and carry out training on the health risk caused by poverty due to climate change.

*Strategic Objective 3.* Strengthen the capacity of response measures and early warning of hazards and risks to human health caused by climate change:

- to develop policy on health care and service during migration, movement due to environmental degradation and climate,
- to create the conditions required for the national and local units to respond emergency situations (machinery, equipment, infrastructure, budget, and heating and cooling facilities),
- to organize the consultation meeting on the strengthening of capacity building of health system on climate change adaptation at management level every 2 years,
- to develop and implement regulations on strengthening the capacity of response measures and early warning of hazards and risks to human health by caused climate change,
- to organize regional workshops among the doctors, hospital managers on the protection of negative impact of climate change on human

health and adaptation,

- to carry out training and develop guidelines, manual on prevention, diagnosis, treatment and new kinds of sickness and disease associated with climate warming,
- to organize distant and video training on the protection of negative impact of climate change on human health and adaptation among medical personnel,
- to organize meetings on focusing on international projects and programmes to strengthen management systems of national public health care during the disaster,
- to expand database and registration system of the health sector, improve the capacity (improve capacity building of human resources, training equipment, and facilities).

*Strategic Objective 4.* Mitigation of climate change conditions and increase involvement of local community and inter-sectoral cooperation in adaptation issues:

- to organize joint training and demonstration to strengthen national capabilities among relevant organizations in every year,
- to develop recommendations and conduct a risk assessment of health organizations and enterprise to overcome the effect of climate and weather-related disasters,
- to establish a reference laboratory to monitor environmental factors (water, food, air, soil) that affect human health due to climate change,
- to promote "Green Hospital" movement at all levels of healthcare organizations in order to reduce greenhouse gas emissions and air pollution and dust.

## 5.2. Building up resilience against climate change (Concept and goal to achieve sustainable development as considering climate change adaptation)

Scientific research results show that climate change will continue to intensify in future (IPCC, 2013). Climate change intensity in Mongolia will be much high compared to the world average of climate change due to geographic location and topography features of the country and likely to continue to keep this trend in near future. The environment and socio-economy of Mongolia are extremely vulnerable to climate change. Mongolia is one of few countries of the world, which preserves historical traditions of nomadic culture and civilization with relatively wild nature. Therefore, it is essential to consider climate change-related already revealed environmental and social-economic trends, mitigation of possible negative consequences of the future changes and effective use of positive impacts of climate change in the mid and long-term planning of sustainable development of the country. This problem is clearly stated in the concept of national security of Mongolia but is not much yet formulated in sectoral strategic documents.

Future climate change impacts to grandeur national interests of Mongolia including:

- healthy and safe living environment for Mongolian people
- food safety and security
- economic security
- cultural and civilization security
- environmental safety etc.

An increase in the frequency of natural disasters, especially unexpected extreme sudden events (sudden warming in the winter season, heavy snowfall in late summer and early fall, spring and autumn sleet which damaged power transmission lines and increased off-road accidents, etc.) likely to cause significant adverse effects on human security.

The risk of river and flash floods are increased due to an increase in heavy rainfall percentage in total rainfall events and also increase summer rainfall intensity. The increase of heavy snowfall in winter season causes blockage of road course at hillside and sliding of roads which also caused a delay transport and communication and moreover even affect very unfavorable way to the human health of the rural population. On the other hand, it increases the risk of harsh winter or dzud.

Deterioration of water quality and drinking water and agricultural water supply due to depletion of surface and groundwater resources can increase disease risk associated with water quality and supply.

There is a high probability of an increase of frequency and variety of zoonotic diseases of wild animals and also pets and entering of different transmitting diseases associated with climate warming from outside (particularly from South).

All these require strengthening of capacity building and provision of participation of central and local government agencies, professional organizations, the private sector and communities and carry out vulnerability reduction measures at the national level and finally strengthening of disaster management systems. Special attention should be paid here to create community-based disaster management system.

Climate change will affect most heavily on food safety. In the "National security concept of Mongolia", it states that "take the technical and economic measures to ensure at least 70 percent of life essential food products of Mongolian people by domestic production in a sustainable way". To achieve this goal, ensuring the sustainable growth in agricultural production shall be the high priority for the policy strategy. Issues related to the creation of diversified and rational economic structure should be in the first place in order to ensure the country's economic safety. In particular, special attention should be paid to create a versatile source of income for herders in order to reduce poverty.

Nomadic civilization is a unique culture, which adapted to nature and based on the ecosystem services. But it is needed to promote changes consistent with the trend of human development and environmental change.

Preservation of the natural environmental balance, water resource conservation, mitigation of negative consequences of climate change and land degradation, prevention of biodiversity degradation, reduction of environmental pollution, risks of natural extreme events and disasters are the basis for ensuring healthy human life and environmental safety.

Up to now, traditionally at first formulate economic models of the development and then separately provides ideas on how to solve environmental problems in the planning of regional and country's development policies. Therefore, it could be one of the main causes of environmental degradation in the country.

According to Green development principles, medium and long-term planning is based on future trends of the environment and climate changes; positive and negative consequences to socio-economy are expected under the umbrella of international and domestic situations, technical and technological future trends. In other words, the initial condition of any planning or umbrella of development model should be environment including climate condition and its changes and consequences.

## 5.3. Adaptation tools

Article 4.1 of UNFCCC states "All Parties, taking into account their common but differentiated responsibilities and the specific national and regional development priorities, objectives, and circumstances"

In the Mongolian national economic and social development policy documents, adaptation to climate change has been reflected to some extent. For example, "Green Development Policy" had been approved by Parliament in 2014. Issues related to adaptation to climate change quite widely reflected in action plans of implementation of this document.

### 5.3.1. Adaptation strategies

Green development is based on the close coordination of environment and economic activity. Most of the economic activities in our country will be dependent on natural resources such as pasture, animal husbandry, agriculture and water resources.

Although, today like other developing countries, Mongolia is facing common problems caused by climate change we have our own specific concerns depending on the country's geography and climate-specific conditions. For example, melting of permafrost due to climate warming which occupies one-third of Mongolian territory can have a serious impact on agricultural activities, water resources, infrastructure development such as roads, bridges and buildings. In addition, climate change also will have a serious impact on ecosystems, natural pasture, farming, animal husbandry, water resources and soil quality.

Therefore, issue of adaptation to climate change will be a higher priority than issues of reducing greenhouse gas emissions in our country. But, in terms of long-term goals, should take a balanced strategy for climate adaptation and reducing greenhouse gas emissions for the solution of the climate change related issues.

The historical tradition of activities of livestock and agriculture sectors already adapted to risks of the climate fluctuation of the country, to solve problems driven by the current climate change the government required to make certain efforts such as to increase crop diversity and innovation of methods and technologies. Due to the shift of geographical transition zone which is the basis for agricultural lands, pasture availability and crop development of arable farming will be changed and even in some cases crop yield can be improved to some extent in some regions. However, most agricultural producers are needed to make substantial investments in order to adapt to the climate change and potentially may face significant losses. And change will affect to increase competition for water resources in regions with water scarcity and impacts on the well-being of the community.

Therefore, the government adaptation strategies in agriculture and water resources sectors should focus on the following key issues. This includes:

- organizing broad activities on public awareness campaign among decision-making authorities, farmers and rural people,
- providing herders and farmers with information and new technology,
- inventing technology and conducting R&D studies oriented towards resolving the different environmental issues efficiently in the 21st century and to provide sustainable agricultural development,
- taking management actions targeted on providing links between research work and monitoring information.

There are many issues remaining uncertain in the assessment of options for adaptation measures and direct and indirect impacts of climate change on the agriculture and natural resources. Adaptation technologies often require huge initial investments. And, the end results, outcomes of adaption technologies cannot be seen directly and clearly. Therefore, to see the adaptation results will need to make great efforts and wait for a long time.

The climate could not be changed as currently expected; the above-mentioned adaptation options are even significant. These actions to be implemented in various sectors are highly complex, multi-faceted for decision-makers and policy developer policymakers and issues are necessary to be resolved.

To prioritize adaptation actions and measures in accordance with importance have been used for the test matrix (Screening Matrix) method. Also, selected adaptation options were evaluated using specific criteria and indicators which express them better. Depending on necessity, importance and immediate need of implementation of adaption options, for evaluation has given qualitative values as a high, medium and low rating. Measures and actions at low-cost with fewer barriers can be implemented easily.

Measures such as control livestock numbers in connection with adequate pasture, regulation of river flows are required high costs and also will be more difficult to implement due to barriers posed by the society. To ensure economic, social, technical and environmental sustainability, to eliminate uncertainty and to develop future strategies for adaptation, it requires long-term research activities. Comprehensive and detailed scientific analysis and research play an important role in understanding and cognition of complex nature of the climate system in order to provide support for decision-making on climate change.

# Chapter 6

## POLICIES AND MEASURES TO MITIGATE GHG EMISSIONS

## 6.1. Energy sector

### 6.1.1. Energy industries

1. Present situation

Given large coal reserves, estimated at 173 billion tonnes, Mongolia's primary source for energy has been coal, with the rest made up by Renewable energy (hydropower and wind), oil, biomass and imported electricity from Russia and China.

There are five energy systems: The Central Energy System (CES), Western Energy System (WES), and Altai-Uliastai Energy System (AUES), Eastern Energy System (EES), Southern Energy System (SES) and comprising eight thermal power plants with heat extraction and distribution systems (Figure 6.1).

The CES supplies power and heat to the capital city of Ulaanbaatar and to fourteen nearby aimags[1], including the industrial towns of Darkhan and Erdenet, and that represents 70% of all of Mongolia's electricity supply. The CES is based on five coal-fired generating plants and Salkhit wind farm and it is connected to the Russian Electricity System.

The other four grids are quite small (Figure 6.2).

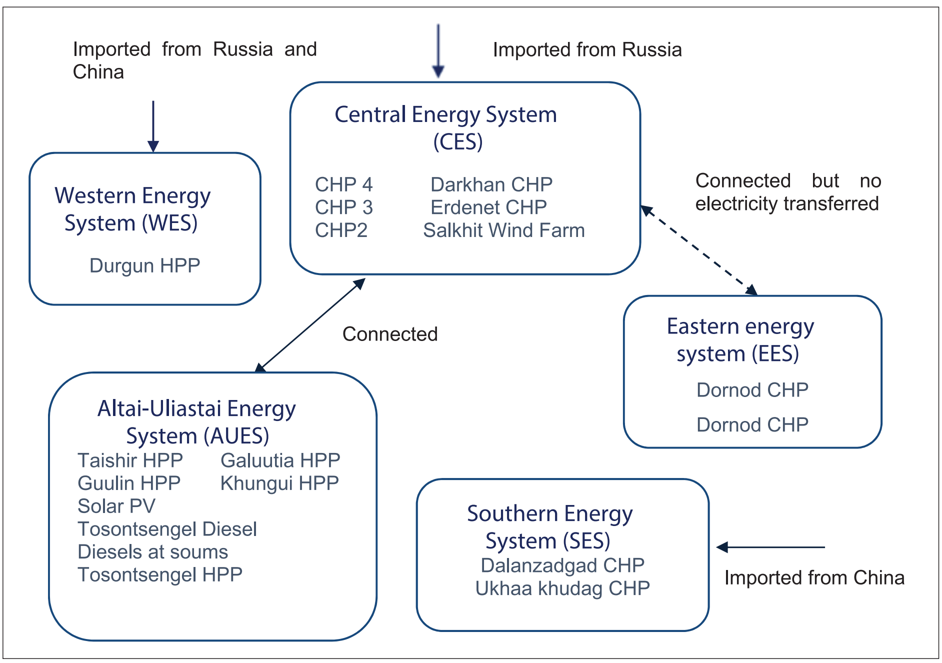



Figure 6.1 Electricity supply system of Mongolia

1 The aimag is a first level administrative subdivision of Mongolia. Mongolia is divided into 21 aimags.

The Western Energy System serves the consumers in Uvs, Bayan-Ulgii and Khovd Aimags. The Western Energy System has only one generating source, the 12 MW Durgun Hydro Power Plant, which was put into operation in 2008. Most electricity, on average 70%, is imported from the Russian Krasnoyarsk energy system, importing electricity operating at the capacity of approximately 25 MW.

The EES is centered in Choibalsan town and in EES operates Choibalsan CHP with capacity 36 MW and supplies electricity to EES and heat to Choibalsan city. The Eastern Energy System has a 190 km long 110 kV single circuit line that connects the 110 kV substations at the two aimag centers of Choibalsan and Baruun Urt.

The Altai-Uliastai Energy System provides electricity to Zavkhan and Govi-Altai aimags with an annual electricity consumption of 33 million kWh and peak demand of 16 MW from 11 MW Taishir Hydro Power Plant and diesel power plants at Uliastai and Esunbulag.

The Southern Energy System provides electricity to Umnugovi province. Dalanzadgad thermal power plant with capacity 9 MW supplies power and heat to Dalanzadgad-central city of Southgobi province. Dalanzadgad is connected to the Tavantolgoi substation by 110 kV overhead lines. In Tavantolgoi operates Ukhaa-Khudag thermal power plant with capacity 18 MW, which was commissioned in 2011.

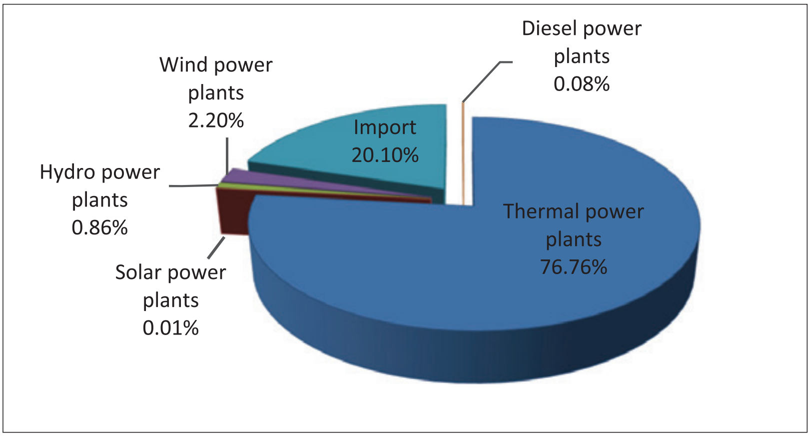



Figure 6.2 Breakdown of Mongolia's power supply by sources in 2015

Chapter 6

Table 6.1 Total electricity and heat production

| | 1990 | 2000 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Electricity generation, billion kWh | 3.10 | 2.94 | 4.70 | 4.54 | 4.86 | 5.13 | 5.39 | 5.54 |
| Heat production, million Gcal | 5.33 | 6.90 | 8.32 | 8.68 | 9.32 | 9.51 | 10.03 | 10.68 |

*Source: NRSO, 2015*

The electricity production by different type of sources is shown in Table 6.2. Most electricity generation comes from coal-fired thermal power plants, accounting for 96.1% of the total in 2015. Most of these plants were built from 1960 to 1980 and would likely be retired in the coming years.

In 2015, 5541.74 GWh of electricity was produced, according to the Energy Regulatory Commission (ERC, 2015). The breakdown, shown in Table 6.3 and, reflects the decline in the share of thermal power plants or and the continued growth in imported electricity to meet the widened supply-demand gap. This was largely due to behind-schedule installations of new power generating capacity, leading to diminishing reserve capacity to supply the increasing peak load demand.

Table 6.2 Electricity production, million kWh

| Sources | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|
| | GWh | % | GWh | % | GWh | % | GWh | % |
| CHPs | 4775.50 | 98.34 | 5014.00 | 97.70 | 5191.30 | 96.28 | 5323.50 | 96.06 |
| Diesel power plants | 28.70 | 0.59 | 5.40 | 0.11 | 8.20 | 0.15 | 5.80 | 0.10 |
| Solar power plants | | 0.00 | | 0.00 | 0.60 | 0.01 | 0.54 | 0.01 |
| Hydro power plants | 52.10 | 1.07 | 59.90 | 1.17 | 66.30 | 1.23 | 59.40 | 1.07 |
| Wind power plants | 0.00 | 0.00 | 52.90 | 1.03 | 125.40 | 2.33 | 152.50 | 2.75 |
| | 4856.30 | 100.00 | 5132.20 | 100.00 | 5391.80 | 100.00 | 5541.74 | 100.00 |

*Source: ERC, 2015*

Table 6.3 Breakdown of Mongolia's power supply in 2015

| | million kWh | % |
|---|---|---|
| Combined heat and power plants | 5323.5 | 76.76 |
| Diesel power plants | 5.8 | 0.08 |
| Solar power plants | 0.54 | 0.01 |
| Hydropower plants | 59.4 | 0.86 |
| Wind power plants | 152.5 | 2.20 |
| Total generation | 5541.74 | 79.90 |
| Import | 1393.8 | 20.10 |
| Total demand | 6935.54 | 100.00 |

*Source: ERC, 2015*

A total of six CHPs of different capacities located mainly in big cities of Ulaanbaatar, Darkhan, Erdenet, and Choibalsan, generate approximately 77 percent of the country's total heat energy production. Several projects have been implemented to improve the efficiency of outdated steam boilers and to install new equipment at the CHPs. Successful implementation of the projects resulted in significant improvement of the reliability of the CHP operation and its efficiency of the energy production.

The district heating systems in aimag centers and industrial settlements have medium-capacity. An installed capacity is 20-30 MW and efficiency is not high (0.60-0.65) (MEGD, 2014). Currently, only Khovd, Ulgii, Ulaangom, Sainshand, Sukhbaatar, Murun, Dalanzadgad, and Baruun-Urt cities in rural areas have access to the district heating systems.

Some parameters of district heating systems of the aimag centers are shown in Table 6.4.

An average design heat load of aimag center is about 10-15MW and an average annual coal consumption ranges between 12 000 to 15 000 tonnes. According to the Ministry of Energy, it is planned to construct heating plants in 9 aimag centers of Arkhangai, Bayankhongor, Dundgovi, Uvurkhangai, Khentii, Tuv, Bulgan, Zavkhan, and Govi-Altai.

Table 6.4 District heating system of some aimag centers, 2016

| № | Aimag/District | | Installed and actual heat capacity, Gcal/h | Boiler type and number, producer | Design heat load, Gcal/h (2015/2020) | Coal mines nearby | Annual coal consumption, 1000t |
|---|---|---|---|---|---|---|---|
| 1 | Nalaikh | | 80/56 | 3xKBTC 20-150<br>2xKBTC 10-150 | 37,6 /140 | Nalaikh, Baganuur | 60.0 |
| 2 | Baganuur | | 170/140 | 8xKBTC 20-150<br>KBTC 10-150 | 62 /210 | Baganuur | 65.0 |
| 4 | Baruun-Urt | | 13/13 | SHX-7,0-/130/80 | | | |
| 7 | Sainshand | | 64.5/58 | 3xKE-25-14,<br>KE-10-14 | 14 /25 | Shi-vee-Ovoo | 19.0 |
| 10 | Khovd | Old | 48/38 | 16 /25 | 16.0 | Khartar-vagatai | 15.0 |
| | | New | 36/36 | 6 /26 | 6.0 | Khushuut | 16.0 |
| 11 | Ulaan-gom | Old | 48/38 | 8 /25 | 8.0 | Khartar-vagatai | 15.0 |
| | | New | 30/30 | 9 /30 | 9.0 | Khartar-vagatai | 16.0 |
| 12 | Ulgii | | 68/54 | 16/30 | 16.0 | Nuurstkhot-gor | 15.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | Murun | 30/30 | 19/30 | 19.0 | Mogoingol, Jiljigbulag | 16.0 |
| 14 | Sukhbaatar | 106/84 | 4xKE-25-14; KBTC 20-150 | 28/35 | Baganuur | 20.0 |
| 15 | Sharyn gol | 16.6/16 | DZL 7, 2xDZL2.8 | 8,0/15 | Sharyn gol | 12.0 |
| 16 | Bulgan | | 2xSHX14-1.6 | | | |

*Source: Prepared by Prof. Namkhainyam*

The district heating system of Ulaanbaatar city covers only central parts of the city - most the city population live in ger[2] areas with no assess to the district system. To generate required heating, aimag centers have an average of 6-12 heating boiler houses and supply to administrative facilities and residential buildings. There are approximately 150 boiler houses in Ulaanbaatar, 40 in other cities with district heating, and 50 in cities with no district heating systems (MEGDT, 2015). Small-capacity boilers are the hot water boilers with a capacity higher than 300 kW. As a result, there is an inevitable need to supply heating to both government and business organizations such as schools, kindergartens, hospitals, pharmacies, police stations, military bases, restaurants, shops, bathhouses, barber shops in ger residential areas not only in Ulaanbaatar city but also in above-mentioned aimags.

Over 4000 small-capacity hot water boilers, those operate in ger residential area of bigger cities, aimag, and soum centers of Mongolia, consume 2.0 million tonnes of coal or 20% of the total coal consumption of the country annually. These boilers don't comply with current technological requirements (MEGD, 2014).

## 2. Policy and measures

***Main policy documents**: Mongolia's 2030 Sustainable Development Vision*

In April 2016, Parliament of Mongolia endorsed Mongolia's 2030 Sustainable Development Vision which charts the country's development path for the period of the Sustainable Development Goals.

The vision outlines important priorities for the coming 15 years to achieve sustainable development and emphasizing national accountability. It offers an ambitious set of goals centered on human development, inclusive growth, and equity, and entails the establishment of a regular monitoring mechanism

2 A ger is the traditional Mongolian felt tent used by herders: ger area in Ulaanbaatar is sections of town where peoples have settled in their gers.

as a country's clear commitment to providing for systematic follow – up and review of progress at all levels. By 2030, the Development Vision envisages Mongolia to be one of the leading Middle-Income Countries – that has eradicated poverty in all its forms and preserves the ecological balance while continuing to build strong and stable governance systems.

Energy supply related goals in Mongolia's 2030 Sustainable Development Vision are:

- The share of power demand supplied by domestic power generation sources will be 85% in 2020, 90% in 2025 and 100% in 2030.
- The share of renewable energy sources in total installed power capacity for domestic supply will be 20% in 2020, 25% in 2025 and 30% in 2030.
- One of the goals for the period 2025-2030 is to use nuclear energy for electricity and heat generation

*State policy on energy (Parliament resolution #63, 2015)*

The State Policy for Energy Sector development for 2015-2030 was approved in 2015 by the Parliament through Resolution No.63 The State Police on Energy aims to ensure uninterrupted and reliable supply of energy to meet the increasing energy demands of the country and to transform Mongolia into an energy exporting country.



The Policy reviews the existing situation and identifies the main policy direction, the key principles, and the strategic goals for each main direction and the objectives under each goal.  The Policy will be implemented in two phases (between 2015-2023 and 2024-2030). The target outcomes of the policy in two stages are shown in Table 6.5.

For the period 2015-2023, the aim is to develop sources for energy security and back up capacity; establish a foundation for the development of renewable energy; start the operation of the large-scale power plant. It aims to double the installed power capacity, with hydropower contributing to at least 10% of total installed power generation capacity, increase back up capacity by 10% and create an environment conducive to the development of the renewable sector.

For the period 2024-2030, the expected outcome is to be able to export energy and increase the share of Renewables on total Installed Capacity for Domestic Supply to 30%, have integrated smart energy systems connecting regions with high voltage transmission lines. The energy sector will operate in a competitive market with regulations. Excess energy will be exported to

Northeast Asian countries through high voltage direct current transmission lines.

*Energy Law*

Mongolia's Energy Law was approved in 2001 with the latest update done in 2015. Its purpose is to regulate the energy generation, transmission, distribution, dispatching and supply activities, as well as the construction of energy facilities and energy consumption. It calls for the unbundling of the energy industry resulting in the creation of separate entities to manage and operate the generation, transmission, dispatch, distribution, and supply. The law established the Energy Regulatory Commission (ERC) to administer the provisions of the law.

Recent amendments involved the addition of a new regulation setting energy prices and tariffs. The tariff rates for electricity and heating production and the amount of fuel supplied (for generation of heat and electricity) are now regulated. The amendment aims to increase private sector participation, business development and investments in the energy sector

Table 6.5 Target outcome of the policy

| Indicators | 2014 /Base year/ | 1st stage /by 2023 / | 2nd stage /by 2030/ |
|---|---|---|---|
| Reserve Capacity for Electricity Generation | -10% | 10 % ≤ | 20% ≤ |
| Reserve Capacity for Heat Generation in Cities | 3% | 10 %≤ | 15 % ≤ |
| Profit Share on Tariff Structure in Central Region | -16.22 % | 0% | 5% |
| Own Use of CHP's | 14.4 % | 11.2% | 9.14 % |
| Transmission & Distribution Loss /excluding Oyu-Tolgoi/ | 13.7% | 10.8% | 7.8% |
| The share of Renewables on total Installed Capacity for Domestic Supply | 7.62% | 20% | 30% |
| GHG Emission per 1 Gcal Power Generation | 0.52 $tCO_2$eq. | 0.49 $tCO_2$eq. | 0.47 $tCO_2$eq. |
| Reduction of Building Heat Loss | 0% | 20% | 40% |

*Source: Parliament (2015).*

*Renewable Energy Law (2007, 2015)*

Mongolia's Renewable Energy Law was approved in 2007 and renovated in 2015. Its purpose is to regulate the generation and delivery of power from renewable energy resources and to encourage the development of privately financed power projects by setting up the legal framework that will allow electricity from Renewable energy to be bought.

The law provides feed-in tariffs for RE Power projects, which allow recovery of capital and investment costs thus making RE investment attractive to developers and financiers (Table 6.6).

Table 6.6 Feed-in tariffs on renewable energies in Mongolia (unit: USD/kWh)

| Type of renewable energy generation | Connected to the transmission grid | Independent power generation capacity | | |
|---|---|---|---|---|
| | | Up to 500 kW | 501-2000 kW | 2001-5000 kW |
| Hydropower station (up to 5000 kW) | 0.045-0.06 | 0.08-0.10 | 0.05-0.06 | 0.045-0.050 |
| Wind power source | 0.08-0.095 | | | 0.10-0.15 |
| Solar power source | 0.15-0.18 | | | 0.20-0.30 |

*Source: Parliament (2007)*

The Law on Renewable Energy motivates potential foreign and domestic companies to carry out and invest renewable energy projects in Mongolia. As an example, Newcom LLC, a Mongolian company, has constructed a wind farm in Salkhit Uul, about 70 km south-southeast of Ulaanbaatar. The wind farm is a landmark project that is a result of close cooperation between the private sector, international development institutions, and the Government of Mongolia. In June 2013, the Salkhit wind farm is connected to the grid and has started producing electricity. The wind farm has a capacity of 50 MW and generates 168.5 GWh of electricity per year (http://www.cleanenergy.mn). As the first wind park in Mongolia, the project will greatly assist the country in stimulating the commercialization of grid-connected renewable energy technologies and markets. The project helps to reduce GHG emissions versus the coal-burning power plants.

*Nuclear Energy Law*

The Parliament of Mongolia passed the Nuclear Energy Law in July 2009. The Nuclear Energy Law aims to regulate all aspects of dealing with nuclear materials, from uranium exploration and mining to the running of nuclear reactors. But recently there is no concrete plan to construct nuclear power stations in Mongolia.

*Action Programme of the Government of Mongolia for 2016-2020*

To ensure the continuous, reliable operation of the core sector of the country's economic security and sustainable development, measures will be taken to expand and renovate existing thermal power plants' capacity (Choibalsan CHP and Ulaanbaatar CHP3).

- Resolve issues related to ensuring reliable energy supply of Mongolia, building new sources of energy to meet growing demands, and construct a power plant at the Tavan Tolgoi coal mine to meet South Gobi mine electricity needs.
- Develop a project to build export-oriented high capacity power plants at Shivee Ovoo, Tevshiin Gobi and other coal mines, and direct current transmission line network.
- Develop renewable energy production in the proper ratio, start construction work of a hydroelectric power station on the Eg River.
- Continue to build country's consolidated electrical power grid by constructing transmission airlines and substations which connect regional grids, heavy industries and large-scale customers with power plants.
- Take step-by-step measures to build and/or expand heating plants and district heating systems in aimag centers, major cities, and urban areas to fully meet their heat consumption needs.

*Green Development Policy*

The Green Development Policy of Mongolia was approved by the Parliament in June 2014. To formally establish the Green Development Policy two high-level documents were prepared: The Green Development Policy and the Action plan for Implementation of Green Development Policy. The concept paper sets the goals and purposes for green development until 2030, while the Action plan designs policy and strategies to ensure that the goals and purposes are implemented.

To achieve the strategic objective #1 (Promote a sustainable consumption and production pattern with efficient use natural resources, low greenhouse gas emissions, and reduced waste management), measures to be implemented were identified which includes, among others:

Reduction of greenhouse gas emission in the energy sector through increased energy efficiency by 20 by 2030 ensuring the share of renewable energy in total energy production to 20 and 30 percent by 2020 and 2030 respectively and by renewing energy and industrial sector technologies, reducing wasteful consumption and losses and through optimization of pricing policies.

The action plan for implementation of national Green Development Policy (2016-2030) (Government, 2016) includes following implementation measures on energy industries:

- Create and implement favorable and economic incentives to support production and consumption of renewable energy

- Establish solar photovoltaic power stations of 10-50 MWh step by step.
- Establish wind power stations of 50-250 MWh step by step.
- Create water reservoirs at bigger rivers and construct multi-purpose systems for water use (Egiin River, Selenge River Basin 550 MW, Khovd River Basin 150 MW, and Orkhon River Basin 100MW).
- Study and test optimum solutions of using renewable energy technology for heat supply, and hot water supply, and introduce solutions and provide promotion and support for such actions.
- Reduce GHG emission per unit production through setting requirements for advanced clean technology and efficiency improvements of new coal-fired power stations and heat-only boilers (Baganuur, CHP-5, Mogoin Gol, Tavan Tolgoi thermal power stations).
- Carry out step by step refurbishments of the currently operating combined heat and power plants, heat only boilers and industrial purpose incinerators and reduce waste released into the environment in compliance with relevant international standards.
- Implement projects and programmes to improve efficiency and reduce GHG emission through reducing power and heat transmission and distribution network losses with international financing mechanism.
- Conduct research and testing to introduce potential technologies to store energy.
- Test and create new sources of fuel and energy sources (processed coal, biomass, coal bed methane, and natural gas).

*The 100,000 solar ger (house) programme*

Mongolian government implements "The 100,000 Solar Ger" Project to provide portable solar power systems (Solar Home System - SHS) to satisfy the basic energy needs of nomadic herders' families. The Government of Mongolia adopted resolution No.158 in 1999 to implement "The 100,000 Solar Ger" Project and 1032 SHS sets introduced to nomadic families in the period 2001-2002. During the period 2003-2005, 31,790 SHS sets funded by Japanese and Chinese aid have been delivered to nomadic households by 50% discount price. During 2007-2008, 40,400 SHS sets the capacity 50 W each has been delivered to nomadic households by 50% discount from the State Budget. The Implementation status of 100,000 solar home national programmes is shown in Table 6.7.

Table 6.7 Implementation status of 100,000 solar home national programme

| Implementation period | 2001-2002 | 2003-2005 | 2007-208 | 2009-2011 | Total |
|---|---|---|---|---|---|
| Number of households supplied by solar home system | 1,032 | 31,790 | 40,400 | 26,778 | 100,000 |
| Percentage | 1.0% | 31.8% | 40.4% | 26.8% | 100% |
| Cumulative Percentage | 1.0% | 32.8% | 73.2% | 100% | 100% |

*Source: Ministry of Energy*

The present situation after implementation of 100000 solar home government programme is shown in Table 6.8. The table shows that the number of nomadic households reaches 127400 as of 2015.

Recently, the Ministry of Energy intends to continue the solar home national programme increasing capacity of solar PV up to 150-200W.

Table 6.8 Number of nomadic household with individual power sources

| Year | Type of power sources, thousand households | | | | Type of power sources, % | | | |
|---|---|---|---|---|---|---|---|---|
| | Solar PV | Wind | Other | Total | Solar PV | Wind | Other | Total |
| 2011 | 120.6 | 3.9 | 11.5 | 136.0 | 88.7 | 2.9 | 8.5 | 100.0 |
| 2012 | 112.8 | 2.0 | 5.0 | 119.8 | 94.2 | 1.7 | 4.2 | 100.0 |
| 2013 | 117.3 | 1.4 | 3.6 | 122.3 | 95.9 | 1.1 | 2.9 | 100.0 |
| 2014 | 125.0 | 1.0 | 8.9 | 134.9 | 92.7 | 0.7 | 6.6 | 100.0 |
| 2015 | 127.4 | 1.3 | 8.4 | 137.1 | 92.9 | 0.9 | 6.1 | 100.0 |

*Source*: *NRSO (2015a)*

### *Mongolia Liquefied Gas Fuel Programme*

The use of Liquefied Gas (LG) is increasing rapidly, and the Government of Mongolia gives an importance to the development of LG use as a new fuel mix, as a relatively "clean" fuel compared to fossil fuel. LG Programme was adopted by the government in 2006 and is aimed at promoting the usage of LG in the household and transportation sectors and to introduce necessary safety standards and regulations.

Currently, no significant gas deposits have been found and there is almost no consumption of any gaseous fuels in Mongolia, except Liquefied Petroleum Gas (LPG), which is imported from Russia for use either as a vehicle fuel or for cooking purposes in household and restaurants. Recently 15 companies have licensees to sale gas fuels, of which Dashvaanjil, Unigas, and Gorgas have licensees to import LPG from Russia.

The volume and cost of imported LPG are shown in Table 6.9.

Currently, there are about 738,000 vehicles in Mongolia, 10,000 of which run on LG.

Table 6.9 Volume and cost of imported LPG

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| LPG, $m^3$ | 16371.5 | 15392.4 | 11785.1 | 18563.3 | 33427.5 |
| Cost, 1000 USD | 5007.6 | 3495.3 | 4902.8 | 9032.8 | 18867.4 |

*Nationally Appropriate Mitigation Actions*

Mongolia expressed its intention to agree to the Copenhagen Accord, and subsequently Mongolia submitted a list of proposed Nationally Appropriate Mitigation Actions (NAMAs) to the UNFCCC secretariat in January 2010. In its list of NAMAs, the measures relevant to Energy supply from the NAMA list are:

- PV and Solar Heating
- Wind power generators and Wind farms
- Hydropower plants
- Coal beneficiation
- Coal briquetting
- Improve efficiency of existing HOBs and install boilers with a new design and high efficiency
- Convert hot water boilers into small capacity thermal power plants
- Change fuels for household stoves and furnaces
- Modernize existing and implement the new design for household stoves and furnaces
- Improve efficiency and reduce internal use in CHPs
- Use of electricity from the grid for individual households for local heating in cities

*Intended Nationally Determined Contribution*

In October 2015, the government of Mongolia submitted to the UNFCCC the country's set of the specific measure referred to as Intended Nationally Determined Contribution (INDC) (MEGDT, 2015). Measures related to

Energy supply are:

- Increase renewable electricity capacity from 7.62% in 2014 to 20% by 2020 and to 30% by 2030 as a share of total electricity generation capacity.
- Reduce electricity transmission losses from 13.7% in 2014 to 10.8% by 2020 and to 7.8% by 2030.
- Reduce internal energy use of Combined Heat and Power plants (improved plant efficiency) from 14.4% in 2014 to 11.2% by 2020 and 9.14% by 2030.
- Implement advanced technology in energy production such as supercritical pressure coal combustion technology by 2030.

## Mitigation measures

*Efficiency improvement of CHP*

To increase efficiency and reliability of existing Combined Heat and Power Plants (CHP), the Government of Mongolia promotes projects from foreign countries, international Banks, and financial organizations. During the period 1990-2008, 67 projects have been implemented in the Energy sector with a total investment cost of USD 575 million as a foreign loan or technical assistance (Batbaatar Ts. 2009). 53.4 percent of this amount of investment has been used for rehabilitation and improvement of CHP. The results were positive and the reliable operation and efficiency of energy production were improved. The Station own of CHPs reduced from 22% in 2001 to 13.78 in 2015. The specific energy use for electricity generation reduced from 414.3 to 314.9, for heat generation from 185.4 to 177.2 respectively from 2001 to 2015 (Table 6.10).

Table 6.10 Station own use and Specific energy consumptions of CHPs in the Central energy system

| | 2001 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Station own use of electricity, % | 22.0 | 19.8 | 15.62 | 15.14 | 14.86 | 14.56 | 14.47 | 13.78 |
| Specific energy use for electricity generation, gram/kWh | 414.3 | 378.3 | 336.8 | 329.8 | 324.1 | 326.2 | 327.7 | 314.9 |
| Specific energy use for heat generation, kg/Gcal | 185.4 | 183.3 | 178.6 | 179.0 | 179.9 | 178.8 | 177.9 | 177.2 |

*Source: ERC, 2009; ERC, 2015*

*Reduction of power losses in transmission and distribution systems*

With financial support from World Bank, the Government of Mongolia has implemented the Energy Project during the period 2003-2010 to improve the financial sustainability of the energy sector through reducing losses and improving revenue collection in Ulaanbaatar and 9 other provinces in Mongolia. The energy project has helped to reduce technical and non-technical losses from 30.67% in 2004 to 22.7% in 2009 in UB. For 9 other provinces, technical and non-technical losses have been reduced by 7.6 -30%. The Power transmission and distribution losses of Central Energy System are shown in Table 6.11.

Per State policy on energy approved by Mongolian Parliament in 2015 (resolution No.63), power transmission & distribution Losses (excluding Oyutolgoi) will be reduced to 10.8 by 2023 and 7.8 by 2030.

Table 6.11 Power transmission and distribution losses of Central Energy System

| | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Power T&D losses, % | 23.0 | 19.8 | 17.3 | 16.6 | 16.19 | 15.82 | 15.29 | 15.07 |

*Source: ERC, 2009; ERC, 2015*

*Efficiency improvement of Heat Only Boilers*

The technology of the small-capacity boilers is very old and their efficiency rate does not meet current technical and efficiency requirements. Fuels often do not combust completely because of poor design of the most small-scale hot water boilers and its incompatibility to fuel quality and composition. The efficiency of the hot water boilers ranges between 0.4 to 0.5 and thus, the coal consumption of boilers is very high (MEGD, 2014).

Over recent years, needs to heat newly constructed small-size buildings in Ulaanbaatar, Darkhan, and Erdenet cities and in the center of aimags and soums centers have been increasing gradually. The buildings include private residential buildings, schools, kindergartens, khoroo hospitals, khoroo administrations, drug stores, police units, canteens, shops, bathhouses and barbershops in ger areas.

Two to three studies have been conducted on low-pressure small-sized hot water boilers in Ulaanbaatar city. As of 2010, there were 1005 of low-pressure boilers in the city (MNET, 2009). The technical condition and negative impact on an environment of these boilers are similar as those are in operation in other cities and center of aimags and soums.

Thus, the quality of heating services is now extremely poor. Improving the existing heating systems in soum centers (through refurbishment and modernization) is a high priority to sustain livelihoods in these areas.

Efficiency improvement of heating systems in province centers gives benefit from better quality heating services during winter. In addition, boiler efficiency is expected to be increased from 40% to 70%, thereby decreasing coal consumption and $CO_2$ emissions. This results both in reduced boiler-related air pollution and savings in soum center government budgets.

*Heat efficiency improvement of Stoves and Small water heating boilers in ger district area*

Stoves and Small water heating boilers of households in cities have low energy efficiency, and pollute the environment and threaten human health due to insufficient fuel burning. Stoves of households in cities have low efficiency and pollute environment due to the insufficient burning of fuel. The government of Mongolia and Municipality of Ulaanbaatar city implemented some actions to improve the efficiency of household's stoves from the point of view these are the major source of air pollution but is not much result achieved.

One of potential option to reduce environmental pollution and greenhouse gas emission is to change raw coal used in stoves by LPG and other alternative sources.

## Promotion of Clean Coal Technology

Mongolia has substantial coal reserves. Coal remains to be the most important fuel for power and heat generation and for heat generation. There exists no provision for coal preparation at mine sites, and thus there is no quality control in the supply system. Coal quality often does not meet the minimum standard requirements, and in many cases, emergency situations at the power stations are caused by the low quality of coal.

Coal washing can be introduced at the biggest coal mines in Mongolia, such as Baganuur and Shivee-Ovoo. This technology is already introduced in Mongolia. Coal handling and preparation plant is in operation at Ukhaa Khudag since June 2011. Mongolian Mining Corporation is the first washed coal producer in the country and the new plant is the first of its kind in Mongolia.

### 6.1.2. Energy consumption

### 1. Present situation

The electricity and heat consumption by main economic sectors is shown in Table 6.12. The Table shows that the large electricity and heat consumers are industry, construction, households and communal services.

Table 6.12 The electricity and heat consumption by main economic sectors

| | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Electricity, million kWh | | | | | | | | |
| **Total** | **1910.0** | **2534.0** | **3375.9** | **3453.0** | **3772.6** | **4732.1** | **5158.4** | **5283.5** |
| Industry and Construction | 1182.0 | 1569.1 | 2093.8 | 2140.8 | 2338.9 | 2930.7 | 3170.6 | 3261.4 |
| Households communal housing | 463.0 | 609.3 | 809.7 | 829.5 | 906.7 | 1139.2 | 1251.4 | 1277.5 |
| Transport and communication | 79.0 | 105.8 | 140.4 | 143.7 | 156.8 | 196.9 | 211.4 | 216.5 |
| Agriculture | 21.0 | 27.5 | 35.6 | 36.4 | 39.8 | 49.9 | 63.7 | 54.8 |
| Other | 165.0 | 222.3 | 296.2 | 302.6 | 330.4 | 415.4 | 460.4 | 473.3 |
| Heat, 1000 Gcal | | | | | | | | |
| **Total** | **6514.0** | **7180.2** | **7820.2** | **8032.6** | **8692.7** | **8671.7** | **9163.1** | **9706.9** |
| Industry and Construction | 2620.1 | 2275.9 | 2082.9 | 2067.1 | 2108.7 | 2161.8 | 2176.6 | 2358.5 |
| Households communal housing | 2655.1 | 3051.2 | 3361.8 | 3473.9 | 3737.0 | 3818.5 | 3930.2 | 4039.6 |
| Transport and communication | 410.6 | 407.5 | 281.7 | 278.7 | 281.1 | 309.1 | 299.9 | 316.7 |
| Agriculture | 33.3 | 70.5 | 40.5 | 42.7 | 33.4 | 49.0 | 43.3 | 47.6 |
| Other | 794.9 | 1375.1 | 2053.4 | 2170.2 | 2532.5 | 2333.3 | 2713.1 | 2944.5 |

*Source: NRSO, 2010; NRSO, 2015*

The number of electricity and heat consumers by energy supply region is shown in Table 6.13 – Table 6.15.

Table 6.13 Number of electricity consumers by energy supply region and by year

| | | 2011 | 2012 | 2013 | 2014 | 2015 | |
|---|---|---|---|---|---|---|---|
| 1 | Central Energy system | 384722 | 404152 | 429047 | 452169 | 493959 | 83.38% |
| 2 | Western Energy system | 26141 | 26261 | 30558 | 37917 | 42811 | 7.23% |
| 3 | Eastern energy system | 20038 | 20190 | 23562 | 23267 | 24373 | 4.11% |
| 4 | Southern energy system | 6339 | 6581 | 9090 | 10221 | 10629 | 1.79% |
| 5 | Altai-Uliastai energy system | 10588 | 13116 | 16620 | 19632 | 20677 | 3.49% |
| | TOTAL | 447828 | 470300 | 508877 | 543206 | 592449 | 100% |

*Source: ERC, 2015*

Chapter 6

Table 6.14 Number of electricity consumers by energy supply region and by consumer types in 2015

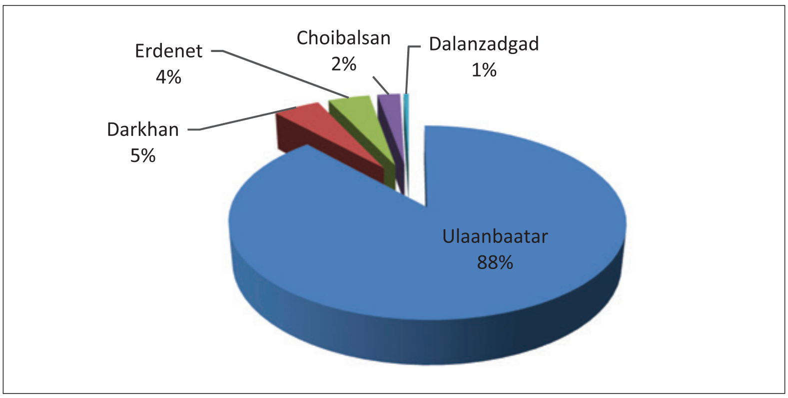
| | | Industry and enterprises | Households | | Other | Total |
|---|---|---|---|---|---|---|
| | | | in an apartment | in ger area | | |
| 1 | Central Energy system | 36240 | 205540 | 250347 | 1832 | 493959 |
| 2 | Western Energy system | 3975 | 3732 | 35104 | 0 | 42811 |
| 3 | Eastern energy system | 1961 | 6023 | 16091 | 298 | 24373 |
| 4 | Southern energy system | 1084 | 1303 | 8242 | 0 | 10629 |
| 5 | Altai-Uliastai energy system | 1798 | 2526 | 16353 | 0 | 20677 |
| | Total | 45058 | 219124 | 326137 | 2130 | 592449 |
| | Total, % | 7.61% | 36.99% | 55.05% | 0.36% | 100% |

*Source: ERC, 2015*

Table 6.15 Number of heat consumers supplied from centralized district heating systems (by CHP) in Ulaanbaatar, Darkhan, Erdenet, Choibalsan and Dalanzadgad cities

| | | 2011 | 2012 | 2013 | 2014 | 2015 | |
|---|---|---|---|---|---|---|---|
| 1 | Industry and Enterprises | 22287 | 22910 | 23475 | 33839 | 35134 | 12.0% |
| 2 | Households | 165952 | 166747 | 201639 | 237539 | 256615 | 88.0% |
| 3 | Total | 188239 | 189657 | 225114 | 271378 | 291749 | 100.0% |

*Source: ERC, 2015*




*Source: ERC, 2015*

Figure 6.3 Share of heat consumers supplied from centralized district heating systems (by CHP) in 2015

The priority sub-sectors in Mongolia based on their electricity and heat energy consumptions are mining; metal processing; cement; food & beverage; building and construction; and utility. These energy-intensive sub-sectors are mostly in the mining and manufacturing which account for 28.2% of the country's GDP in 2014 (NRSO, 2014).

## 2. Policy and measures

### *Main policy documents*

*Energy Conservation Law*

The Energy Conservation (EC) Law of Mongolia was approved by the Parliament on 26 November 2015. The EC Law mandates large energy consumers to undergo an energy audit and to report annually its energy consumption as well as its plans and activities to reduce their energy consumption. These entities are referred to as Designated Consumers/ Entities

The Designated Consumers/Entities are required to have an Energy Conservation Manager who can either be hired or appointed from its existing officers or employees. It is the duty of the Energy Conservation Manager to submit a report to the Energy Conservation Council every year and is responsible for organizing and implementing the plan of the Designated Consumer/ Entity on energy conservation and efficiency measures.

An organization or an individual chosen by the Designated Consumer/Entity shall conduct an energy audit on the operation/facilities of the Designated Consumer/Entity and make recommendations on how energy conservation and efficiency can be achieved.

Energy Service Companies (ESCOs) are authorized to provide energy services.

The Energy Conservation Council to be established shall be responsible for regulating and implementing the policies on energy conservation nationwide. Reports from the Designated Consumers/Entities are to be submitted to the Energy Conservation Council. The council will operate under the direction of the Energy Regulatory Commission (ERC).

In March 2016, the Energy Efficiency and Conservation Division (EECD) was established under the Energy Regulatory Commission (ERC) to implement the mandate of the Energy Conservation Council.

On 31 May 2016, EECD got the approval of the Government of Mongolia on implementing the four rules as stated in the law. The rules are:

- The rule on energy auditing rules
- The rule on accreditation requirements for Energy auditing entities and ESCOs.
- The rule on organizing training for energy conservation manager, energy auditor, and issuance and termination of certificates of the manager and auditor
- The rule defining the characteristics of the designated consumers and its programme, annual plan for EE activities and reporting requirements.

The thresholds of the Designated Consumer/Entities defined by Government are as follows:

For Electricity:

- Public buildings and services consuming 2000MWh/year or more.
- Industries consuming 3000MWh/year or more,
- Mining firms consuming 5000MWh/year or more

For heating, all entities consuming 5000Gcal/year or more are considered Designated Consumer/ Entity. Most energy companies including thermal power plant, transmission & distribution are also to be considered Designated Consumer/Entity. These are energy generators consuming 10% or more of its energy production, electricity transmission companies with electricity transmission loss of 2% and above and energy distribution companies with electricity distribution loss of 9% and above and/ or heat distribution loss of 7% and above Table 6.16. These Designated Consumers/Entities will have the right to select the entity that will conduct the energy audit.

Table 6.16 Definition of the Designated Consumer according to Government resolution on 31 May 2016

| № | Consumer classification | Measuring unit | Energy consumption of designated consumers |
|---|---|---|---|
| | A. Heat consumers | | |
| 1. | State-owned | Gcal/year | 5,000 and more |
| 2. | Industry and service | Gcal/year | 5,000 and more |
| | B. Electricity consumers | | |
| 1. | State-owned | kWh/year | 2,000,000 and more |
| 2. | Manufacturing Industry | kWh/year | 3,000,000 and more |
| 3. | Mining | kWh/year | 5,000,000 and more |
| 4. | Services | kWh/year | 2,000,000 and more |

| | C. Utilities | | |
|---|---|---|---|
| 1. | Energy producers | Station own use (%/year) | 10 and more |
| 2. | Energy transmission companies | Electricity losses (%/year) | 2 and more |
| 3 | Energy distribution companies | Electricity losses (%/year) | 9 and more |
| | | Heat losses (%/year) | 7 and more |

## Mitigation measures

*Motor efficiency improvement*

It is estimated that motor systems (i.e., electric motors coupled with pumps, fans, and other machines) consume about 70% of industrial electricity in Mongolia. These motor systems are often less efficient than the ones in industrialized countries. Motor efficiency improvement technology includes energy-efficient motors; variable speed drives; improved operation and maintenance; correction of the previous over-sizing; improved mechanical power transmission, the efficiency of driven equipment. There is no detailed inventory of motors and variable speed drives in Mongolia, however, it is estimated that the electricity saving potential equals 20% of electricity consumption by industrial motors (IIEC, 2016).

*Promotion of ESCO activities*

The Netherland-Mongolian project "ESCO Development in Mongolia" has been introduced ESCOs in Mongolia in 2010-2013. The general objective of this project was to overcome the barriers to implementation of Energy Efficiency Projects in Mongolia, by creating a basis and concept for the development of ESCOs. But the ESCO activities was not implemented in Mongolia because of the absence of legal environment, the low tariff of energy and therefore no interest of energy saving in energy consumers. But after approval of energy conservation law in 2015, the ESCO activity will be promoted. The Mongolian Government has issued the Rule on Accreditation requirements for Energy auditing entities and ESCOs in 2016.

*Good housekeeping practices and energy management*

Mongolian industry has significant potential for saving energy through improvement of energy use and management. The energy savings potential by "easy" savings (good housekeeping practices that minimize the use of heat and electricity and energy management) is 15-25 percent with a cost recuperation period of less than 1 year.

### 6.1.3. Building (energy)

#### Present situation

The current housing options in Mongolia range from gers, small affordable apartments to luxury houses, apartments, and penthouse. Rural migrants generally settle in ger area around UB city. Crowded Gers without access to heat grid and sewage system intensify environmental problems in UB with smoke from coal stoves for ger space heating.

The construction sector buildings which are concentrated in major cities, particularly in UB, Erdenet, and Darkhan are mostly heavyweight, multi-store commercial, residential apartment buildings and private houses, and these buildings are connected to water supply, sewage, district heating and domestic hot water systems.

During the long-lasting winter season in Mongolia, heating of homes, apartments, and offices is a necessary condition as air temperatures drop to as low as -40°C. The heating season lasts for 8 months which exerts additional constraints on energy demand. This poses a challenge to both the local and global environment since coal remains the major fuel used to meet the demands.

Although the total database for building volume or floor areas in Mongolia is not available the total building volume was calculated based on heat load of centers of aimags and soums[3] (Table 6.17).

The table shows that 129.0 million $m^3$ volume or 38.0 million $m^2$ area in total are connected to the district heating system of small, medium and big capacity in Mongolia as of 2014. Approximately, 66% of them are in Ulaanbaatar city

Table 6.17 Total volumes of buildings in Mongolia, 2014-2015

| Name of companies | Public/Commercial building, $1000m^3$ | Apartments, houses, $1000m^3$ | Total volume, $1000m^3$ |
|---|---|---|---|
| Ulaanbaatar, district heating system | 41,008.2 | 45,573.0 | 86,500.0 |
| Ulaanbaatar, water boilers in ger residential area | 2,867.0 | | 2,867.0 |
| Ulaanbaatar, low-pressure boilers in ger residential area | 1,378.5 | | 1,378.5 |
| Darkhan city, district heating system | | 1,816.3 | 1,816.3 |
| Erdenet city, district heating system | 509.3 | 2,557.0 | 3066.3 |
| Nalaikh district | 368.18 | 309.7 | 677.9 |

3 The soum is a second level administrative subdivision of Mongolia. The 21 aimags of Mongolia are divided into 329 soums.

| | | | |
|---|---|---|---|
| Choibalsan city, district heating system | 700.0 | | 700.0 |
| Zuunkharaa city | 1085.0 | | 1085.0 |
| Erdenet, Ore Enrichment Plant | 858.0 | | 858.0 |
| Tsetserleg, Arkhangai aimag | 265.0 | 604.6 | 869.4 |
| Bulgan, Bulgan aimag | 362.0 | 250.9 | 612.9 |
| Aimag centers | 12,000.0 | | 12,000.0 |
| Soum centers | 16,750.0 | | 16,750.0 |
| TOTAL | | | 129,181.0 |

*Source: GGGI, 2016*

With an increase in housing demand from economic growth and a surging rural to urban migration, the construction sector had been thriving over the past decade. However, with the current economic slowdown in Mongolia new construction activity is expected to slow down in the next 3-4 years from its boom year levels of 2010-2014 (Table 6.18).

Table 6.18 Buildings put into operation by types

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Residential - number of apartments | 9,899 | 11,349 | 11,413 | 18,012 | 22,546 | |
| Hospitals - number of beds | 305 | 424 | 613 | 228 | 530 | |
| School and cultural Institutions-number of seats | 17,593 | 16,539 | 19,628 | 20,012 | 24,806 | |

*Source: NRSO, 2015*

Living quarters with 1262.9 thou.m$^2$ floor space was put into operation in 2015 at the national level. Thus, the housing stock reached 14365.6 thou.m$^2$ and increase 9.6 percent compared with 2014 (Table 6.19).

Table 6.19 living quarters put into operation, 1000m$^2$

| | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| Housing stock by floor space | 10592.8 | 11499.2 | 13102.7 | 14365.6 |
| Living quarters put into operation | | | | |
| Total floor space | 606.4 | 1237.3 | 1898.2 | 2308.7 |
| Public | 12.5 | 17.4 | 31.3 | 27.2 |
| Private | 593.9 | 1219.9 | 1866.9 | 2281.5 |
| Living floor space | 530.5 | 906.4 | 1603.5 | 1262.9 |
| Public | 9.6 | 9.4 | 30.0 | 22.3 |
| Private | 520.9 | 897.0 | 1573.5 | 1240.6 |

*Source:* NRSO, 2015

## 2. Policies and Measures

### *Main policy documents*

*Green Development Policy*

Reduction of building heat losses by 20 and 40 percent by 2020 and 2030 respectively through the introduction of green solutions, energy efficient and advanced technologies and standards, including green building rating system, energy audit and the introduction of incentives to promote these initiatives.

- Develop and promote Green building rating systems and its methodologies.
- Localize international and EU norms and standards on building energy efficiency and heat losses calculation, improve and upgrade relevant national norms and standards.
- Strengthen the capacity of building sector human resources in areas of green building design and construction.
- Develop and implement incentive mechanisms to promote green building and energy efficiency measures.
- Take measures to reduce energy and heat losses through the energy auditing.
- Implement pilot projects of designing and construction of demonstration green public kindergarten and school facilities.
- Develop and implement green building design for construction of new buildings to be funded by state budget in compliance with green building standards and requirements.
- Initiate and implement heat losses reduction programmes and projects for existing concrete- panel buildings.
- Conduct best practice and demonstration studies on energy efficiency and zero emission green building solutions such as passive building, and implement pilot projects.

### *Mitigation measures*

*Insulation improvements for existing buildings and implementation of new energy-efficient standards for new buildings*

Thermal energy is used for heating of private and public building, production of goods and services and preparation of household hot water. The introduction of technologies aimed at improving building insulation is critical to achieving increased energy efficiency. Building losses are also high and residential consumers have no means to regulate the temperature inside of their homes. There is enormous potential to save energy and reduce greenhouse gas emissions in building insulation options.

Starting from 1995, the Government has begun to promote the citizens' interest to have own houses and adopted state policies and national programmes in that field; and thus, an optimum condition is created.

However, there is strong lack of information, knowledge, and practice among the citizens on how to build the energy-efficient house with appropriate materials. Because most of the insulation materials are imported from abroad, the Government should promote domestic production and research & technology development of ecologically friendly new materials at the policy level. Mongolia has a wide range of raw materials that could be used in the insulation material production. Ministry of Construction and Urban Development and the UNDP in Mongolia has been implementing the Building Energy Efficiency Project (BEEP) that is aimed at reducing the annual growth rate of greenhouse gas emissions from the building sector in Mongolia. BEEP will contribute to it through the transformation of the Mongolian buildings market towards more energy-efficient building technologies and services, sustainable private house insulation and energy efficiency financing mechanisms. The project objective is the improvement of the energy utilization efficiency in Mongolian buildings by refining the energy efficiency levels of new construction sector buildings and improving the energy efficiency of new and existing ger and private houses in urban areas.

The government policies for reduction of energy losses in buildings are targeting for:

- Standards for new buildings
- Insulation of old buildings

Insulating currently used buildings at the standard level, we can reduce heat losses by 40 percent

*Heat metering*

In Mongolia, about 30 percent of the country's population lives in public apartments connected to the central heat supply network. None of those apartments have heat meters and heating fee and the price is calculated based on a fixed tariff. Also, as most of the apartments are not installed with the technical instrument to adjust own heat consumption, the owner's open windows during increased indoor air temperature and release warm air. There huge potential to save heat energy by installing heat meters and heat consumers especially in apartments.

*Green heat sources for heating building*

In general, heat energy is used for heating and hot water supply of buildings. However, more than 90% of the heat generated in Mongolia is solely used only for heating. This shows that there is an immediate need to introduce technologies that improve system efficiency of building heating in the country.

Green Energy Heating Systems Analysis for Mongolia for GGGI (GGGI, 2016) suggests following green technologies for further analysis to improve heating systems in province centers and cities of Mongolia:

- Ground source heat pump
- The solar water heater system
- Use Coal mine/bed methane for heating boilers
- High-efficiency boilers with circulating fluidized bed (CFB)
- Reducing building heat loss

*Implement NAMA in Building*

The project named "Nationally Appropriate Mitigation Actions in the Construction Sector in Mongolia" is started in Mongolia by United Nations Development Programme (UNDP). The objective of the project is to facilitate market transformation for energy efficiency in the construction sector through the development and implementation of NAMA in Mongolia. This objective will be achieved by removing barriers to increased adoption of energy efficiency technology in construction sector through three components; i) establishment of baseline energy consumption and GHG emission in the construction sector ii) development and implementation of NAMA in the construction sector iii) measuring, reporting and verification (MRV) system for NAMA. This project will be implemented over a 40 months' period and is expected to achieve GHG emission reductions through the displacement of electricity-heat generation from coal power plants and CHPs.

### 6.1.4. Transport (energy)

***Present situation***

Due to a sparsely populated, geographically large national territory, the Mongolian transport sector is of strategic importance and consists of road, rail, air, and water transport sub-sectors.

All types of cargo transport turnovers, as well as passenger turnover, are shown in Table 6.20. Per the table, in 2014, the total cargo traffic rail freight turnover was 63%, transportation 37%, total passenger automobile circulation 55%, 22% for rail transport, and 23% for air transport.

Table 6.20 All types of cargo transport turnover and passenger turnover

| No. | Specifications and types of transport | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| 1 | Cargo turnover, million t/km: | 12,124.8 | 16,336.7 | 15656.4 | 14641.9 | 17419.5 | 14610.2 |
| | railway | 10,286.7 | 11,418.7 | 12142.7 | 12076.5 | 12473.7 | 11462.6 |
| | road | 1,834.0 | 4,910.3 | 3503.9 | 2555.8 | 4936.4 | 3139.9 |
| | air | 4.2 | 7.7 | 9.7 | 9.6 | 9.4 | 7.7 |
| 2 | Passenger turnover, million passengers per km: | 3,607.4 | 4,695.4 | 4,972.4 | 4,604.2 | 5,235.4 | 4061.2 |
| | railway | 1,220.0 | 1,399.7 | 1,485.4 | 1,394.4 | 1,194.5 | 996.7 |
| | road | 1,480.2 | 2,321.6 | 2,263.1 | 1,897.5 | 2,793.0 | 1940.5 |
| | air | 907.2 | 973.9 | 1,223.1 | 1,311.8 | 1,247.1 | 1123.1 |
| | water | 0.044 | 0.252 | 0.765 | 0.506 | 0.825 | 0.902 |

*Source: NRSO, 2015*

Chapter 6

Table 6.21 shows the total number of cars, their types, and classifications by used years. Per the table, in 2013 amongst the total vehicle fleet 10 and more years old cars accounted for 72.5%, while 4-9 years old cars accounted for 20.6%. In 2010 the number of cars less than 3 years old accounted for 3.4%, increasing to 6.9% by 2013.

Table 6.21 Number of cars, types and used period

| No. | Specifications and types of transport | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| | Total | 254,486 | 312,542 | 345,473 | 384,864 | 437,677 | 482049 |
| 1 | Type of car: | | | | | | |
| | Passenger automobile | 172,583 | 208,514 | 228,650 | 259,309 | 303,724 | 343288 |
| | Truck | 61,841 | 75,090 | 83,718 | 89,473 | 96,581 | 110024 |
| | Buses | 16,366 | 22,547 | 21,642 | 20,400 | 20,650 | 20744 |
| | special Purpose | 3,696 | 6,391 | 11,463 | 15,682 | 16,722 | 7993 |
| 2 | Used period: | | | | | | |
| | 3 years | 8,585 | 10,770 | 20,325 | 26,492 | 21,430 | 14562 |
| | 4-9 years | 54,283 | 46,114 | 79,022 | 79,470 | 86,337 | 98019 |
| | 10 and above | 191,618 | 255,658 | 246,126 | 278,902 | 329,910 | 369468 |

*Source: NRSO, 2015*

Table 6.22 shows the length of several types of the national road network in Mongolia. In 2010, 3,016 km, or 45% of the total road length was a paved road, increased to 5,838 km, or 65% in 2013, and tends to increase in future.

Table 6.22 Improved roads by length

| Indicators | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Improved road length, km | | 6,734.4 | 7,633.5 | 7,652.9 | 8,875.6 | 9,428.2 | |
| | Paved road | 3,015.6 | 4,063.5 | 4,082.9 | 5,838.2 | 6,461.0 | |
| | Gravel top road | 2,071.6 | 1,959.2 | 1,959.2 | 1,864.8 | 1,782.5 | |
| | Improved soil road | 1,647.2 | 1,610.8 | 1,910.8 | 1,172.6 | 1,184.7 | |

*Source: NRSO, 2015*

The number and structure of vehicles participated in traffic of Ulaanbaatar city is shown in Table 6.23.

Table 6.23 Number and structure of vehicles participated in traffic of Ulaanbaatar city, 2014

| Structure of vehicles | Number of vehicles | Percentage of vehicles |
|---|---|---|
| Vehicles with a gasoline engine | 191400 | 63.8 |
| Vehicles with diesel engine | 75600 | 25.2 |
| Hybrid vehicles | 32100 | 10.7 |
| Vehicles with gas engine | 900 | 0.3 |
| Total | 300000 | 100 |

*Source: MUST, 2014*

## Policies and Measures

### *Main policy Documents*

*Mongolian Government Action Programme 2016-2020:*

- Finalize paved road connection of capital city with aimag centers;
- Improve road network in Ulaanbaatar by transferring to the orbital road system, building bridges;
- Implement user and environment-friendly transport smart system;
- Implement bus rapid transport in public transport in Ulaanbaatar to reduce traffic jam.

*Copenhagen Accord APPENDIX II Mongolia: Nationally appropriate mitigation actions*

- To use fuel-efficient vehicles;
- Support import of fuel-efficient vehicles by alleviating certain taxes.

*Intended Nationally Determined Contribution of Mongolia*

- Improve national paved road network. Upgrading/Paving 8000 km by 2016, 11000 km by 2021.
- Improve Ulaanbaatar city road network to decrease all traffic jam by 30-40% by 2023.
- Increase the share of private hybrid road vehicles from approximately 6.5% in 2014 to approximately 13% by 2030.
- Shift from liquid fuel to LPG for vehicles in Ulaanbaatar and aimag (province) centers by improving taxation and environmental fee system.
- Improve enforcement mechanism of standards for road vehicles and non-road based transport.
- Develop Bus Rapid Transit (BRT) system and improvement of the public transport system in Ulaanbaatar

*Green Development Policy*

- Introduce bus-rapid transit service for public transportation in UB city;
- Implement "UB metro" project;
- Implement environmentally friendly public transportation based on piloting and experimental activities;

### *Mitigation measures*

*The efficient management of traffic demand*

*Expand public transportation system*

*Promote fuel-efficient cars and flexible/alternative fuel vehicles*

The government has encouraged the use of fuel-efficient cars as well as hybrid fuel cars to reduce the negative impact of cars on the environment and human health. The Excise Duty Tax Law (2006) cut import taxes on hybrid vehicles and increased taxes on used cars. From 2011, public transportation vehicles more than 12 years old and taxis more than 10 years old were banned.

## 6.2. Non-energy sector

### 6.2.1 Industry

*Present situation*

Energy consumption in the industrial sector is rapidly increasing due to the development of mining and quarrying, as well as other industries. GHG emission from these industries is included in the energy sector above. Therefore, in this sector cement and lime production, as well as potential emissions from consumption of HFCs, are included.

The domestic production and import of cement and lime in Mongolia are shown in Table 6.24 and Table 6.25. Per table, in 2010 domestic producers were covering 41.4% of total cement demand, reduced to 14.5% in 2013, and followed by an increase by 21.5% in 2014 and 31.7% in 2015.

Until 2013 two mail cement plants were operating in Mongolia- Darkhan cement plant, built in 1968 and Khutul cement plant, built in 1982.

Table 6.24 Cement consumption, thou. tonnes

| Parameter | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Import | 455.9 | 785.9 | 1192.3 | 1525.4 | 1506.0 | 884.3 |
| Domestic production | 322.5 | 425.8 | 349.4 | 258.8 | 411.3 | 410.1 |
| Total demand | 778.4 | 1211.7 | 1541.7 | 1784.2 | 1917.3 | 1294.4 |
| Percentage of domestic production in total demand, % | 41.40 | 35.14 | 22.66 | 14.51 | 21.45 | 31.68 |

*Source: NRSO, 2015*

Table 6.25 Lime consumption, thou. tonnes

| Parameter | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Production | 50.20 | 45.30 | 68.20 | 56.70 | 58.00 | 62.20 |

*Source: NRSO, 2015*

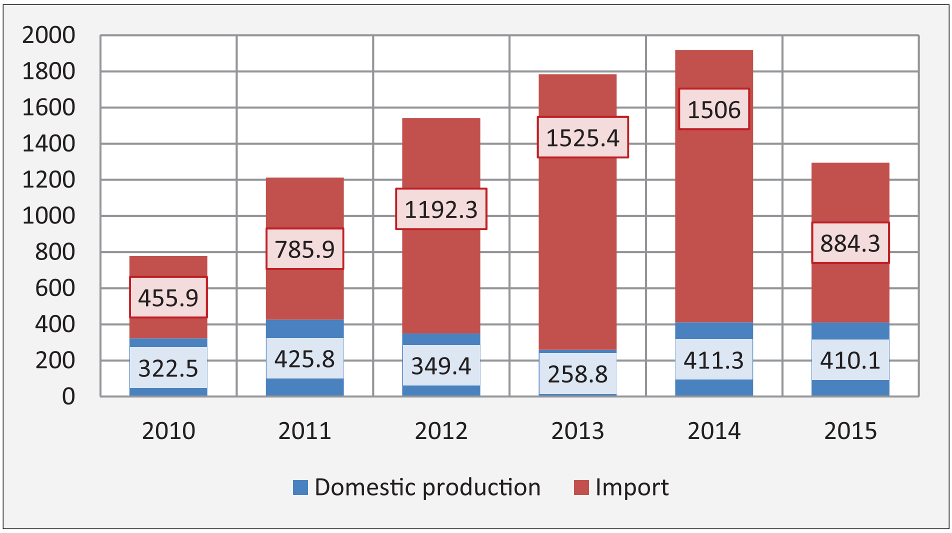



Figure 6.4 Cement consumption, thou. tonnes

In 2014, using dry technology, Khutul cement plant started its operations generating a capacity of 1 million tonnes of cement a year.

Recently following projects are in commence their activities, meeting domestic needs

- Mon Cement factory of 1 million tonnes, of Mon Polimet LLC in Urgun soum of Dornogovi aimag;
- Cement factory of 1.0 million tonnes, factory with 100% private equity investment of China in Sergelen soum, Tuv aimag;
- Khukh Tsaviin cement factory of 1 million tonnes, of “Mongolian Alt” LLC is constructed in Dalanjargalan soum of Dornogovi aimag and will be in operation the first half of 2017.

### *Policies and Measures*

### *Main policy documents*

*Copenhagen Accord APPENDIX II Mongolia: Nationally appropriate mitigation actions*

- Improve housekeeping practices;
- Implement motor efficiency improvements;
- Introducing dry-processing in cement industry;

*Intended Nationally Determined Contribution of Mongolia*

- Reduce emissions in the cement industry through upgrading the processing technology from wet- to dry-processing and through the construction of new cement plant with dry processing up to 2030.

*Mitigation measures*

*Introducing dry-processing in the cement industry*: Changing the wet-processing of cement to dry-processing saves a large amount of energy. There is only one cement factory in Mongolia with wet-processing technology for cement production Darkhan cement factory.

GHG emissions from the cement plant will be reduced by converting the clinker manufacturing process from wet type to dry type, and by introducing the advanced energy-conserving technologies.

Per the study under Joint Credit Mechanism (JCM), 78,000t$CO_2$/yr. of emission reductions are expected, by converting clinker manufacturing process from wet type to dry type at 180,000t/yr. production in Darkhan Cement Factory.

### 6.2.2. Agriculture

*1. Present situation*

The agriculture sector is the main livelihood and source of wealth in Mongolia and the country's economy substantially depends on the production and development of this sector. The value added of agriculture sector is 13.6 percent of GDP of Mongolia as of 2015. The livestock production comprises 80 percent of the total agriculture production.

The number of livestock by type of animals for the period 1990-2015 is shown in Table and in Figure 6.5.

The table shows that for the period 1990-2015 the total number of animals is increased 2.16 times from 25856.9 to 55979.8 head.

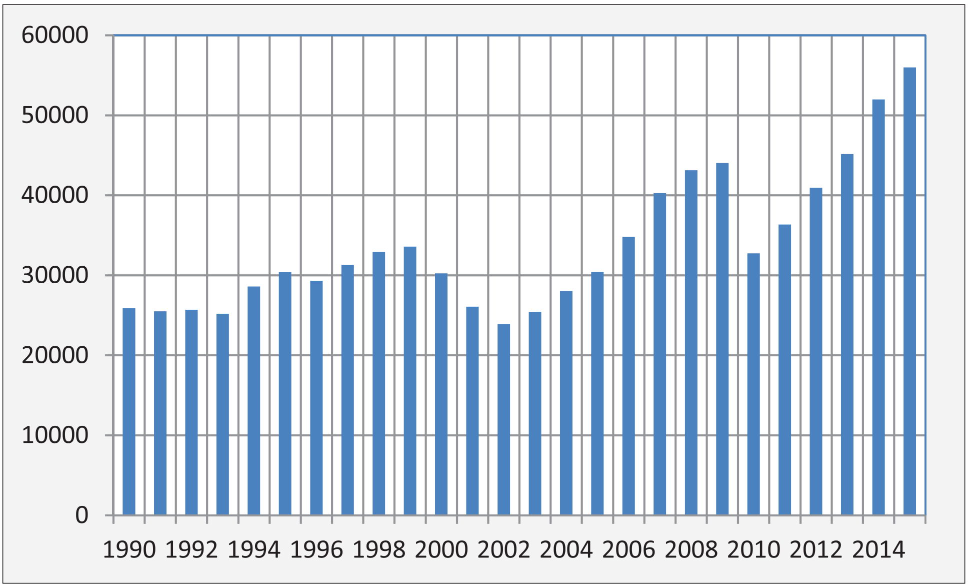



Figure 6.5 Livestock population changes for the period 1990-2015

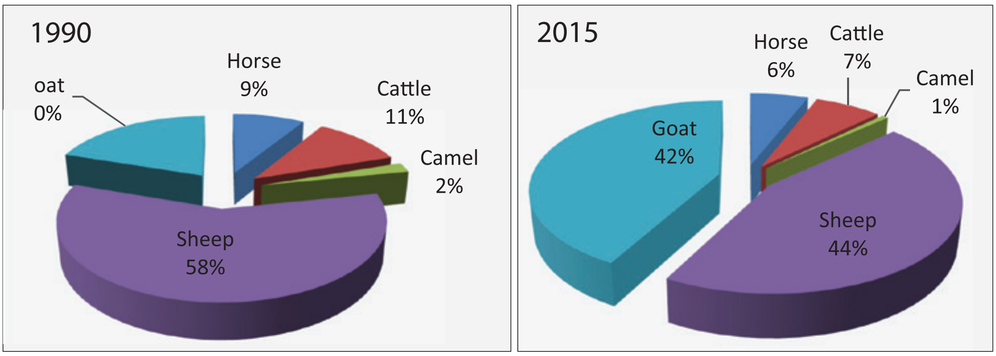



Figure 6.6 Livestock structure changes in 1990 and 2015

The structural changes of the types of animals in a total animal population are shown in Table 6.26. The percentage of the coat in total animal population is increased dramatically from 20% in 1990 to 42% in 2015 due to an increase in market demand and cost of coat cashmere.

An animal population depends on climate or weather condition. It can be seen in Figure 6.7. The number of animal population is decreased because of hard winter-dzud[4] in winter 2001-2002, 2010-2011.

4 A dzud is a Mongolian term for a severe winter in which livestock are unable to find nourishing foodstuff through the snow cover and starve.

Table 6.26 Number of livestock by type of animals for the period 1990-2015

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Horse | 2262.0 | 2648.4 | 2660.7 | 2191.8 | 1988.9 | 1968.9 | 2005.3 | 2029.1 | 2114.8 |
| Cattle | 2848.7 | 3317.1 | 3097.6 | 2069.7 | 1884.3 | 1792.8 | 1841.6 | 1963.6 | 2167.8 |
| Camel | 537.5 | 367.5 | 322.9 | 285.2 | 253.0 | 256.7 | 256.6 | 254.2 | 253.5 |
| Sheep | 15083.0 | 13718.6 | 13876.5 | 11937.3 | 10636.6 | 10756.4 | 11686.4 | 12884.5 | 14815.1 |
| Goat | 5125.7 | 8520.7 | 10269.8 | 9591.3 | 9134.8 | 10652.9 | 12238.0 | 13267.4 | 15451.7 |
| **Total** | **25856.9** | **28572.3** | **30227.5** | **26075.3** | **23897.6** | **25427.7** | **28027.9** | **30398.8** | **34802.9** |

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| Horse | 2239.5 | 2186.9 | 2221.3 | 1920.3 | 2112.9 | 2330.4 | 2619.4 | 2995.8 | 3295.3 |
| Cattle | 2425.8 | 2503.5 | 2599.3 | 2176.0 | 2339.7 | 2584.6 | 2909.5 | 3413.9 | 3780.4 |
| Camel | 260.6 | 266.4 | 277.1 | 269.6 | 280.1 | 305.8 | 321.5 | 349.3 | 368.0 |
| Sheep | 16990.1 | 18362.3 | 19274.7 | 14480.4 | 15668.5 | 18141.4 | 20066.4 | 23214.7 | 24943.2 |
| Goat | 18347.8 | 19969.4 | 19651.5 | 13883.2 | 15934.6 | 17558.7 | 19227.6 | 22008.9 | 23592.9 |
| **Total** | **40263.8** | **43288.5** | **44023.9** | **32729.5** | **36335.8** | **40920.9** | **45144.4** | **51982.6** | **55979.8** |

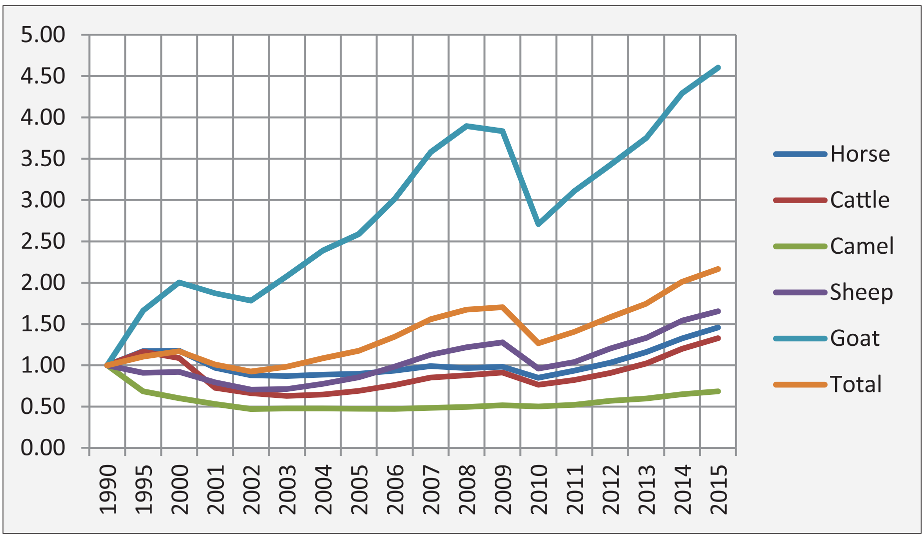



Figure 6.7 Livestock growth from 1990-2015 by type of animals

Changes of a number of survivals, livestock for consumption and losses of adult animals from 1990 to 2015 are shown in Figure 6.8. The livestock balance is shown in Table 6.27.

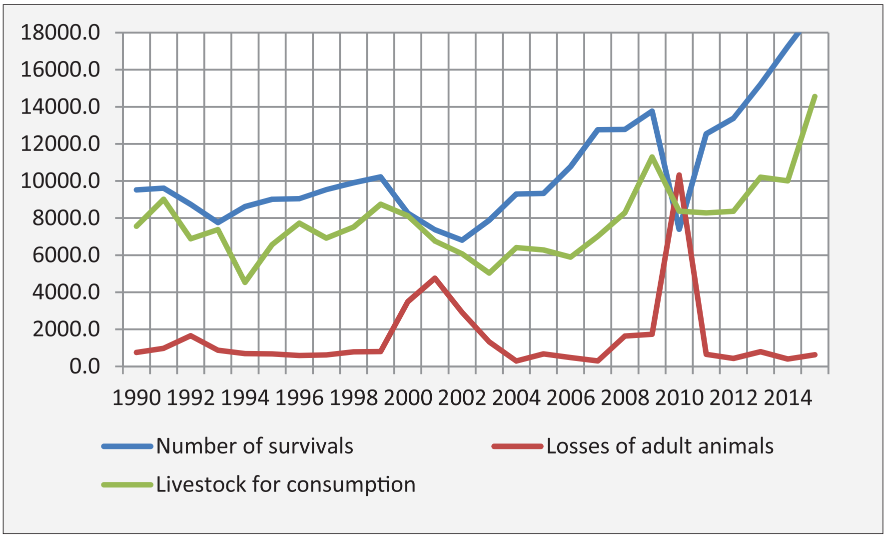



Figure 6.8 Changes of number of survivals, livestock for consumption and losses of adult animals between 1990-2015

Table 6.27 Livestock balance by years

| Average | At the begin-ning of the year | Num-ber of surviv-als | In % of the total popula-tion | Losses of adult animals | In % of the total popu-lation | Live-stock for con-sump-tion | In % of the total popula-tion | At the end of the year | Annual growth % |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 24674.9 | 9519.1 | 38.58 | 751.9 | 3.05 | 7559.8 | 30.64 | 25882.3 | 4.89 |
| 1991 | 25882.5 | 9611.8 | 37.14 | 978.3 | 3.78 | 9016.0 | 34.83 | 25500.0 | -1.48 |
| 1992 | 25500.0 | 8736.3 | 34.26 | 1652.1 | 6.48 | 6884.2 | 27.00 | 25700.0 | 0.78 |
| 1993 | 25700.0 | 7761.8 | 30.20 | 871.1 | 3.39 | 7380.7 | 28.72 | 25200.0 | -1.95 |
| 1994 | 25200.0 | 8621.5 | 34.21 | 690.0 | 2.74 | 4531.5 | 17.98 | 28600.0 | 13.49 |
| 1995 | 28600.0 | 9012.4 | 31.51 | 673.9 | 2.36 | 6567.3 | 22.96 | 30371.2 | 6.19 |
| Average 1990-1995 | **25926.2** | **8877.2** | **34.3** | **936.2** | **3.6** | **6989.9** | **27.0** | **26875.6** | **3.7** |
| 1996 | 28572.3 | 9047.5 | 31.67 | 586.8 | 2.05 | 7726.2 | 27.04 | 29306.8 | 2.57 |
| 1997 | 29300.1 | 9537.3 | 32.55 | 617.7 | 2.11 | 6920.0 | 23.62 | 31299.7 | 6.82 |
| 1998 | 31292.3 | 9907.3 | 31.66 | 785.7 | 2.51 | 7511.4 | 24.00 | 32902.5 | 5.15 |
| 1999 | 32897.5 | 10220.9 | 31.07 | 800.1 | 2.43 | 8743.9 | 26.58 | 33574.4 | 2.06 |
| 2000 | 33568.9 | 8273.3 | 24.65 | 3491.2 | 10.40 | 8119.3 | 24.19 | 30231.7 | -9.94 |
| Average 1990-1995 | **31126.2** | **9397.3** | **30.3** | **1256.3** | **3.9** | **7804.2** | **25.1** | **31463.0** | **1.3** |
| 2001 | 30228.0 | 7370.7 | 24.38 | 4758.9 | 15.74 | 6763.4 | 22.37 | 26076.4 | -13.73 |
| 2002 | 26075.3 | 6808.7 | 26.11 | 2917.6 | 11.19 | 6076.1 | 23.30 | 23890.3 | -8.38 |
| 2003 | 23898.0 | 7885.5 | 33.00 | 1324.3 | 5.54 | 5034.5 | 21.07 | 25424.7 | 6.39 |
| 2004 | 25427.7 | 9296.1 | 36.56 | 291.7 | 1.15 | 6404.9 | 25.19 | 28027.2 | 10.22 |
| 2005 | 28027.9 | 9333.1 | 33.30 | 677.2 | 2.42 | 6284.0 | 22.42 | 30399.8 | 8.46 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Average 1990-1995** | **26731.4** | **8138.8** | **30.7** | **1993.9** | **7.2** | **6112.6** | **22.9** | **26763.7** | **0.6** |
| 2006 | 30398.8 | 10778.5 | 35.46 | 476.4 | 1.57 | 5898.0 | 19.40 | 34802.9 | 14.49 |
| 2007 | 34802.9 | 12767.6 | 36.69 | 294.1 | 0.85 | 7012.5 | 20.15 | 40263.9 | 15.69 |
| 2008 | 40263.8 | 12780.0 | 31.74 | 1640.6 | 4.07 | 8285.3 | 20.58 | 43117.9 | 7.09 |
| 2009 | 43288.5 | 13767.4 | 31.80 | 1732.9 | 4.00 | 11299.0 | 26.10 | 44024.0 | 1.70 |
| 2010 | 44023.9 | 7399.2 | 16.81 | 10319.9 | 23.44 | 8373.7 | 19.02 | 32729.5 | -25.66 |
| **Average 2006-2010** | **38555.6** | **11498.5** | **30.5** | **2892.8** | **6.8** | **8173.7** | **21.1** | **38987.6** | **2.7** |
| 2011 | 32729.5 | 12540.7 | 38.32 | 651.3 | 1.99 | 8283.2 | 25.31 | 36335.7 | 11.02 |
| 2012 | 36335.8 | 13379.0 | 36.82 | 428.9 | 1.18 | 8365.0 | 23.02 | 40920.9 | 12.62 |
| 2013 | 40920.9 | 15221.0 | 37.20 | 792.6 | 1.94 | 10205.0 | 24.94 | 45144.3 | 10.32 |
| 2014 | 45144.3 | 17246.0 | 38.20 | 401.4 | 0.89 | 10006.4 | 22.17 | 51982.5 | 15.15 |
| 2015 | 51982.6 | 19179.5 | 36.90 | 625.6 | 1.20 | 14556.7 | 28.00 | 55979.8 | 7.69 |
| **Average 2011-2015** | **41422.6** | **15513.2** | **37.5** | **580.0** | **1.4** | **10283.3** | **24.7** | **46072.6** | **11.4** |
| **Global Average** | **32235.9** | **10463.8** | **32.46** | **1543.7** | **4.79** | **7762.9** | **24.08** | **33392.6** | **3.59** |

*Source: 1) NRSO, 2015 2) NRSO, 2015a*

## 2. Policies and Measures

### *Main policy documents*

### *Mongolia's 2030 Sustainable Development Vision*

- Ensure appropriate numbers and flock structure in the total livestock, have no less than 10 percent in 2020, 30 percent in 2025 and 60 percent in 2030 of Mongolia's territory as disease free, for trade and quarantine, confirmed by the World Organization for Animal Health, develop veterinary services that are compliant with animal health standards for the export of livestock and livestock products to the neighboring countries.
- In 2030, increase the share of animal and livestock 'having high output potential' in the total animal and livestock population to eight percent, increase the pure breed cattle heads to 200 thousand in intensive livestock farming

*Mongolian Livestock National programme*

- The objective of the Programme is to ensure the sustainable development of the livestock sector and create a legal environment that would promote economic development. Per the programme, the number of livestock is expected to reduce from 44 million in 2008 to about 36 million in 2021 as result improving animal breeding services based on social needs, increasing the productivity and quality of livestock products to increase the competitiveness of the sector.

*Action programme of the Government of Mongolia for 2016-2020*

- Support the export of meat and meat products by developing an effective mix of pasture-based and intensive livestock farming, increase export to 50 thou. tonnes per year and raise herder household's income.
- Implement the programme to develop intensive farming, preserve and enrich traditional practice and knowledge of animal husbandry, ensure the appropriate ratio of the number, and breed composition of the livestock.

*Mitigation measures*

As mentioned in the previous chapter, the main contributor to the total methane emissions is enteric fermentation from animals in the agricultural sector, contributing about 92-93% of the total methane emissions. Livestock husbandry is the main livelihood and source of wealth in Mongolia and the country's economy substantially depends on the production and development of this sector. The value added of agriculture sector is about 20 percent of GDP of Mongolia

*Limit the increase in the total number of livestock by exporting meat and meat products*

The National Mongolian Livestock Programme has been approved by the Parliament of Mongolia in 2000. The objective of the programme is to ensure the sustainable development of the livestock sector and create a legal environment that would promote economic development. According to the programme, the number of livestock is expected to reduce from 44 million in 2008 to about 36 million in 2021 as result improving animal breeding services based on social needs, increasing the productivity and quality of livestock products to increase the competitiveness of the sector.

*Limit the increase in the total number of livestock by increasing the productivity of each type of livestock*

The livestock sector development strategy aims to build risk management capabilities to ensure reliable protection for herders' wealth and incomes and increase production at optimal levels taking into consideration regional advantages to increase productivity. The low efficiency leads to an increased quantity of livestock that is vulnerable to natural disasters. The livestock number has exceeded the estimated carrying capacity of Mongolia's pasture, causing land degradation and desertification.

### 6.2.3. Waste

*Present situation*

In 2014, Mongolia's total urban population was 1 990 320 and 2/3 of which lives in Ulaanbaatar city. There are 3 operational controlled landfill sites in Ulaanbaatar city.

The estimated Municipal Solid Waste (MSW) in urban areas in Mongolia is shown in Table 6.28

Table 6.28 Urban population and estimated MSW in urban areas in Mongolia

| Indicators | Units | 1970 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| Population | thou. per-son | 541.6 | 839.0 | 964.2 | 1226.53 | 1202.3 | 1361.27 | 1579.39 | 1910.75 | 1990.32 |
| Generated Waste | Gg | 66.03 | 102.28 | 117.55 | 149.53 | 146.57 | 298.12 | 345.89 | 586.22 | 610.63 |
| Deposited MSW | Gg | 42.92 | 66.48 | 76.4 | 97.19 | 95.27 | 193.78 | 224.83 | 381.04 | 396.91 |
| Biodegrad-able waste | Gg | 22.75 | 35.24 | 40.49 | 51.51 | 50.49 | 102.7 | 119.16 | 201.95 | 210.36 |

*Source: MET, 2017*

According to the Japanese International Cooperation Agency (JICA, 2007), the amount of waste generated in an urban area is estimated to be 0.590-0.640 kg per day per person in winter and 216-286 kg per day per person in summer. 75 percent of waste generated in UB is collected and transported to landfills by a waste collection company, 15 percent by citizens and enterprises themselves and remaining 5-10 percent is not collected and wasted.

The composition of MSW of Ulaanbaatar city is shown in Figure 6.9. The figure shows that 74.2% of total MSW is combustible.

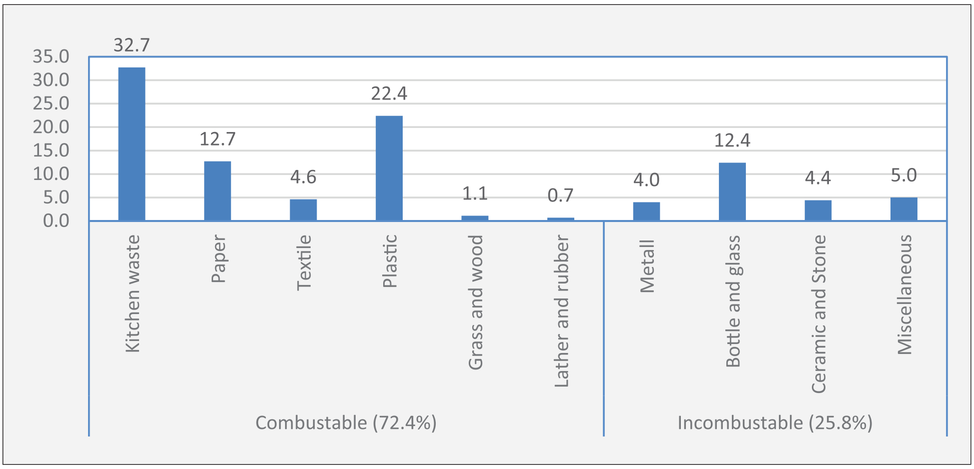



Figure 6.9 The composition of MSW of Ulaanbaatar city, % (JICA, 2007)

### *Policies and measures*

### *Main policy document*

*Mongolia's 2030 Sustainable Development Vision*

- Increase the amount of recycled waste to 20 percent in 2020, 30 percent in 2025 and 40 percent in 2030 of the total waste.

*Green Development Policy*

- Establish solid waste disposal site with high sanitation standards;
- Develop and implement a master plan to improve hazardous waste management;
- Reduce solid waste in landfills and promote economic circulation through waste recycling eco complex facilities (based on Naran and Tsagaan Davaa waste disposal sites);
- Implement a project to dispose or re-use dated vehicle spare parts raw materials.

Action programme of the government of Mongolia for 2016-2020

- Reduce air, water and soil pollution and implement appropriate waste management in cities and other urban areas.
- Protect water resources, implement integrated management to prevent their depletion and support the introduction of wastewater recycling technology.

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# Chapter 7

## GHG EMISSION PROJECTIONS

## 7.1. Baseline Scenario

### 7.1.1. Energy sector

The projection of GHG emissions from Power and heat plants was calculated by using LEAP model. The Long-range Energy Alternatives Planning system (LEAP) (SEI, 2016) is a scenario-based energy-environment modeling tool. Its scenarios are based on a comprehensive accounting of how energy is consumed, converted and produced in each region or economy under a range of alternative assumptions on population, economic development and technology and so on (See Box 7.1).

#### 7.1.1.1. The energy demand

The energy demand in the LEAP model is divided into four sectors:

- Buildings
- Industry
- Transport
- Agriculture

*1. Buildings*

Buildings, both for housing and businesses, demand significant quantities of energy, especially for heating.

The buildings sector in Mongolia is divided into two main subsectors, the household subsector, and the “commercial and other” subsector. The household subsector includes urban and rural households, with urban households further divided into households in Ulaanbaatar, and households in other cities. Rural households are divided into those in soum centers and herder households with and without connections to the fixed power grid. Urban households in UB are modeled in three groups: apartments, most of which are served by district heat, houses, which are not served by district heat, and gers also not served by district heating systems. Household end-uses include heating, cooking, lighting, and other uses that vary depending on the type of the household.

In the baseline scenario, energy use in households is is partly driven by population growth, and an ongoing decrease in the size of households, with the combination leading to an increase in the number of households, as well as by growth in personal income.

Improvements in energy efficiency, e.g. due to more-efficient appliances or to better-insulated buildings, will tend to be more than balanced by increase in consumption due to greater size of dwellings and higher use of appliances and electronics.

Development of commercial and institutional dwellings expected to increase in urban areas, especially in UB, which has a city development plan calling for increases in both housing and social infrastructure-commercial, education, recreation, healthcare, and other services.

Energy demand in the household and commercial and other buildings subsectors in Baseline scenario is shown separately in Figure 7.1 and Figure 7.2.

Box 7.1

The Long-range Energy Alternatives Planning (LEAP) System

The Long-range Energy Alternatives Planning system (LEAP) is software tool for energy policy analysis and climate change mitigation assessment. LEAP was developed at the Stockholm Environment Institute (SEI).

LEAP is an integrated modeling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy. LEAP is a demand-driven tool, in that the user first describes current and future energy requirements for households, transport, industry, and other sectors, then uses LEAP to model processes such as electricity generation, coal mining, and other energy supply systems that provide fuels for final consumption. LEAP can be used to account for both energy sector and non-energy sector greenhouse gas (GHG) emission sources and sinks. In addition to tracking GHGs, LEAP can also be used to analyze emissions of local and regional air pollutants. Finally, LEAP can track the direct costs of fuels and resources, of devices and systems that use energy, and of energy supply infrastructure to estimate the relative costs of different approaches to providing energy for an economy.

LEAP is not a model of an energy system, but rather a tool that can be used to create models of different energy systems, where each requires its own unique data structures. LEAP supports a wide range of different modeling methodologies: on the demand side these range from bottom-up, end-use accounting techniques to top-down macroeconomic modeling. LEAP also includes a range of optionally specialized methodologies including stock-turnover modeling for areas such as transport planning. On the supply side, LEAP provides a range of accounting and simulation methodologies that are powerful enough for modeling electric sector generation and capacity expansion planning, but which is also sufficiently flexible and transparent to allow LEAP to easily incorporate data and results from other more specialized models.

LEAP is designed around the concept of long-range scenario analysis. Using LEAP, policy analysts can create and then evaluate alternative scenarios by comparing their energy requirements, their costs and benefits and their environmental impacts.

LEAP was developed by the Stockholm Environment Institute (SEI). More information, including access to the LEAP software and licensing options, a LEAP Users' Guide, examples of studies carried out using LEAP, and other energy-environment modeling resources are available on the LEAP website: www.energycommunity.org.

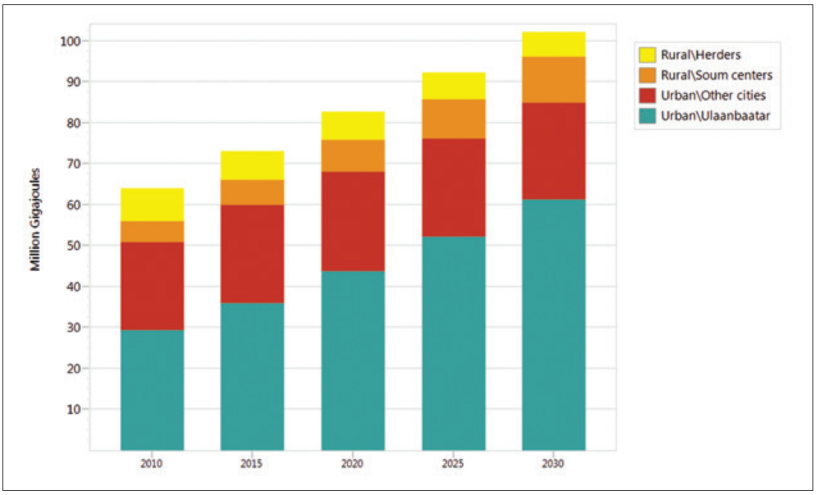


Figure 7.1 Energy demand in the household subsector in Baseline scenario: Million Gigajoules

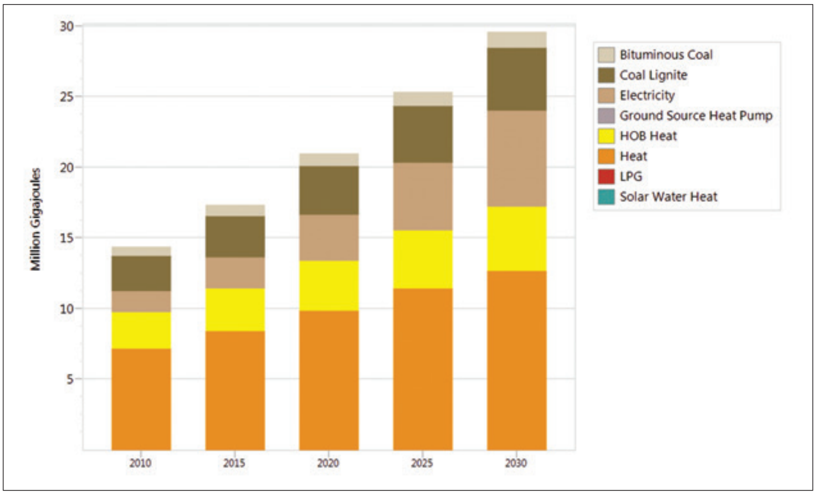


Figure 7.2 Energy demand in the commercial and other buildings in the Baseline scenario

Figure 7.3 presents overall energy demand in the buildings sector in the baseline scenario. Household energy use dominates energy demand in the buildings sector, which is projected to 1.6 times, energy use in the commercial and other building is projected 2 times between 2010 and 2030.

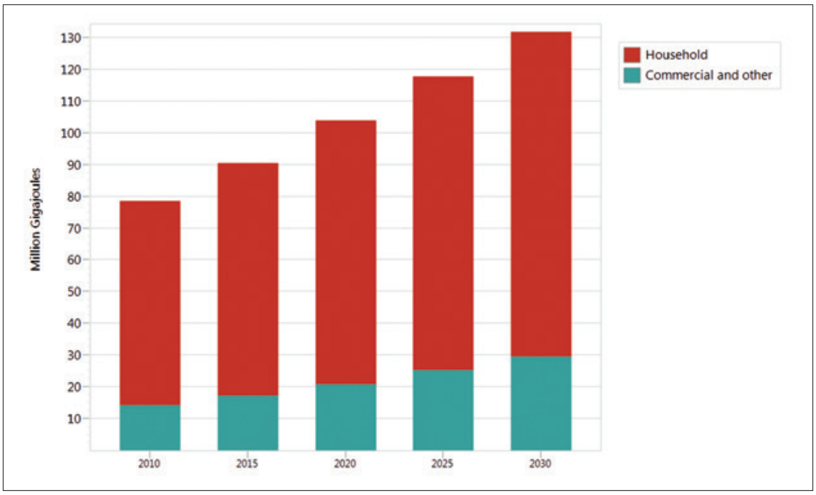


Figure 7.3 Energy demand in the building sector in Baseline scenario: Million Gigajoules

### *2. Industry*

Exploration of fossil and mineral resources were undertaken rapidly in Mongolia, especially for coal and copper. Copper extraction is poised to be a major driver of economic growth in Mongolia, due in large part to the Oyu Tolgoi copper and gold mine, which contains an estimated 25 million tonnes of copper and 1,100 tonnes of gold. The Oyu Tolgoi mine, situated in the south Gobi region, is also expected to be a large electricity user, due to the demands of ore processing equipment such as crushers, grinders, and separators.

The territory of Mongolia may contain as much as 160 billion tonnes of coal resources. By far the largest single deposit of economically recoverable coal reserves is the Tavan Tolgoi deposit, with an estimated 7.5 billion tonnes of mineable reserves of coking coal.

Mongolia also has significant iron ore, gold, and crude oil resources, and production of these commodities may also be poised to grow rapidly in the projection years. Domestic crude oil is mainly exported to China; however, plans exist for Mongolia's first refinery.

In addition to these primary resources, other resource industries will also grow in Mongolia: iron and steel production, cement production, and a host of other secondary industries.

In the baseline scenario, production of most commodities increases rapidly, with energy intensity declining gradually due to the installation of new, more efficient equipment.

The Oyu Tolgoi mine produced 202,200 tonnes of copper in 2015 (Oyu Tolgoi, 2016), rising to roughly 400,000 tonnes in 2021. Production at Mongolia's other copper mines, especially Erdenet, continues at about 123,000 tonnes of copper annually.

Tavan Tolgoi coal output was 9.5 million tonnes in 2010 and will rise to 40 million tonnes in 2030. The output of other coal mines increases from about 15 million tonnes per year in 2010 to 35 million tonnes per year by 2030. The energy intensity of coal mining holds constant in the reference scenario, as gains in the efficiency of equipment are offset by gradually increasing the difficulty in extracting coal and/or, in the case of electricity use, increased use of electricity for mining processes.

Production of iron ore expands from just over 3 million tonnes in 2010 to 7.5 million tonnes in 2020, remaining at that level thereafter.

Mining for gold increased three times between 2010 and 2015, but then remains steady out to 2030. As for copper and iron ore mining, increasingly lower grade ore quality serves to cancel out decreased energy intensity from improved technology, leaving energy intensity essentially unchanged through 2030 in the reference scenario.

Steel and iron production is predicted to increase by 5 percent annually till 2030 with a constant energy demand per unit.

Cement output is expected to increase from 426,000 tonnes in 2011 to 2.5 million tonnes in 2020, and then the rate of growth will slow down to 3.5 million (as the economy matures and growth in the building sector slows) to 3.5 million tonnes in 2030. Modest improvements in energy intensity of output for both electricity (-0.5%) and coal heat (-0.3%) are achieved in the reference scenario.

Figure 7.4 and Figure 7.5 shows the growth in energy consumption by subsector and by fuel, respectively, for the industrial sector.

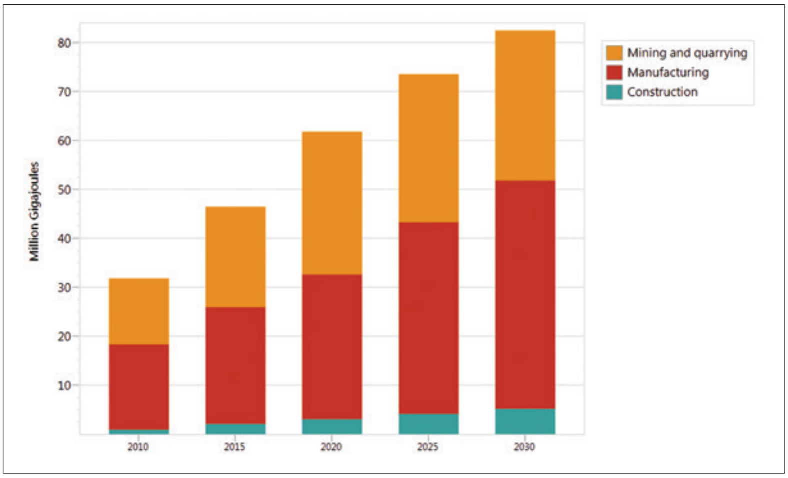


Figure 7.4 Growth in energy consumption by subsector for the industrial sector

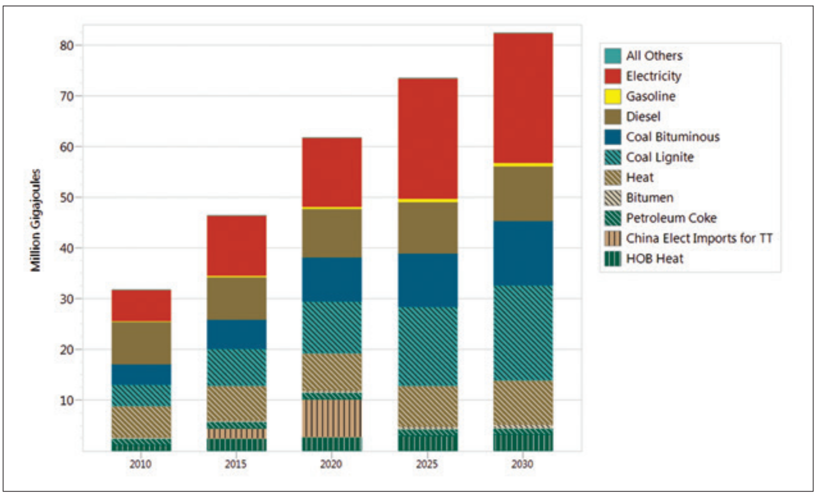


Figure 7.5 Growth in energy consumption by fuel for the industrial sector

### *3. Transport*

Transportation activity has been expanding in Mongolia, both for passenger and freight travel. There has been a strong strong trend increase in the number of private passenger vehicles, with rates of private vehicle ownership over 15 times higher in 2010 than they were in 1990. Passenger travel has increased from 980 passenger-kilometers (p-km) per person in 1990 to 1,200 p-km in 2010. Freight transport has increased from 3,300 tonne-kilometers (t-km) per person in 1990 to 4,400 t-km in 2010, with a large majority by rail (NRSO, 2012).

In the reference scenario, expansion of private passenger travel continues, and although some improvements are expected, efforts to reduce transport energy use are assumed to be modest in scale. The reference scenario is also characterized by a continued increase in personal travel, continued increase in freight travel and a gradual decline in energy intensity of vehicles.

Figure 7.6 and Figure 7.7 show the baseline scenario trends in energy demand in the transport sector, respectively, by subsector and fuel. Freight and passenger road transport dominates.

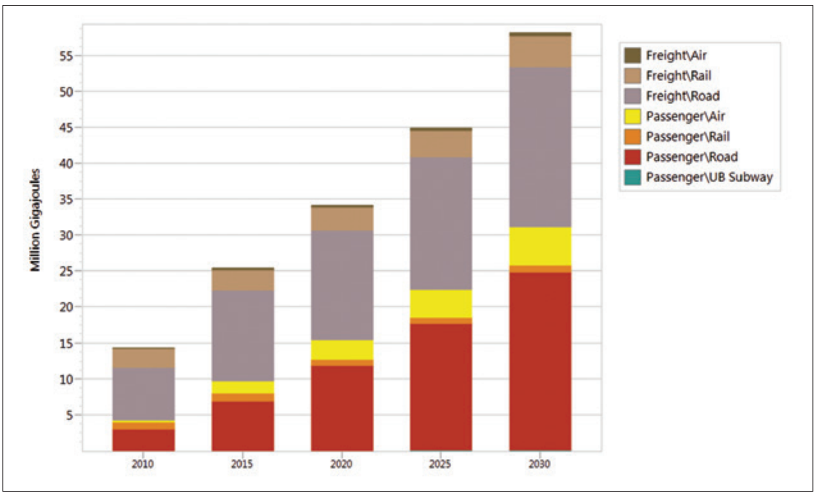


Figure 7.6 Trends in energy demand by subsector in the transport sector

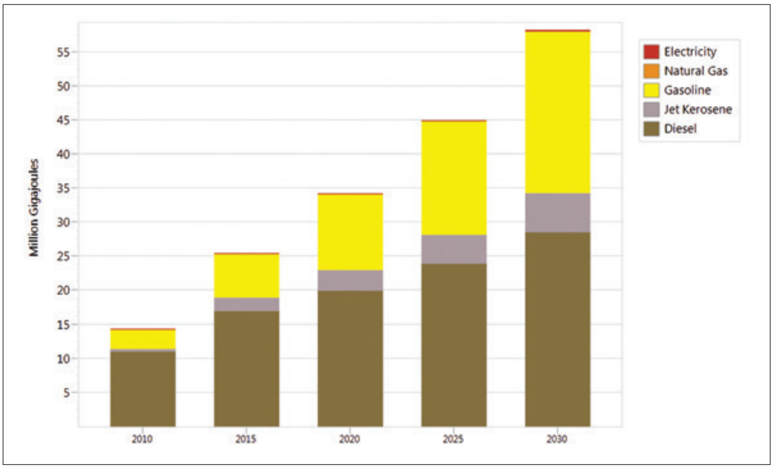


Figure 7.7 Trends in energy demand by fuel in the transport sector

### *4. Agriculture*

Mongolia's agricultural output has been and is still driven strongly by livestock production, with about three-quarters of output (on an economic basis) deriving from livestock, the remainder from crops. Traditionally, livestock production has required relatively limited amounts of commercial energy (oil products, coal, and electricity), although in recent years' herders have adopted greater use of gasoline-powered vehicles, including motorcycles, for herding of animals, and a programme of providing solar PV power for herding households has been very successful (NRSO, 2015a).

Figure 7.8 shows baseline scenario energy demand by fuel. Fuel use is dominated by gasoline use for cars and motorcycle herding.

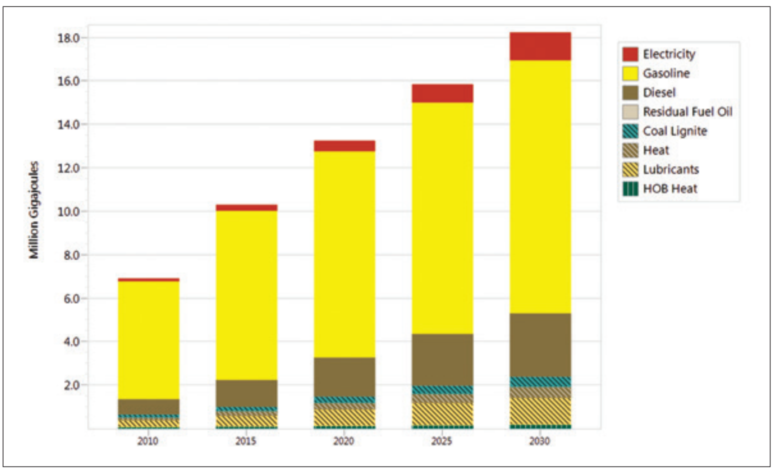


Figure 7.8 Trends in energy demand by fuel in the agriculture sector

### *5. Overall energy demand*

Overall energy demand including all sectors (buildings, industry, transport, and agriculture) is shown in Figure 7.9 and Figure 7.10. Total energy demand is increased 2.2 times from 2010 to 2030.

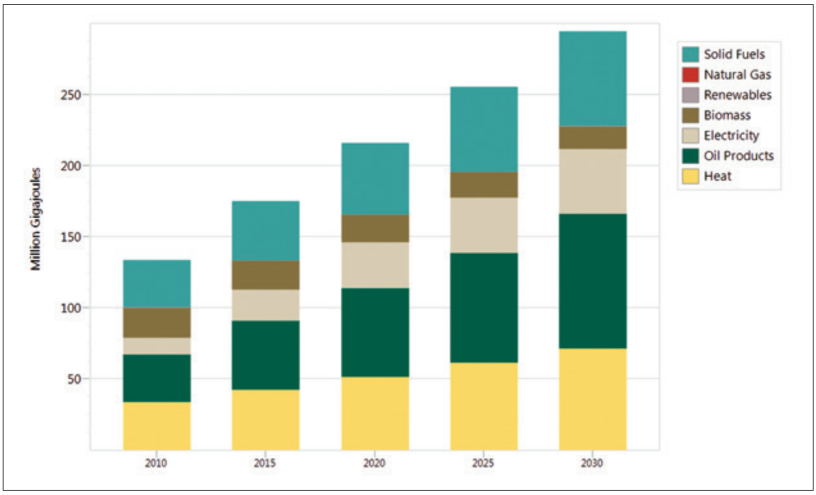


Figure 7.9 Overall energy demands by fuel types Units: Million Gigajoules

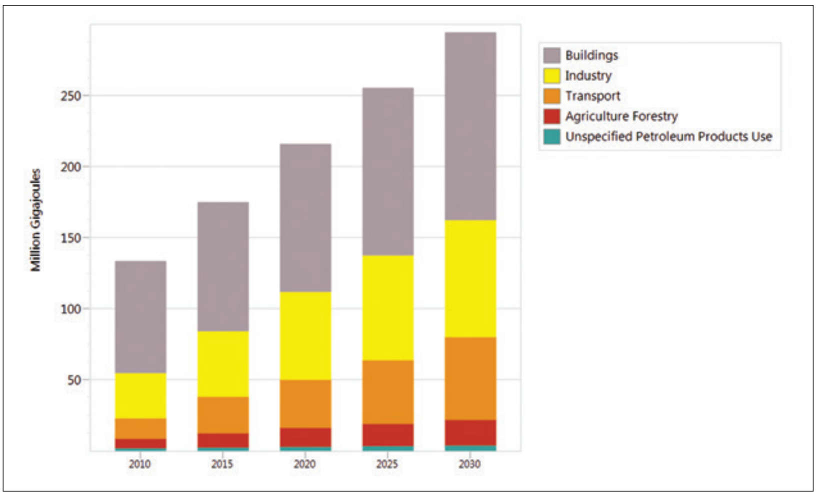


Figure 7.10 Overall energy demands by energy consumer sectors

### 7.1.1.2. Power and heat supply

The baseline scenario sees a continuation of Mongolia's coal-dominated power and central heat supply through the projection period 2030. New subcritical coal-fired units, including CHP and non-CHP units, are the predominant source of new capacity. Existing CHP's will be expanded as shown in Table 7.1.

Table 7.1 Expansion of existing CHPs in the projection period

| Existing CHPs | Capacity in 2010, MW | Expansion | | Total Capacity, MW |
|---|---|---|---|---|
| | | Capacity, MW | Year | |
| CHP-2 | 21.5 | - | - | 21.5 |
| CHP-3 | 136 | 50 | 2014 | 436 |
| | | 250 | 2019 | |
| CHP-4 | 580 | 125 | 2015 | 705 |
| Darkhan CHP | 48 | 35 | 2018 | 83 |
| Erdenet CHP | 28.8 | 35 | 2018 | 63.8 |
| Choibalsan CHP | 36 | 50 | 2021 | 86 |
| Dalanzadgad CHP | 9 | 15 | 2025 | 24 |
| **Total** | **859.3** | **560** | | **1419.3** |

*Source: ERC, 2015; Government, 2016; Parliament, 2016; Parliament, 2015*

New capacities include the Tavan Tolgoi power plant at 150 MW in 2021, 450 MW thereafter and the Baganuur power plant at 350 MW in 2021,700 MW thereafter, Telmen power plant at 100 MW in 2022, West coal-fired power plant at 60 MW in 2026 and Shivee Ovoo power plant at 276 MW in 2026.

About 65 percent of diesel generating units are retired by 2030, as the transmission grid expands and interconnects previously isolated systems.

Through the several large combined heat and power plants, including those operating today, those to be expanded, and those to be built new, a significant portion of the district heat requirements of cities and industries are met. Additional district heat requirements are provided by existing and construction of new heat-only boilers (HOB). The Amgalan heat station with a capacity of 300MW comes in line in 2015 and 2016.

The baseline scenario also includes continued operation of the Salkhit wind farm (50MW) as well as several existing smaller hydro, solar, and wind plants.

Capacity and electricity generation of power plants are shown in Figure 7.11 and Figure 7.12.

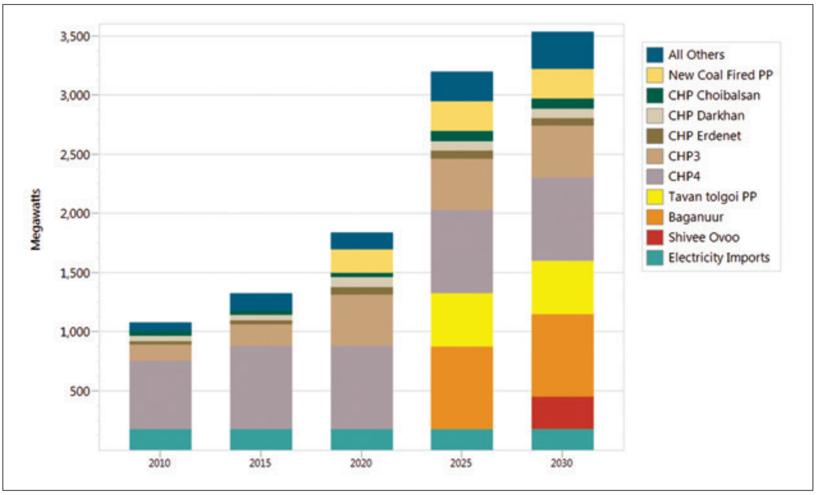


Figure 7.11 Capacity of power plants

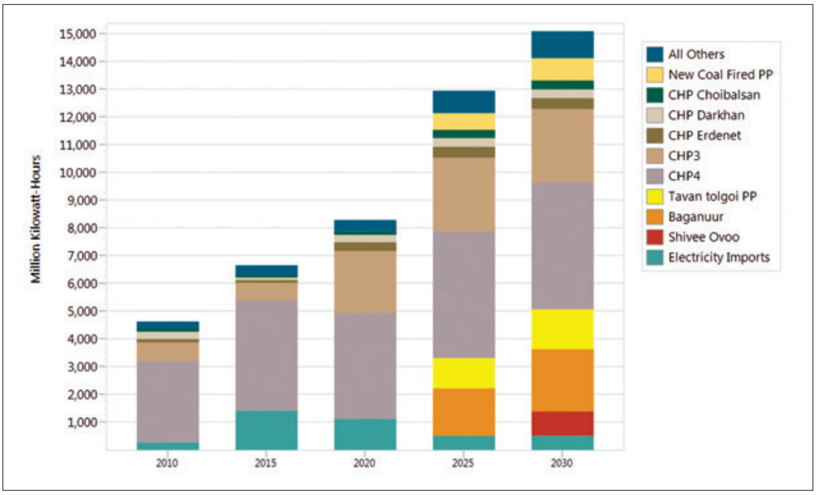


Figure 7.12 Electricity generation of power plants

### 7.1.1.3. Greenhouse gas emissions

Figure 7.13, Figure 7.14 and Figure 7.15 show baseline scenario GHG emissions, respectively, by sector and by generation sources. Electricity generation (including combined heat and power) produces the largest share of GHGs throughout the modeling period, with emissions from coal comprising GHG emissions until 2030. Overall GHG emissions will rise to about 39.8 million tonnes of carbon dioxide equivalent by 2030 (Table 7.2).

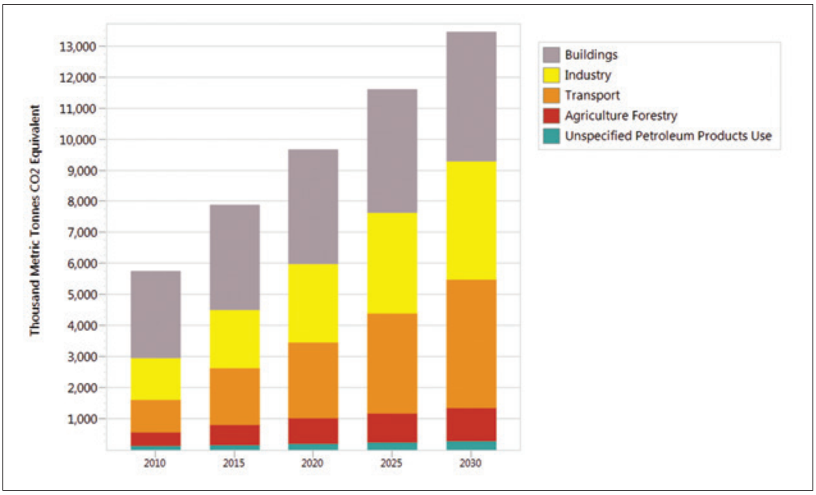


Figure 7.13 GHG emissions from energy demand sectors

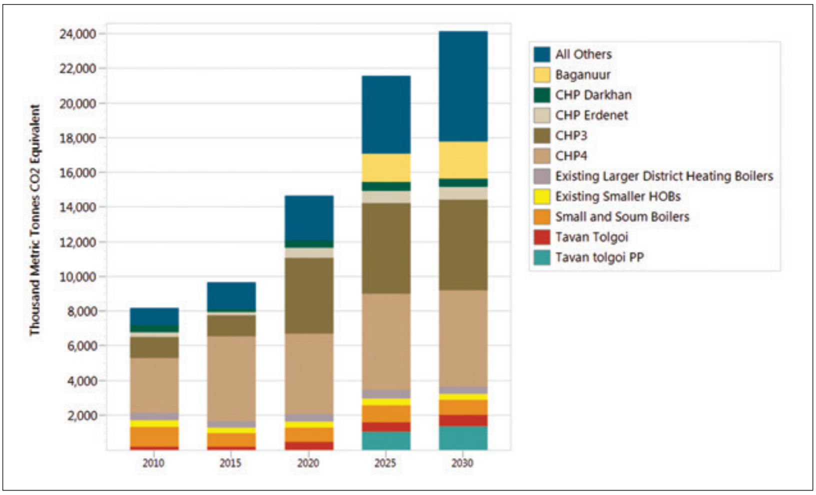


Figure 7.14 GHG emissions from energy generation sources

Chapter 7


Figure 7.15 Overall GHG emissions from the energy sector

Table 7.2 Overall GHG emissions from the energy sector, Gg $CO_2e$

| Branches | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Demand | 5.742 | 7.889 | 9.674 | 11.594 | 13.444 |
| Transformation | 8.149 | 9.514 | 14.479 | 21.370 | 23.864 |
| Total | 13.891 | 17.403 | 24.153 | 32.964 | 37.308 |

## 7.1.2. Non-energy sector

### 7.1.2.1. Industrial process

Energy consumption in the industrial sector is rapidly increasing, due to the development of mining and quarrying and other industries. The projection of GHG emissions from these industries are included in the energy sector above. Therefore, in this sector mineral industry (cement and lime production), metal industry (Iron and Steel Production), Non-Energy Products from Fuels and Solvent Use (Lubricant Use) and Product Uses as Substitutes for Ozone Depleting Substances (Refrigeration and Air Conditioning) are presented. But for the future projection of GHG emissions in the Industrial process, we consider only cement and lime production because GHG emissions from other subsectors are too small.

### *1. Cement and lime production*

*Cement production*

Domestic production of cement has increased from 322500 tonnes in 2010 to 410100 tonnes in 2015 (NRSO, 2015) and is expected to increase 5.4 times in 2020 and 8.5 times in 2030 from the 2015 level, due to a construction of new cement factories and an increase in building construction, and urban and industrial development. Cement demand growth in Mongolia for the period 2010-2030 is shown in Table 7.3.

Table 7.3 Cement demand growth in Mongolia (2010-2030)

| Indicators | 2010 | 2012 | 2014 | 2015 | 2016 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| The total demand, thou. tonnes | 778.4 | 1541.7 | 1917.3 | 1294.4 | 1400 | 2200 | 2700 | 3500 |
| Domestic production, thou.tonnes | 322.5 | 349.4 | 411.3 | 410.1 | 800 | 2200 | 2700 | 3500 |
| Share of the domestic industry | 41.4 | 22.7 | 21,5 | 31.7 | 57.1 | 100 | 100 | 100 |

*Source: NRSO, 2015 and experts' own estimates*

*Lime production*

The production of lime is projected to increase 1.4 times in 2020 and 1.8 times in 2030 from the 2010 level (Table 7.4).

Table 7.4 Lime demand growth in Mongolia (2010-2030)

| Indicators | 2010 | 2012 | 2014 | 2015 | 2016 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Production | 50.20 | 68.20 | 58.00 | 62.80 | 64.67 | 73.52 | 84.59 | 95.65 |

*Source: NRSO, 2015 and experts' own estimates*

### *2. GHG emissions from cement and lime production*

GHG emissions projections until 2030 from the Industrial process are shown in Table 7.5 and Figure 7.16.

In 2030, GHG emissions in cement production are expected to increase by a factor of 8.5, and in the lime production by 1.9 times from the base year 2010.

The total GHG emission from industrial processes will be 7.3 times in 2030 from the base year 2010.

Table 7.5 GHG emissions from the Industrial process, 1000t $CO_2$e

| Years | Cement production, 1000t | Emissions from cement production, $GgCO_2$e | Lime production, 1000t | Emissions from lime production, $GgCO_2$e. | Total GHG emissions |
|---|---|---|---|---|---|
| 2010 | 322.50 | 171.55 | 50.20 | 37.65 | 209.20 |
| 2015 | 410.10 | 170.19 | 62.80 | 47.10 | 217.29 |
| 2020 | 2200.00 | 913.00 | 73.52 | 55.14 | 968.14 |
| 2025 | 2700.00 | 1120.50 | 84.59 | 63.44 | 1183.94 |
| 2030 | 3500.00 | 1452.50 | 95.65 | 71.74 | 1524.24 |

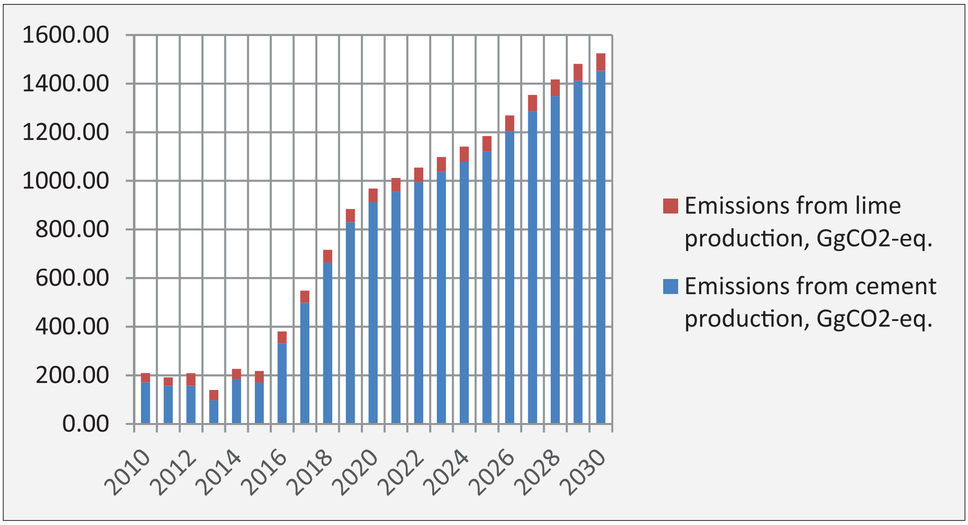


Figure 7.16 GHG emissions from the Industrial process, 1000t $CO_2$e

### 7.1.2.2. Agriculture sector (Livestock)

*1. Projection of livestock population*

The GHG emissions from livestock depend on a number of population of livestock. To make projections of GHG emissions from livestock it is important to forecast how will be changed livestock population in the future.

Modeling of livestock population by linear trend line, Exponential trend line and Polynomial is shown in Figure 7.17.

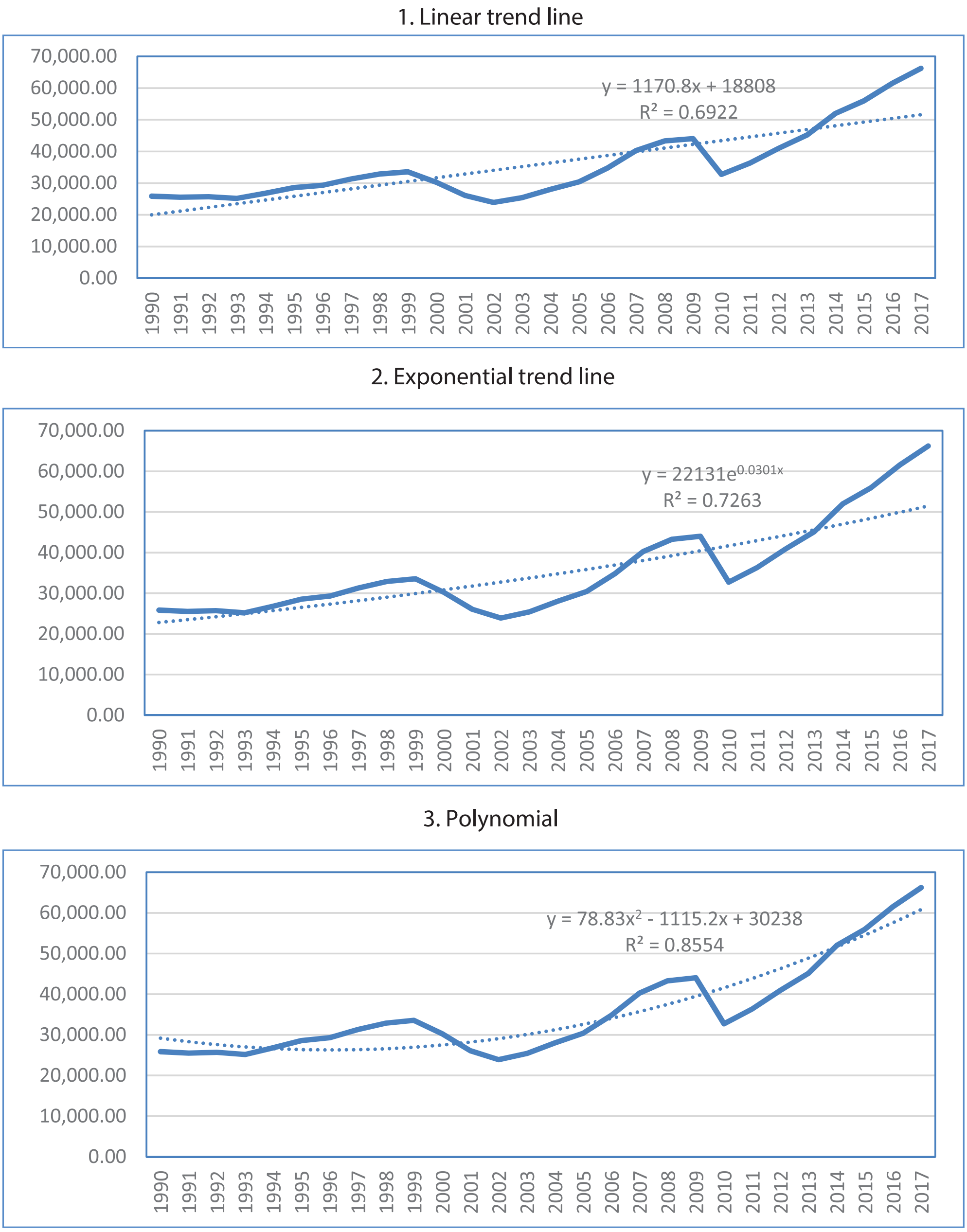


Figure 7.17. Modeling of livestock population

A total quantity of livestock population is projected up to 2030 by using this statistic models and results are shown in Table 7.6.

Table 7.6. Projection of livestock population

| | Exponential | linear | Polynomial | Average |
|---|---|---|---|---|
| 2020 | 56265 | 55103 | 71394 | 60921 |
| 2021 | 57985 | 56274 | 75243 | 63167 |
| 2022 | 59757 | 57444 | 79250 | 65484 |
| 2023 | 61583 | 58615 | 83414 | 67871 |
| 2024 | 63464 | 59786 | 87736 | 70329 |
| 2025 | 65404 | 60957 | 92216 | 72859 |
| 2026 | 67402 | 62128 | 96853 | 75461 |
| 2027 | 69462 | 63298 | 101648 | 78136 |
| 2028 | 71585 | 64469 | 106600 | 80885 |
| 2029 | 73772 | 65640 | 111710 | 83707 |
| 2030 | 76026 | 66811 | 116978 | 86605 |

*Source: Own calculation results*

Table 7.7. Balance of livestock population

| | At the beginning of the year | Number of survivals | Losses of adult animals | Livestock for consumption | At the end of the year (Baseline scenario) |
|---|---|---|---|---|---|
| 2018 | 66219.0 | 21190.1 | 3311.0 | 15892.6 | 68206 |
| 2019 | 68205.6 | 21825.8 | 3410.3 | 16369.3 | 70252 |
| 2020 | 70251.7 | 22480.6 | 4215.1 | 16860.4 | 71657 |
| 2021 | 71656.8 | 22930.2 | 5016.0 | 17197.6 | 72373 |
| 2022 | 72373.3 | 23159.5 | 5066.1 | 17369.6 | 73097 |
| 2023 | 73097.1 | 23391.1 | 3654.9 | 17543.3 | 75290 |
| 2024 | 75290.0 | 24092.8 | 3764.5 | 18069.6 | 77549 |
| 2025 | 77548.7 | 24815.6 | 3877.4 | 18611.7 | 79875 |
| 2026 | 79875.1 | 25560.0 | 3993.8 | 19170.0 | 82271 |
| 2027 | 82271.4 | 26326.8 | 4113.6 | 19745.1 | 84740 |
| 2028 | 84739.5 | 27116.7 | 5084.4 | 20337.5 | 86434 |
| 2029 | 86434.3 | 27659.0 | 5186.1 | 20744.2 | 88163 |
| 2030 | 88163.0 | 28212.2 | 5289.8 | 21159.1 | 89926 |

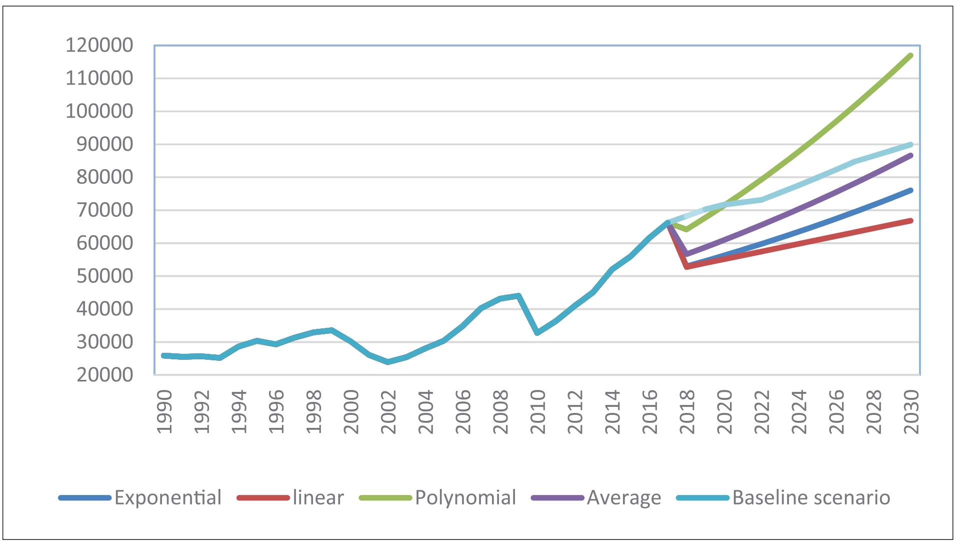


Figure 7.18. Projection of livestock population

### *2. GHG emissions from livestock*

Methane emission from livestock in baseline scenario is projected based on the livestock population and results are shown in Table 7.8.

Table 7.8. Methane emission projections from livestock

| | Livestock population, 1000 heads | Methane emissions from livestock, 1000t CH4 | GHG emissions from livestock, Gg $CO_2$e |
|---|---|---|---|
| 2005 | 30,399 | 278.58 | 5,850.18 |
| 2010 | 32,730 | 298.72 | 6,273.12 |
| 2011 | 36,336 | 327.31 | 6,873.51 |
| 2012 | 40,921 | 365.37 | 7,672.77 |
| 2013 | 45144.3 | 405.61 | 8,517.81 |
| 2014 | 51982.5 | 468.57 | 9,839.97 |
| 2015 | 55979.8 | 498.78 | 10,474.38 |
| 2016 | 61549.0 | 548.40 | 11,516.43 |
| 2017 | 66219.0 | 590.01 | 12,390.24 |
| 2018 | 68205.6 | 607.71 | 12,761.95 |
| 2019 | 70251.7 | 625.94 | 13,144.80 |
| 2020 | 71656.8 | 638.46 | 13,407.70 |
| 2021 | 72373.3 | 644.85 | 13,541.77 |
| 2022 | 73097.1 | 651.30 | 13,677.20 |
| 2023 | 75290.0 | 670.83 | 14,087.51 |
| 2024 | 77548.7 | 690.96 | 14,510.14 |
| 2025 | 79875.1 | 711.69 | 14,945.43 |
| 2026 | 82271.1 | 733.04 | 15,393.75 |
| 2027 | 84739.5 | 755.03 | 15,855.61 |
| 2028 | 86434.3 | 770.13 | 16,172.72 |
| 2029 | 88163.0 | 785.53 | 16,496.18 |
| 2030 | 89926.0 | 801.24 | 16,826.05 |

*Source: MET, 2017; Own calculation results*

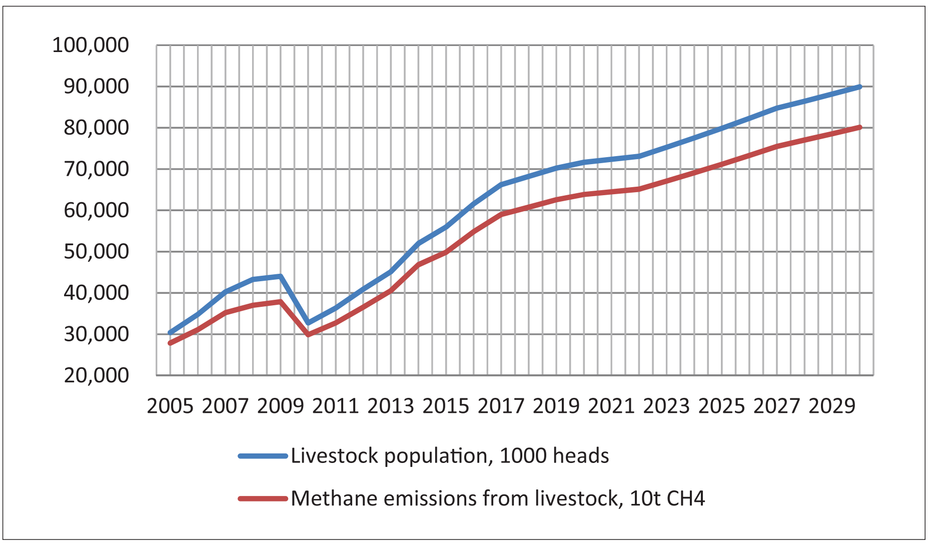


Figure 7.19. Projection of methane emissions from livestock (Baseline scenario)

### 7.1.2.3. Waste sector

The projection of GHG emissions in the waste sector is calculated based on statistics of emissions in the period of 2000-2014 (MET, 2017) (Figure 7.20). In the Figure, the Linear Regression and the Exponential Regression each display an $R^2$ value. Both $R^2$ values show that there is a strong positive linear correlation between GHG emissions and number of years. For the projection of GHG emissions in the waste sector, it is used the linear function with $R^2$ =0.9765.

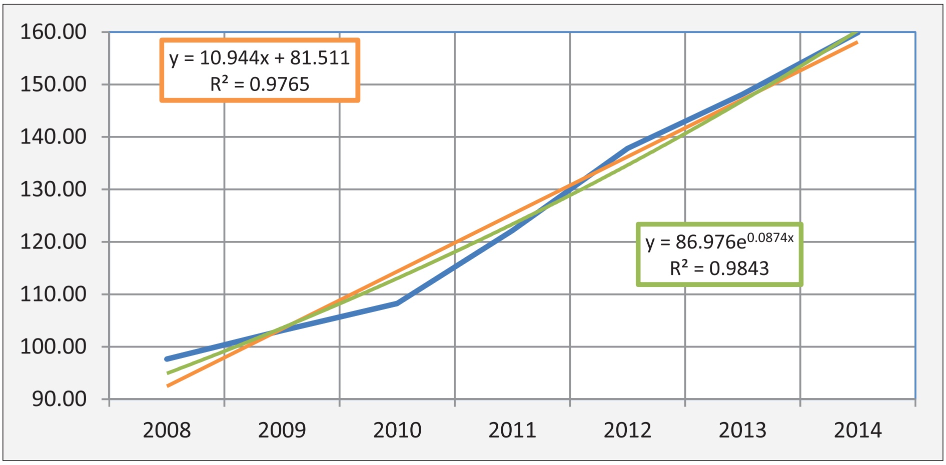


Figure 7.20 Correlation between GHG emissions in waste sector and a number of years.

Table 7.9 Projection of GHG emissions from waste sector, Gg $CO_2e$

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| GHG* Inventory | 55.62 | 55.71 | 66.04 | 83.33 | 108.26 | 159.91 | | | | |
| GHG Projection | | | | | | | 169.06 | 223.78 | 278.50 | 333.22 |

*Source: MET, 2017

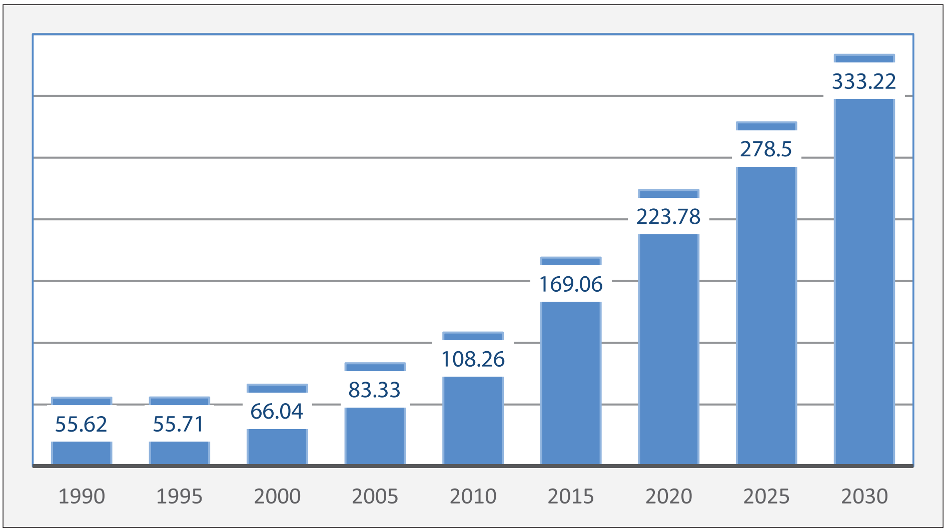


Figure 7.21 Projection of GHG emissions from the Waste sector (Baseline scenario)

### 7.1.2.4. Forestry

The key policy document on forest management is "State Policy on Forest" 2015 and the objectives are to reduce area affected by forest fire by up to 30% in 2020 and 70% in 2030 and to increase naturally grown and cultivated forests areas by 310,000 ha in 2020 and 1,500,000 ha in 2030 and to reduce GHG emissions from deforestation and forest degradation by 2% in 2020 and by 5% in 2030.

The Green Development Policy states to enhance forest absorption of GHGs by intensifying reforestation efforts and expanding forest areas by 8.5% in 2020 and 9% in 2030.

The forecast of change in biomass in Mongolia is shown in Figure 7.22 (MET, 2017).

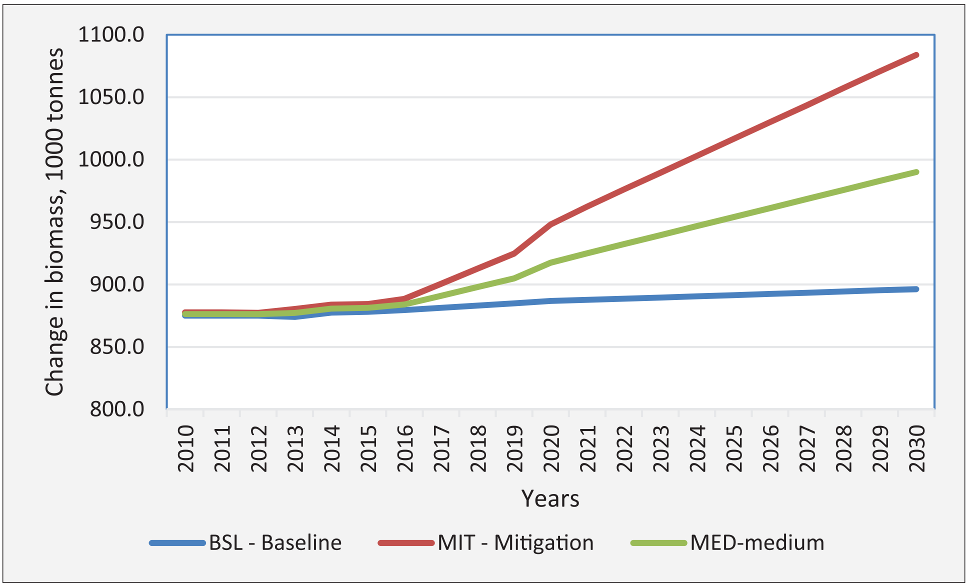


Figure 7.22 The forecast of change in biomass in Mongolia

As indicated in the estimation, carbon sink potential will increase by 7% in 2020 and 17% in 2030 in the Baseline scenario (MET, 2017).

### 7.1.3. Overall GHG emission projections

The total GHG emissions (without LULUCF) during the projection period are expected to gradually increase due to mostly to the increase in the energy industry and energy consumption by economic sectors and livestock population.

The aggregated projections of GHG emissions by sector are shown in Table 7.10 and Figure 7.23.

Table 7.10. Projections of GHG emissions by sector up to 2030, Gg $CO_2$e

| Sectors | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Energy | 13891 | 17403 | 24153 | 32964 | 37308 |
| Industrial process/Cement and lime | 209 | 217 | 968 | 1184 | 1524 |
| Agriculture/Livestock (Methane from Enteric fermentation and Manure management) | 6273 | 10474 | 13408 | 14949 | 16826 |
| Agriculture/Livestock (Total Nitrous oxide ($N_2O$) emissions) | 4266 | 7253 | 9284 | 10348 | 11651 |
| Waste | 108 | 169 | 224 | 279 | 333 |
| Total | 24747 | 35516 | 48037 | 59724 | 67642 |

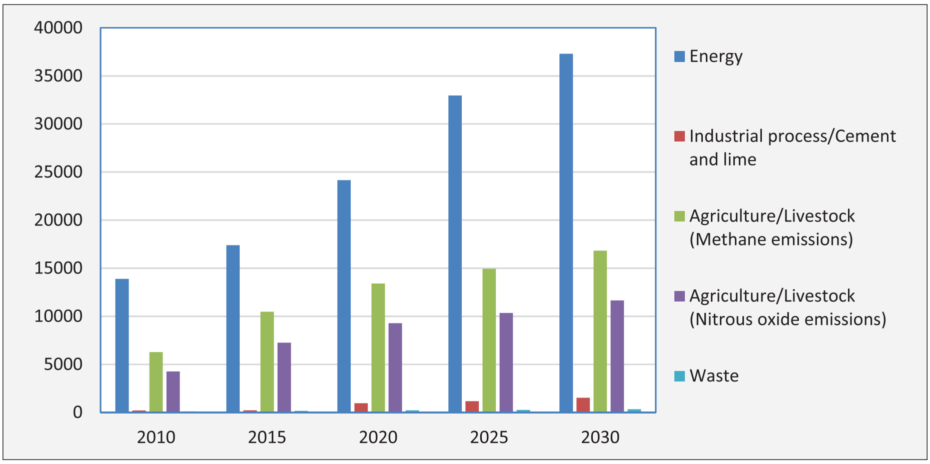


Figure 7.23. Projections of GHG emissions by sector up to 2030, Gg

The projections indicate that Mongolia's overall GHG emissions will rise above 2010 levels by about 1.9 times in 2020 and 2.7 times in 2030 (Table 7.10).

During the period 2010-2030, emissions from the energy sector are expected to increase by 2.68 times while those from the industrial sector/cement and lime production will increase by 7.3 times and emissions from waste by 3.1 times. At the same time, emissions from agriculture sector/livestock are projected to increase 2.7 times (Figure 7.23).

Per total GHG emissions by sectors, the energy sector accounted for 56.1% of total GHG emissions in 2010, but will by 55.1% in 2030. The second largest source of GHG emissions is the agriculture sector/livestock. The share of agriculture sector/livestock in total GHG emissions was 42.6% in 2010 and will be 42.1% in 2030. GHG emissions from industrial process/(cement and lime) and waste sectors accounted for 1.2% in 2010 and 2.8% in 2030 (Figure 7.24).

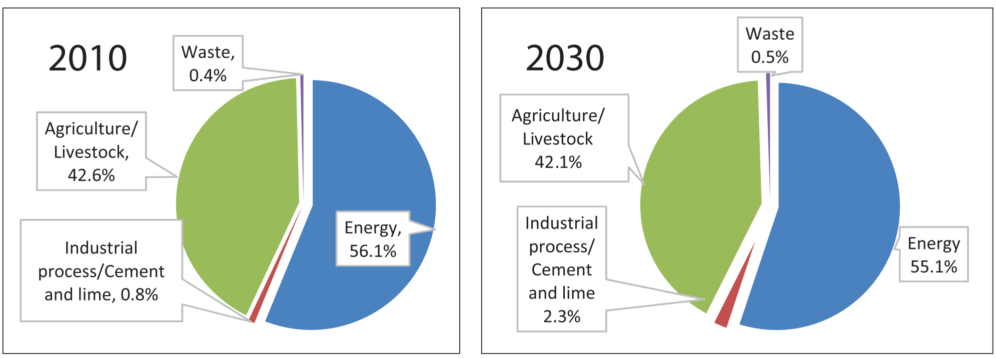


Figure 7.24. Total GHG emissions by sectors in 2010 and 2030

## 7.2. Development of mitigation scenarios

### 7.2.1. GHG Mitigation scenarios in the energy sector

#### 7.2.1.1. Renewable energy scenario

The following mitigation scenarios have been developed by using LEAP Module.

a. Hydropower power plants
b. Wind parks
c. Large-scale solar PV

The Table 7.11 shows renewable energy sources to be implemented up to 2030.

Table 7.11 Capacity of renewable energy sources for electricity generation, MW

| | Type of renewable energy sources | Location | 2016-2020 | 2021-2025 | 2026-2030 |
|---|---|---|---|---|---|
| 1 | Hydropower plants | | | | |
| | Eg HPP | Bulgan, Khutag-Undur | | 315 | |
| | HPP in Selenge River (Shuren) | Bulgan, Khangal | | | 300 |
| | Bayan-Ulzii Altantsogts HPP in Khovd river | Bayan-Ulzii Altantsugts | | 92.8 | |
| | | | | | |
| 2 | Wind farms | | | | |
| | Tsetsii wind farm (Clean Energy Asia LLC) | Umnugovi, Tsogtstsutsii | 50 | | |
| | Oyu Tolgoi wind farm (Cleantech LLC) | Umnu-Govi, Khanbogd | 102 | 148 | 200 |
| | Sainshand wind warm (Sainshand wind park LLC) | Dornogovi, Sainshand | 52 | | |
| | Wind farm "Aydiner global" Co., Ltd | Govisumber, Sumber | | 50.4 | |
| | | | | | |
| 3 | Large-scale solar PV | | | | |
| | Solar PV in Darkhan city | Darkhan city | 10 | | |
| | Monnaran Solar PV | Ulaanbaatar, Songinokhairkhan | 10 | | |
| | Kharkhorin Solar PV | Uvurkhangai, Kharkhorin | | 30 | |
| | Hushug Solar PV | Tuv, Sergelen | 50 | | |
| | Large scale solar PV in Gobi region | Umnugovi aimag | | | 100 |
| | Solar PV in Taishir | Govi-Altai, Taishir | | 10 | |
| | Solar PV in Durgun | Khovd, Durgun | | 10 | |
| | | | | | |
| 4 | Total | | 274 | 656.2 | 600 |

*Source: Government, 2016; Parliament, 2016, Parliament, 2015, and Ministry of Energy*

The GHG emission reductions after implementation of renewable energy mitigation scenario are calculated by using LEAP model and results are shown in Table 7.12 and Figure 7.25.

Table 7.12 Renewable energy mitigation scenario: GHG emissions, Gg $CO_2e$

| Scenarios | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Reference | 13,891.0 | 17,403.0 | 24,153.0 | 32,964.0 | 37,308.0 |
| HYDRO PP TOTAL | 13,891.0 | 17,403.0 | 24,153.0 | 30,579.0 | 34,959.0 |
| SOLAR PV TOTAL | 13,891.0 | 17,403.0 | 23,881.0 | 32,752.0 | 36,919.0 |
| WIND PP TOTAL | 13,891.0 | 17,403.0 | 23,180.0 | 32,031.0 | 36,202.0 |
| RE ALL | 13,891.0 | 17,403.0 | 22,907.0 | 29,230.0 | 33,431.0 |

The Table 7.12 shows that Renewable energy mitigation scenario could reduce total GHG emissions in the energy sector from 37,308.00 Gg $CO_2e$ (Reference scenario) to 33,431.00 Gg $CO_2e$ in the year 2030.

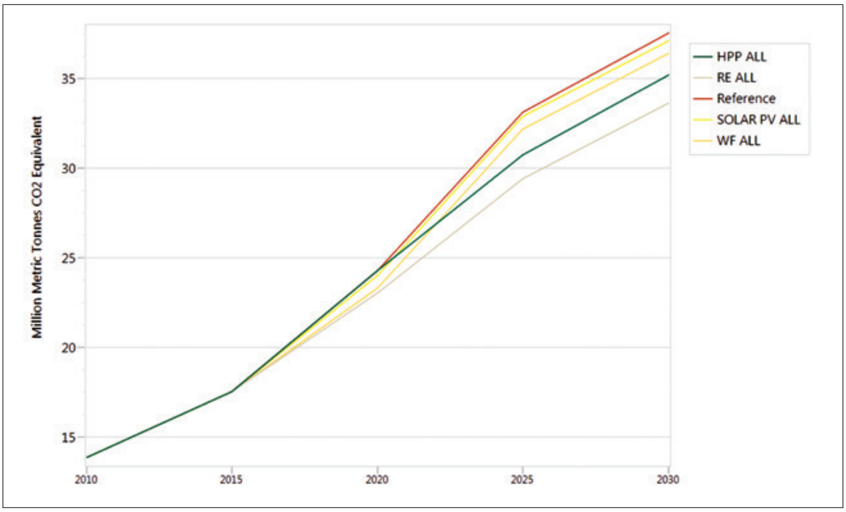


Figure 7.25 Renewable energy mitigation scenario: GHG emissions, Gg $CO_2e$

### 7.2.1.2. Efficiency improvement and energy saving in power plants, utilities and energy consumers

The following mitigation scenarios have been developed by using LEAP Module.

a. Efficiency improvement of new coal-fired power plants by using supercritical pressure coal combustion technology;

b. Efficiency improvement of Heat only boilers;
c. Reduction of electricity transmission and distribution losses.
d. Efficient electric lighting in households
e. Demand side management at designated energy consumers

Assumptions for coal-fired power plant efficiency improvement and for efficiency improvement of Heat only boilers are shown in Table 7.13 and Table 7.14.

Table 7.13 Assumptions for coal-fired power plant efficiency improvement

| Coal-fired power plants | Reference (BAU) scenario (High-pressure technology) | Mitigation scenario (Super-critical pressure technology) |
|---|---|---|
| Tavan Tolgoi coal-fired power plant | 35 | 43 |
| Baganuur coal-fired power plant | 35 | 43 |
| Shivee ovoo coal-fired power plant | 30 | 43 |

*Source: Parliament, 2015*

Table 7.14 Assumptions for efficiency improvement of Heat only boilers

| Heat only boilers | Efficiency, % | |
|---|---|---|
| | Reference (BAU) scenario | Mitigation scenario |
| Existing small and soum HOBs | 39.0 | |
| Improved small and soum HOBs | | 70.0 |
| Existing large district heating boilers | 56.6 | |
| Improved large district heating boilers | | 75.0 |

*Source: MEGD, 2014*

The State Policy for Energy Sector which was approved in 2015 by the Parliament aims to a reliable and efficient supply of energy to meet the increasing energy demands of the country. The Policy will be implemented in two phases (between 2015-2023 and 2024-2030). The target outcomes of the policy related to Transmission & Distribution Loss are shown in Table 7.15 the targets in this table are used for calculation of GHG mitigation scenario in LEAP model.

Table 7.15 The target outcomes of the policy related to Transmission & Distribution Loss

| Indicators | 2014 /Base year/ | 1st stage /by 2023 / | 2nd stage /by 2030/ |
|---|---|---|---|
| Transmission & Distribution Loss /excluding Oyu-Tolgoi/ | 13.7% | 10.8% | 7.8% |

*Source: Parliament, 2015*

*Efficient lighting*

*Technology penetration:* A programme to install efficient lighting systems could reduce electricity consumed in the urban household using compact fluorescent (CFL), light emitting diodes (LED) and other technologies. Assume that the programme starts in 2019 and can reach 40% of all urban households by 2025 and 80% in 2030.

*Technology performance:* Efficient lighting can be assumed to consume only 30% of the electricity used by conventional lighting in urban households.

*Demand side management at designated energy consumers*

The Ministry of Energy has identified 231 entities as large electricity consumers and 321 entities as large heat consumers. In terms of electricity and heat consumption, 65% is accounted by the government-owned facilities and 35% coming from the private sector.

The share of above-identified large electricity and heat consumers is big in total county's electricity and heat consumption, namely 35.7%, and 34.15% respectively.

Per ADB study in 2016 "Assessing Energy Efficiency Potential in Mongolia" (IIEC, 2016), The Energy saving potential in Mongolian industries is 15%-30% of total energy consumption.

For the mitigation scenario, it is assumed that energy saving potential without or with very small investment cost at designated energy consumers is about 15% of total energy consumption.

The results of GHG mitigation scenario for coal-fired power plants heat only boilers and transmission and distribution lines are shown in Table 7.16 and Figure 7.26.

Table 7.16 Scenario for Efficiency improvement and energy saving in power plants, utilities and energy consumers

| Scenarios | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| **Reference** | **13,891.0** | **17,403.0** | **24,153.0** | **32,964.0** | **37,308.0** |
| Coal Plant EE | 13,891.0 | 17,403.0 | 24,153.0 | 32,458.0 | 36,346.0 |
| HOB EE | 13,891.0 | 17,403.0 | 23,678.2 | 32,080.7 | 36,393.7 |
| T&D losses | 13,891.0 | 17,403.0 | 23,827.3 | 32,256.5 | 36,204.7 |
| Efficient lighting | 13,891.0 | 17,403.0 | 24,083.8 | 32,764.6 | 36,960.6 |
| DSM in Industry | 13,891.0 | 17,403.0 | 23,671.2 | 32,448.2 | 36,591.5 |
| ENERGY EFFICIENCY ALL | 13,891.0 | 17,403.0 | 22,815.5 | 30,369.7 | 33,647.0 |

The Table 7.16 shows that Efficiency improvement and energy saving mitigation scenario could reduce total GHG emissions in the energy sector from 37,308.0 Gg $CO_2$e (Reference scenario) to 33,657.0 Gg $CO_2$e in the year 2030.

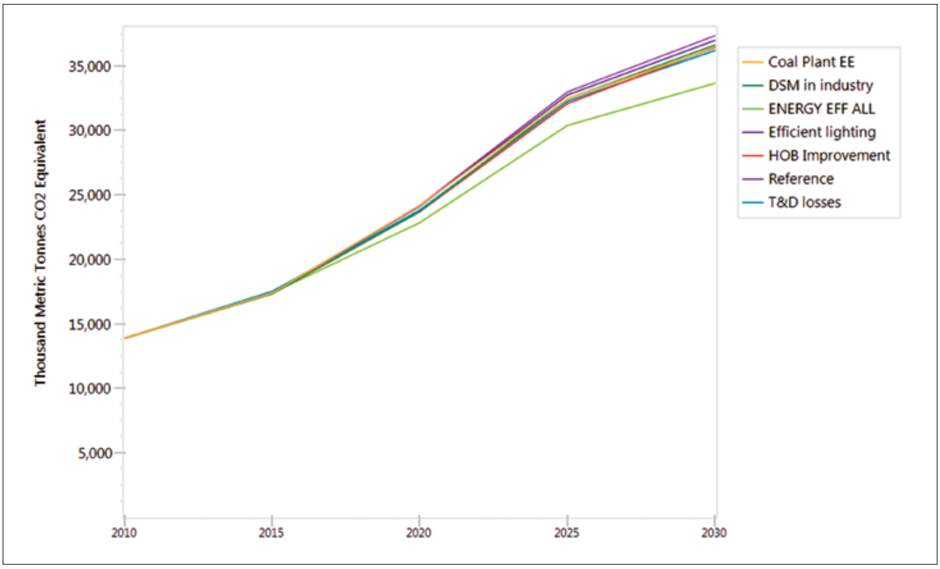


Figure 7.26 Scenario for efficiency improvements in power plants HOBs and utilities

Table 7.17 RE and EE Scenarios

| Scenarios | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| **Reference** | **13,891.0** | **17,403.0** | **24,153.0** | **32,964.0** | **37,308.0** |
| RENEWABLE ALL | 13,891.0 | 17,403.0 | 22,907.0 | 29,230.0 | 33,431.0 |
| ENERGY EFFICIENCY ALL | 13,891.0 | 17,403.0 | 22,815.5 | 30,369.7 | 33,647.0 |
| ENERGY SECTOR | 13,891.0 | 17,403.0 | 21,568.1 | 26,591.2 | 30,108.0 |

The Table 7.17 shows that all mitigation scenarios in the Energy sector could reduce total GHG emissions in the energy sector from 37,308.0 Gg $CO_2$e in Reference scenario to 30,108.0 Gg $CO_2$e in the year 2030.

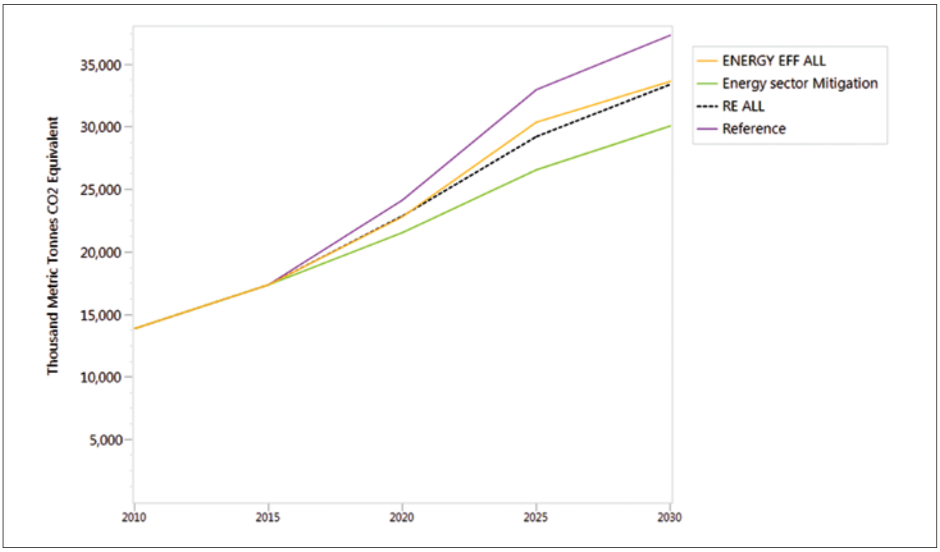


Figure 7.27 Mitigation scenarios in the energy sector

### 7.2.2. GHG Mitigation scenarios in Agriculture sector

The main mitigation scenario for agriculture sector is to reduce livestock population by increasing the volume of meat export to Russia, China and other countries.

Recently, the meat export is too small, notably 3000 tons in 2013, 2300 tons in 2014 and 4700 tons in 2015 (NRSO, 2015).

The assumptions for GHG mitigation scenario in Agriculture sector – to increase meat export:

- The number of survivals is calculated as 32% of livestock population at the beginning of the year
- Losses of adult animals is calculated as 5% of livestock population at the beginning of the year
- Livestock for consumption is calculated as 24% of livestock population at the beginning of the year
- Meat export for the period 2021-2030 is calculated as 6-8% of livestock population at the beginning of the year

The calculation results are shown in Table 7.18. The total population of livestock will be increased from 68 million in 2021 to 83 million in 2030 as result of meat export of 4-7 million domestic animals annually.

Table 7.18. Total population of livestock for GHG mitigation scenario, 1000 heads

| Years | 1000 head | | | | | |
|---|---|---|---|---|---|---|
| | At the beginning of the year | Number of survivals | Losses of adult animals | Livestock for consumption | Export | At the end of the year |
| 2021 | 71656.8 | 22930.2 | 5016 | 17197.6 | 4299 | 68074 |
| 2022 | 72373.3 | 23159.5 | 5066.1 | 17369.6 | 4342 | 68755 |
| 2023 | 73097.1 | 23391.1 | 3654.9 | 17543.3 | 4386 | 70904 |
| 2024 | 75290.0 | 24092.8 | 3764.5 | 18069.6 | 4517 | 73031 |
| 2025 | 77548.7 | 24815.6 | 3877.4 | 18611.7 | 5041 | 74835 |
| 2026 | 79875.1 | 25560 | 3993.8 | 19170.0 | 5591 | 76680 |
| 2027 | 82271.4 | 26326.8 | 4113.6 | 19745.1 | 6170 | 78569 |
| 2028 | 84739.5 | 27116.7 | 5084.4 | 20337.5 | 6779 | 79655 |
| 2029 | 86434.3 | 27659 | 5186.1 | 20744.2 | 6915 | 81248 |
| 2030 | 88163.0 | 28212.2 | 5289.8 | 21159.1 | 7053 | 82873 |

Methane ($CH_4$) and Nitrous oxide ($N_2O$) emissions for Baseline and Mitigation scenarios are shown in Table 7.19 and Figure 7.28. GHG emissions will be reduced in 2030 from 28476.8 Gg $CO_2$e (Baseline scenario) to 26243.4 Gg $CO_2$e (Mitigation scenario) as result of meat export for the period 2021-2030.

Table 7.19 Methane ($CH_4$) and Nitrous oxide ($N_2O$) emissions for Baseline and Mitigation scenarios form livestock sector, Gg $CO_2$e

| Year | Baseline scenario | | | | Mitigation scenario | | | |
|---|---|---|---|---|---|---|---|---|
| | Livestock population, 1000 heads | $CH_4$ | $N_2O$ | Total | Livestock population, 1000 heads | $CH_4$ | $N_2O$ | Total |
| 2005 | 30399.8 | 5850.2 | 3996.0 | 9846.2 | 30399.8 | 5850.2 | 3996.0 | 9846.2 |
| 2006 | 34802.9 | 6531.6 | 4503.0 | 11034.6 | 34802.9 | 6531.6 | 4503.0 | 11034.6 |
| 2007 | 40263.9 | 7392.6 | 5142.0 | 12534.6 | 40263.9 | 7392.6 | 5142.0 | 12534.6 |
| 2008 | 43117.9 | 7776.1 | 5448.0 | 13224.1 | 43117.9 | 7776.1 | 5448.0 | 13224.1 |
| 2009 | 44024.0 | 7960.5 | 5548.0 | 13508.5 | 44024.0 | 7960.5 | 5548.0 | 13508.5 |
| 2010 | 32729.5 | 6273.1 | 4266.0 | 10539.1 | 32729.5 | 6273.1 | 4266.0 | 10539.1 |
| 2011 | 36335.7 | 6873.5 | 4711.0 | 11584.5 | 36335.7 | 6873.5 | 4711.0 | 11584.5 |
| 2012 | 40920.9 | 7672.8 | 5267.0 | 12939.8 | 40920.9 | 7672.8 | 5267.0 | 12939.8 |
| 2013 | 45144.3 | 8517.8 | 5836.0 | 14353.8 | 45144.3 | 8517.8 | 5836.0 | 14353.8 |
| 2014 | 51982.5 | 9840.0 | 6735.0 | 16575.0 | 51982.5 | 9840.0 | 6735.0 | 16575.0 |
| 2015 | 55979.8 | 10474.4 | 7252.7 | 17727.1 | 55979.8 | 10474.4 | 7252.7 | 17727.1 |
| 2016 | 61549.0 | 11516.4 | 7974.2 | 19490.6 | 61549.0 | 11516.4 | 7974.2 | 19490.6 |
| 2017 | 66219.0 | 12390.2 | 8579.3 | 20969.5 | 66219.0 | 12390.2 | 8579.3 | 20969.5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2018 | 68205.6 | 12761.9 | 8836.7 | 21598.6 | 68205.6 | 12761.9 | 8836.7 | 21598.6 |
| 2019 | 70251.7 | 13144.7 | 9101.8 | 22246.5 | 70251.7 | 13144.7 | 9101.8 | 22246.5 |
| 2020 | 71656.8 | 13407.7 | 9283.8 | 22691.5 | 71656.8 | 13407.7 | 9283.8 | 22691.5 |
| 2021 | 72373.3 | 13541.9 | 9376.6 | 22918.5 | 68074.0 | 12737.3 | 8819.6 | 21556.9 |
| 2022 | 73097.1 | 13677.3 | 9470.4 | 23147.7 | 68755.0 | 12864.6 | 8907.9 | 21772.5 |
| 2023 | 75290.0 | 14087.4 | 9754.5 | 23842.0 | 70904.0 | 13267.0 | 9186.3 | 22453.3 |
| 2024 | 77548.7 | 14510.2 | 10047.2 | 24557.3 | 73031.0 | 13664.9 | 9461.8 | 23126.7 |
| 2025 | 79875.1 | 14945.5 | 10348.6 | 25294.1 | 74835.0 | 14002.4 | 9695.6 | 23698.0 |
| 2026 | 82271.1 | 15393.8 | 10659.0 | 26052.8 | 76680.0 | 14347.6 | 9934.6 | 24282.2 |
| 2027 | 84739.5 | 15855.6 | 10978.8 | 26834.4 | 78569.0 | 14701.1 | 10179.3 | 24880.4 |
| 2028 | 86434.3 | 16172.7 | 11198.4 | 27371.1 | 79655.0 | 14904.3 | 10320.0 | 25224.3 |
| 2029 | 88163.0 | 16496.1 | 11422.3 | 27918.5 | 81248.0 | 15202.3 | 10526.4 | 25728.7 |
| 2030 | 89926.0 | 16826.0 | 11650.8 | 28476.8 | 82873.0 | 15506.4 | 10737.0 | 26243.4 |

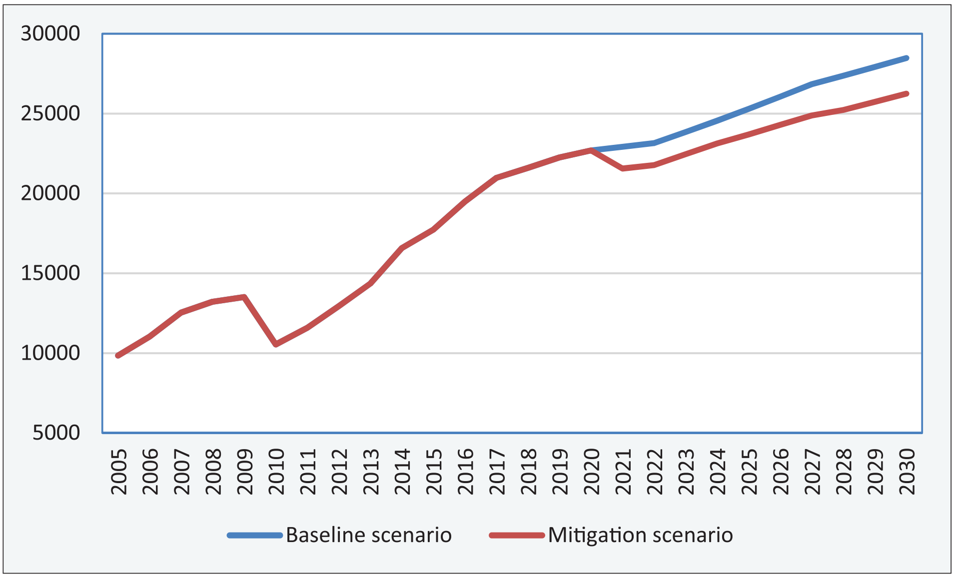


Figure 7.28. Comparison of GHG emissions for Baseline and Mitigation Scenarios from livestock sector, *Gg* $CO_2e$

### 7.2.3. Cost-benefit analysis

Estimation of all costs and benefits depend on several unknown factors (such as rate of reduction in costs in key efficiency and renewable energy technologies) and has large uncertainties. At the same time estimating the cost-effectiveness of options at meeting key goals-such as greenhouse gas reduction-can help planners understand differences in costs, and where measures that save costs (e.g. energy efficiency) may be able to help offset costs of other, higher cost measures that are desirable because they bring extra benefits or to meet the goals of the renewable energy deployment or GHG emission reduction.

This section estimates the cost-effectiveness of the measures assessed in this study per the cost per tonne of GHGs avoided or reduced as it is common in scenario analyses of low emissions development strategy. This method assesses the incremental capital and operating and maintenance costs of key technologies (such as renewable electricity or energy efficiency improvements) as well as saving from avoided fuel usage. It does not include taxes or subsidies, financing costs (e.g. interest), or administrative costs).

Table 7.20 GHG abatement costs showing GHG savings and cost per tonne of $CO_2e$ reduced up to 2030

| | Mitigation options | GHG Savings (Million Tonnes $CO_2e$) | Cost of Avoiding GHGs (USD/Tonnes $CO_2e$) |
|---|---|---|---|
| 1 | DSM in industry | 7.107 | -15.176 |
| 2 | Efficient lighting | 2.216 | -8.433 |
| 3 | Electricity T&D losses reduction | 7.952 | -3.885 |
| 4 | HOB Efficiency Improvement | 9.866 | 8.070 |
| 5 | Wind Farms | 12.286 | 10.793 |
| 6 | Coal-fired Power Plant Efficiency Improvement | 5.456 | 11.303 |
| 7 | Egiin Gol Hydropower plant | 20.019 | 27.751 |
| 8 | Khovd Hydropower plant | 3.131 | 31.822 |
| 9 | Solar PV plants | 3.654 | 40.312 |

All costs after 2010 are discounted using a 5 percent real annual discount rate. Estimating future costs of technologies and fuels is difficult and accordingly, all estimates of these costs are subject to significant uncertainty.

Table 7.18 presents a greenhouse gas abatement cost calculation results of mitigation measures, comparing overall estimated annualized costs with emissions savings that could be realized in the year 2030 relative to the reference scenario.

Some of the options show negative costs of reduced GHG emissions, meaning that the overall direct benefits of the options exceed the costs. For example, DSM in Industry, Efficient lighting and Electricity T&D losses reduction have a cost; it can lead to considerable savings in fuel costs over time.

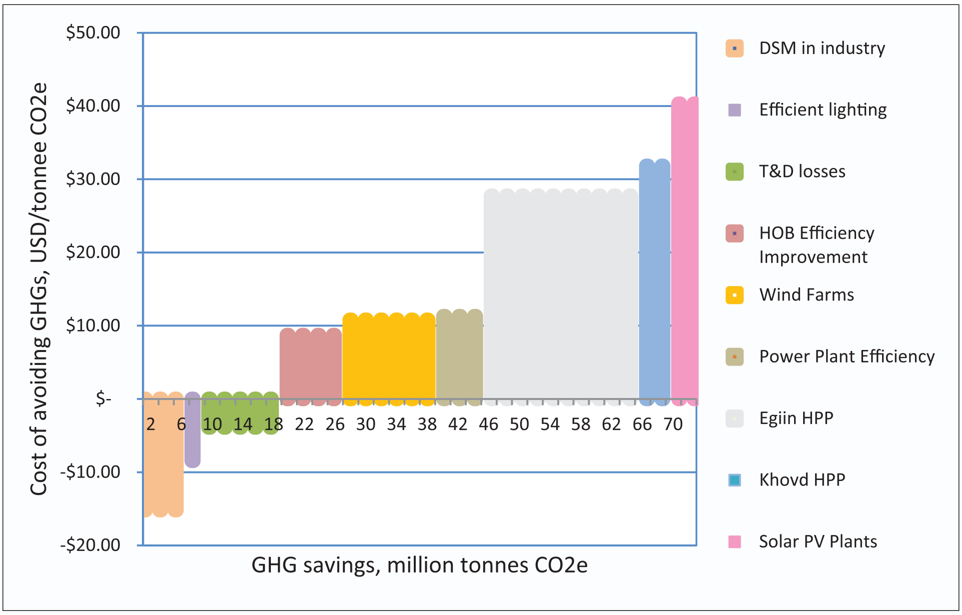


Figure 7.29 GHG abatement costs showing GHG savings and cost per tonne of $CO_2e$ reduced up to 2030

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# Chapter 8

## TECHNOLOGY NEEDS ASSESSMENT

# 8. Technology needs assessment

## 8.1. Adaptation technology

Although mitigation is undertaken for the negative impacts of the climate change, there are still challenges for humans to face when adapting to the changing climate. Therefore, practical work towards the problem is practical important in present days. The first Mongolian technological needs assessment of adaptation has been conducted in 2013 (TNA, 2013). This assessment has done prioritization of technologies for most vulnerable sub-sectors such as arable farming and livestock.

In this study, we have outlined results of latest impacts, vulnerabilities and risk assessments on water resources, permafrost, forest resources, pasture-soil, wildlife, natural disasters, agriculture, livestock and human health sectors which have done within the framework of the Third National Communication, and attempted to conduct adaptation technologies needs assessment, which could be reduced of their vulnerability and risk. The output of previous technology needs assessment of adaptation was used as background data and materials.

### 8.1.1. Overview of impacts, vulnerabilities and risk assessments

Climate change is going on relatively intense in Mongolia and anticipated that the impacts of climate change on the environment and socio-economic sectors will be high in the future.

Table 8.1 summarizes current climate change and its future projection as well as major risks and impacts of climate change on the environment and socio-economic sectors. Direct and indirect impacts of the climate variables and their present and future changes impact to the environment and socio-economic sectors are summarized for each sector, while the current changes, impacts and future impacts, vulnerabilities and risks are presented separately by each sector.

Based on these findings, it is required to consider the following directions and concepts in in order to reduce vulnerability and risk of each sector. Where:

- Water resources
    - reducing of evaporation from open surface and evapotranspiration, the creation of water accumulation using snow and ice melting, increasing of water resource, proper use of water resources, preservation of headwater of river basins their unique natural

systems, maintaining ecosystems of river basins

- Permafrost
  - Restrain land cover change and land use, sustain forest and pasture ecosystems
- Forest resources
  - Prevent forest fire and forest harmful insects, plantation of seeds, trees with high drought resilient, adaptive ability and growth rate, proper use of forest resources, sustainable forest management
- Pasture soil
  - Reduce pasture pressure, monitor-use management, prevent propagation of harmful rodents and insects and support pastoral ecosystems.
- Some biological diversity
  - Supporting the preservation of natural habitats and habitats of animals
- Arable farming
  - Reduce evaporation, effective irrigation systems, increase moisture availability, produce drought-resistant and high-yielding varieties, improve soil fertility
- Livestock
  - Strengthening animal survival quality, breeding high productive animals, pasture management, increase livestock forage and decrease animal diseases and early warning system against drought-dzud risks.
- Natural hazards and disasters
  - Monitoring network, monitoring, and early warning system, disaster preparedness
- Public health
  - Establish human health, disease registration systems, early warning system against disaster, training, awareness, practices, and attitudes.

We created a list of adaptation technologies for each sector and evaluated by multi-criteria analysis method in order to prioritize adaptation technologies.

Table 8.1 Summary of the impacts, vulnerabilities, and risks of climate change in environmental and socio-economic sectors

| Current climate change | Future climate change | Sectors | Current change and impacts | Future impacts, vulnerabilities, and risks |
|---|---|---|---|---|
| • Air temperature has increased by 2.24°C in the last 76 years in Mongolia<br>• The number of cold days decreased by 15 days over the country while the number of hot days increased by 24 days<br>• The number of consecutive hot days is increased for 13 days<br>• Sum of annual precipitation decreased by 7%, on the other hand, winter precipitation increased by 22% | In future respect to climate baseline will be:<br>• Seasonal air temperature is expected to increase by 2.0-2.3°C at the beginning of the century and by 2.4-6.3°C at the end of the century<br>• The number of cold days will be decreased by 10-40 days while the number of hot days is expected to increase by 7-36 days<br>• The number of consecutive hot days will increase by 6-54 days | Water resource | • The river runoff of Mongolia has been slowly increasing during the period of 1978-1993 and since then has declined steadily.<br>• Water levels in most of the lakes are decreasing and according to the 2015 data, 832 lakes have dried up and lake area has decreased by 7.8%.<br>• Area of glacier already has decreased by 29.9% over the last 70 years. Glacier melting is relatively high in the upper mountain region.<br>• The total water resource or volume, depth, and thickness of all kind of water bodies including groundwater, soil moisture, and glacier are likely to decline. | • The monthly mean temperature of rivers from April to October increases by from 0.7-3.3°C in the Arctic Ocean, Pacific Ocean and Central Asian Closed Basins<br>• Precipitation and river runoff remain unchanged in the early period of this century and at the same time, evaporation is expected to increase.<br>• The river runoff is expected to increase slightly in connection with the increase of precipitation in the middle and end of this century, but with the increase of evaporation and evapotranspiration, the outflow of the water balance of river basins and lakes is expected to increase significantly.<br>• Evaporation from open surface water will be impacted much the water balance of small lakes, ponds in the steppe and Gobi region and will be observed clear drying tendency. |
| | | Permafrost | • In general, the temperature of the deep permafrost rises and the intensive degradation of permafrost is observed. | • Mongolia's permafrost area is expected to decrease by 16.46-18.31% during 2016-2035 and 33-61.23% over the 2046-65 periods. |
| | | Forest resource | • Due to degradation of forest, forest cut, forest area is decreased by 6.6% in 1999-2015.<br>• About 571 thou. ha of forest affected by harmful insects and area of degraded forest by insects increased by 76.0 thou. ha or by 127.0%.<br>• At the same time, an average of 206 thou. ha of forest area destroyed by forest fire nearly by every year. The frequency of forest fires increases and the fire occurrences become earlier in spring and late in the fall and thus the duration of fire hazards periods becomes longer. | • Generally, areas occupied by forest steppe and high mountain taiga will decrease and the steppe and desert steppe zone may expand further to the north direction.<br>• A number of forest and steppe fire cases tend to increase from 34 to 51 and forest area affected by fires expected to increase by 1.3-4.5 times.in the early, mid and late of the century<br>• Area of the dominant tree species in Mongolia will be by 0.5-3.2%.<br>• The upper boundary of the forests will retreat and the forest will grow in the high altitudes while forest growth in the along the valleys of hills and lowlands will be further reduced. |

| | | | | |
|---|---|---|---|---|
| • Rainfall amount during vegetation growth season is decreased and a portion of heavy rainfall among total rainfall events is increased<br>• The number of continuous rainfall days is decreased slightly. | • Winter precipitation will be increased by 10.1-14% on average at the beginning of the century and by 15.5-50.2% at the end of the century.<br>• A small increase of summer rainfall is expected to observe and the increase will be 1.1-6.2% at the beginning of the century and some more increase will continue at the end of the century reaching up to 5.1-7.8%. | Pasture and soil | • 76.8% of the total territory was affected by desertification and land degradation.<br>• Area Gobi Desert and Steppe Region has decreased and steppe, mountain steppe, shrub fields have increased over the past 15 years<br>• There has been an observed significant change in pasture vegetation population and communities.<br>• NDVI values have fallen in the last 15 years by -0.007 ~ -0.002 units/year.<br>• The number of livestock heads per hectare has been increased and pasture capacity of the country continuously exceeds since 1991 | • Organic carbon and organic nitrogen contents in 0-20 cm are expected to decrease by 10-30% in peak grazing periods and above ground and below biomass also will be decreased by 50-80%.<br>• Propagation of grasshoppers is expected to increase during the intensive climate change conditions. |
| | | Some biological diversity | • Climate change impacts on the habitat of some fauna groups in Mongolia. | • According to some estimation, future relic and distribution area of some mammals, birds, insects are likely to be reduced. |
| | | Arable farming | • Over 90% of Mongolia's total grain crops, over 60% of potatoes and 70% of cultivated fodders are planted under unirrigated condition.<br>• During the years of drought, overheating, and late planting, crop yields are only 0.4-0.6 tonne/ha or even less ( nationwide average 0.95 tonnes/ha)<br>• The number of days when temperatures exceed 26˚C in the phenological period from June and July months is directly affected the wheat harvest. | • Wheat harvest will be decreased by 9% in 2035, 18% in 2050 and 37% in 2080 under highest GHG emission scenarios RCP8.5. This case, seeding period is selected as present condition and irrigated system is not introduced yet. |

Chapter 8

| | | | | |
|---|---|---|---|---|
| | | Animal husbandry | • The traditional herd composition and ratio is lost and since 2008, goat's reached to 41-46% of whole herds.<br>• The proportion of livestock mortality compare to head of livestock at the beginning of the year was 4.0% during the period of 1991- 2015.<br>• Annual productivity of vegetation is declined and pasture yields also decreased At the same time, the number of hot days which is an unfavorable condition for grazing in summer is increased.<br>• In recent years, there were 26 new diseases of the livestock register, 8 kinds of diseases re-emerge and propagation of 6 more new animal diseases spread out. | • Livestock mortality due to increased frequency and intensity of droughts and dzud may be increased by 5.5% in comparison with livestock head numbers at the beginning of a year at the beginning of the century and by the middle of the century may reach to 7.6%.<br>• Thus, the mortality rate of livestock in the mid-century period is expected to increase by more than 50% and is expected to as double by the end of the century. |
| • Generally, the intensity of droughts is intensified and the frequency of droughts also is increased.<br>• Despite weakening of winter cold, winter precipitation and drought intensity, the frequency of dzud are increased. | • Drought frequency increases by 5-45%<br>• The frequency of dzud increases by 5-40% | Natural hazards and disasters | • The frequency of climate-related natural disasters has doubled over the last 10 years compared to the previous 10 years (about 30 cases per year on average).<br>• At the same time, damage of natural disasters is estimated to be approximately 50-70 billion MNT in each year and the damage to the socio-economic almost 10-14 times compared to the previous 10 years. | • The occurrence of atmospheric originated natural hazardous phenomena will increase by 23-60% in mid of the century compared to the current situation. |
| | | Public health | • Heatwave, air pollution, floods, dryness, water scarcity and pollution which are the impact on human health in direct and indirect ways are increasing in Mongolia.<br>• Increased frequency of natural disasters, such as floods, rains, dzuds and strong winds are causing loss of people's life, mental disorder, homelessness, and delay of medical help and care.<br>• Tick-borne infection is increasing. | • Victims of encephalitis infection will be increased 80% in 2050 and doubled in 2080 according to the relationship between of tick-borne encephalitis and drought index. |

### 8.1.2. List and assessment of adaptation technologies by sectors

Generally, the adaptation technology is divided into 3 groups. Supplies related to the facilities, construction, and infrastructure are called ***hardware,*** knowledge, training, production, software are belong to ***software*** technologies and finally, organizational structure, operational coordination, and legislative regulatory issues are to be ***orgware*** technologies.

The list of adaptation technologies of the mentioned three groups have been developed based on the vulnerability and impact assessment made by researchers and experts from the different sectors, using database and materials of previous technology needs assessments (TNA, 2013) and the Center for Climate Technology and Network (CTCN) and taking into account the rate of mitigating the effects of climate change and specific features of the country. Afterward, adaptation technologies have been providing prioritization of technologies by the method of multiple criteria analysis.

Among the many criteria of the methods, the rate of reducing the vulnerability of climate change, positive impacts on the economic, environmental and social sectors and investment benefits (costs) have been selected to assess adaptation technologies. In case of environmental indicators, biodiversity and ecosystem services are selected as key indicators and public health, livelihood and unemployment are to be the social criteria. Finally, property and infrastructure, business and market activities are considered as economic criteria.

When selecting indicators, the following conditions such as key indicators of environmental, economic and social sectors, data availability, easy to apply for assessment and as well as indicators that can best represent the positive impacts of their direct and indirect impacts has to be considered.

The assessment has been identified for more than 10 technologies in each sector as agriculture, livestock and water resources sectors. Therefore, they have been prioritized based on weighted factors. But for the sectors such as forests, human health, biodiversity, and natural disasters assessment was done only by scores given by researchers and experts. Due to the the relatively few technologies that has been listed for these sectors, weighting is considered to be of little significance.

Considering the above assessment, we have examined some requirements and needs for introduction, transfer, and investment of adaptation technologies in certain sectors.

Moreover, the scores provided by researchers and experts could have some subjective approach, hence, we need to take into account even the lowest technologies.

*Arable farming.* According to the current climate change and future impact assessments, heat accumulation and phenological period of plant growth are likely to increase. However, due to an increase in the intensity of drought, overheating and evaporation, the growth rate of wheat is expected to reduce by 9-37% (Table 8.1).

Considering this situation, 13 adaptation technologies have been listed which include agro-forests, early warning systems, and insurance and information technology in order to ensure the sustainability of crops of the unirrigated (Table 8.2). Researchers and experts evaluated these technologies according to a specific indicator of the 5-score system and then converted these evaluation into the 100 scoring system by weighting each technology and the total weight by multiple criteria analysis.

Ranking of the adaptation technologies according to the above evaluation results as follow:

- Over-summering wheat, fodder plants under straw mulch, potato, vegetable planting under plastic mulch-94.5
- Reducing bare fallow and increasing cereals species diversification and rotation-84.9
- Drought monitoring and prediction-76.7
- Drip irrigation system (potato, vegetable, fruits, bushes, garden)-75.4
- Zero tillage technology for mechanical soil processing-61.7 is listed in first 5 ranks.

Introducing these technologies allows reducing soil moisture loss, evapotranspiration, keeping the soil fertility, preventing wind and watering erosion, save water and irrigation costs etc. Also, provides an early warning system for drought which must support stabilizing crop harvest and yields and mitigation of farmers' risks. Remaining technologies are ranked within 20.5-55.7 scores.

The investment efficiency is the most effective indicator of agricultural technology and much influenced by the assessment results (Figure 8.1).

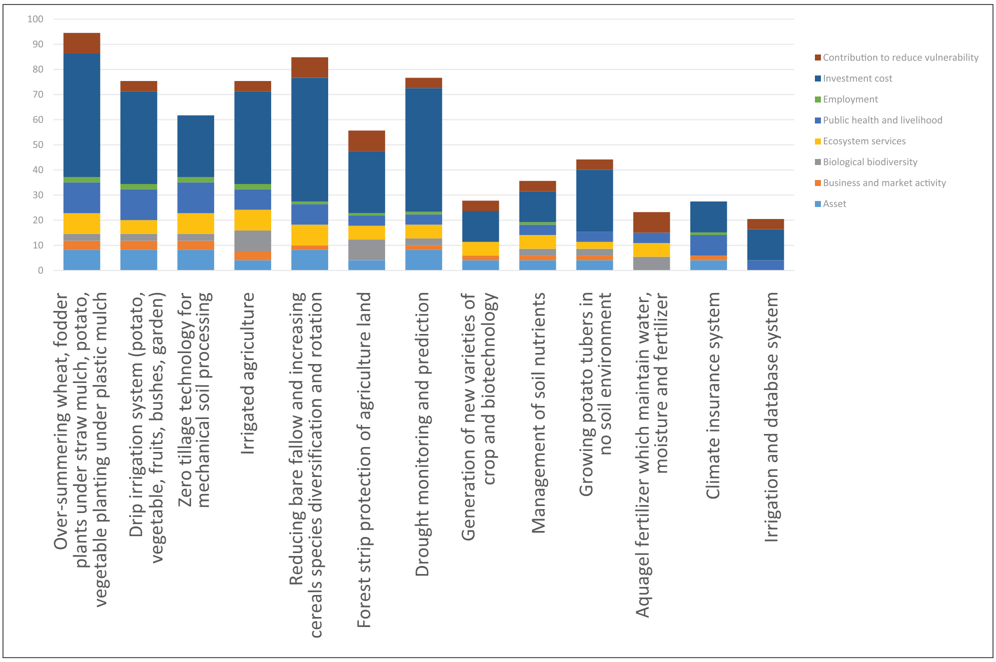


Figure 8.1 Ratio of criteria for adaptation technology in the agricultural sector

Table 8.2 Technology needs assessment of arable farming sector (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts: Economy | | Envi-ron-ment | | Society | | Investment cost | Contribution to reducing vulner-ability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Over-summering wheat, fodder plants under straw mulch, potato, vegetable planting under plastic mulch | Stabilizing and increasing the effi-ciency of planting | 5 | 5 | 3 | 5 | 5 | 4 | 5 | 5 | 37 |
| 2 | Drip irrigation system (potato, vegetable, fruits, bushes, garden) | Stabilizing and in-creasing efficiency of planting | 5 | 5 | 3 | 4 | 5 | 4 | 4 | 4 | 34 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Zero tillage technology for mechanical soil processing | Stabilizing and increasing the efficiency of planting | 5 | 5 | 3 | 5 | 5 | 4 | 3 | 3 | 33 |
| 4 | Irrigated agriculture | Stabilizing and increasing of efficiency of planting | 4 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 35 |
| 5 | Reducing bare fallow and increasing cereals species diversification and rotation | Stabilizing and increasing the efficiency of planting | 5 | 4 | 2 | 5 | 4 | 3 | 5 | 5 | 33 |
| 6 | Forest strip protection of agriculture land | Agro-forest-farming | 4 | 3 | 5 | 4 | 3 | 3 | 3 | 5 | 30 |
| 7 | Drought monitoring and prediction | Early warning system, information technology | 5 | 4 | 3 | 4 | 3 | 3 | 5 | 4 | 31 |
| 8 | Generation of new varieties of crop and biotechnology | Stabilizing and increasing the efficiency of planting | 4 | 4 | 2 | 4 | 2 | 2 | 2 | 4 | 24 |
| 9 | Management of soil nutrients | Stabilizing and increasing of efficiency of planting | 4 | 4 | 3 | 4 | 3 | 3 | 2 | 4 | 27 |
| 10 | Growing potato tubers in no soil environment | Stabilizing and increasing the efficiency of planting | 4 | 4 | 3 | 3 | 3 | 2 | 3 | 4 | 26 |
| 11 | Aquagel fertilizer which maintains water, moisture and fertilizer | Stabilizing and increasing the efficiency of planting | 3 | 3 | 4 | 4 | 3 | 2 | 1 | 5 | 25 |
| 12 | Climate insurance system | Insurance | 4 | 4 | 2 | 2 | 4 | 3 | 2 | 3 | 24 |
| 13 | Irrigation and database system | Information technology | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 4 | 21 |

## Assessment results of the multi–criteria analysis method

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Over-summering wheat, fodder plants under straw mulch, potato, vegetable planting under plastic mulch | Stabilizing and increasing the efficiency of planting | 8 | 4 | 3 | 8 | 12 | 2 | 49 | 8 | 94.5 |
| 2 | Drip irrigation system (potato, vegetable, fruits, bushes, garden) | Stabilizing and increasing of efficiency of planting | 8 | 4 | 3 | 5 | 12 | 2 | 37 | 4 | 75.4 |
| 3 | Zero tillage technology for mechanical soil processing | Stabilizing and increasing the efficiency of planting | 8 | 4 | 3 | 8 | 12 | 2 | 25 | 0 | 61.7 |
| 4 | Irrigated agriculture | Stabilizing and increasing of efficiency of planting | 4 | 4 | 8 | 8 | 8 | 2 | 37 | 4 | 75.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | Reducing bare fallow and increasing cereals species diversification and rotation | Stabilizing and increasing the efficiency of planting | 8 | 2 | 0 | 8 | 8 | 1 | 49 | 8 | 84.9 |
| 6 | Forest strip protection of agriculture land | Agro-forest-farming | 4 | 0 | 8 | 5 | 4 | 1 | 25 | 8 | 55.7 |
| 7 | Drought monitoring and prediction | Early warning system, information technology | 8 | 2 | 3 | 5 | 4 | 1 | 49 | 4 | 76.7 |
| 8 | Generation of new varieties of crop and biotechnology | Stabilizing and increasing of efficiency of planting | 4 | 2 | 0 | 5 | 0 | 0 | 12 | 4 | 27.8 |
| 9 | Management of soil nutrients | Stabilizing and increasing of efficiency of planting | 4 | 2 | 3 | 5 | 4 | 1 | 12 | 4 | 35.6 |
| 10 | Growing potato tubers in no soil environment | Stabilizing and increasing the efficiency of planting | 4 | 2 | 3 | 3 | 4 | 0 | 25 | 4 | 44.2 |
| 11 | Aquagel fertilizer which maintain water, moisture and fertilizer | Stabilizing and increasing of efficiency of planting | 0 | 0 | 5 | 5 | 4 | 0 | 0 | 8 | 23.2 |
| 12 | Climate insurance system | Insurance | 4 | 2 | 0 | 0 | 8 | 1 | 12 | 0 | 27.4 |
| 13 | Irrigation and database system | Information technology | 0 | 0 | 0 | 0 | 4 | 0 | 12 | 4 | 20.5 |

***Livestock.*** Climate change impacts on reduction of in pasture yields brings certain changes plant composition. Due to climate change, the number of unfavorable days for livestock grazing, livestock diseases and mortality, and propagation of rodents and grasshoppers were increased and expanded.

Due to the intensity of drought-dzud, 5.5% of livestock which accounted at the beginning of a year could be lost by mid of this century and even more loss is expected to face at the end of the century reducing livestock number up to 7.6% (Table 8.1).

Therefore, another 12 adaptation technologies are ranked in the livestock sector including early warning systems, fodder production, water supply, pasture management, livestock management, training and governance and legal environment (Table 8.3).

Similarly, based on the 5-point rating of the researchers and experts, the technologies are ranked by the multi-criteria analysis methods. Results of assessment are given below.

- Livestock forage reserve-76.3
- Management of livestock diseases-74.6
- Monthly and seasonal prediction and dzud early warning system-72.9

- The traditional herding of herders-66.1
- Improvements of livestock breeding-62.7 are listed in the first 5 rank according to the scores.

The key benefits of these technologies would be to improve immunity to overcome disaster and dzud, to improve the livestock breeding, to reduce disaster damage by introducing early warning system and to improve herder skills and education. The other remaining technologies are listed between 37.3-57.6 points.

Market support and business activities have the most influential weight among listed technologies in the assessment of livestock sector (Figure 8.2).

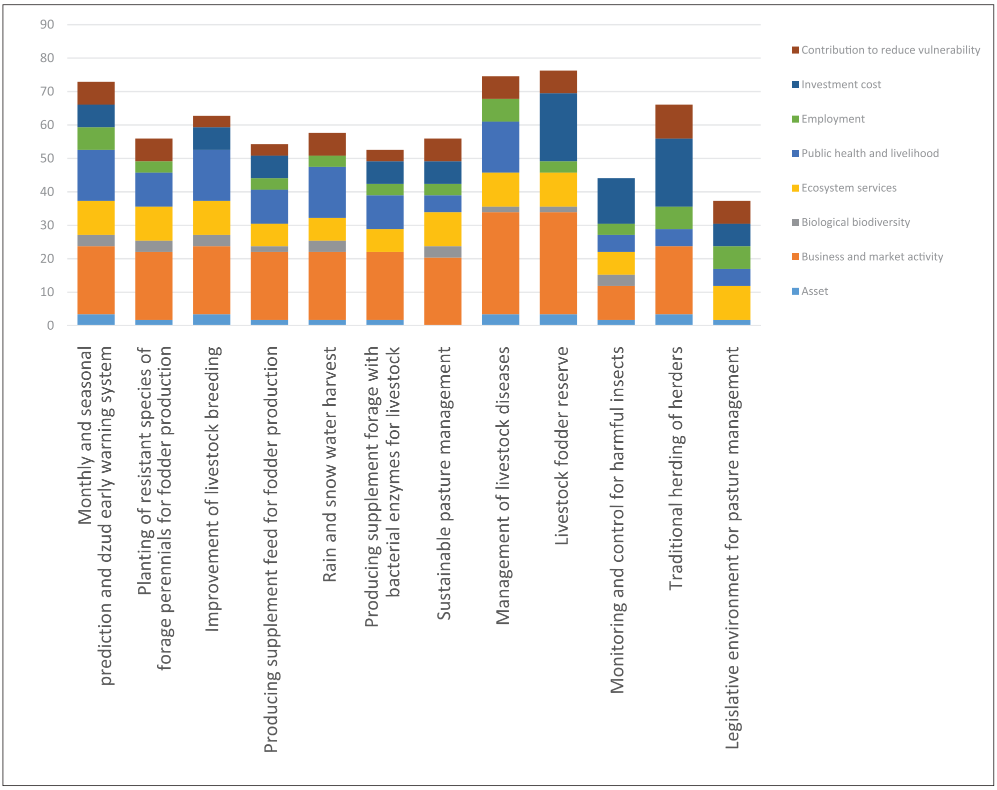


Figure 8.2 Ratio of criteria for adaptation technology in the livestock sector

Table 8.3 Technology needs assessment of livestock sector (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts | | | | | | Investment cost | Contribution to re-ducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Economy | | Environ-ment | | Society | | | | |
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Monthly and seasonal prediction and dzud early warning system | Early warning system and IT | 4 | 3 | 4 | 4 | 4 | 3 | 2 | 4 | 28 |
| 2 | Planting of resistant species of forage perennials for fodder production | Livestock fodder production | 3 | 3 | 4 | 4 | 3 | 2 | 1 | 4 | 24 |
| 3 | Improvement of livestock breeding | Increase of live-stock productivity | 4 | 3 | 4 | 4 | 4 | 1 | 2 | 3 | 25 |
| 4 | Producing supplement feed for fodder production | Livestock fodder production | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 22 |
| 5 | Rain and snow water harvest | Water supply | 3 | 3 | 4 | 3 | 4 | 2 | 1 | 4 | 24 |
| 6 | Producing supplement forage with bacterial enzymes for livestock | Livestock fodder production | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 21 |
| 7 | Sustainable pasture manage-ment | Pasture | 2 | 3 | 4 | 4 | 2 | 2 | 2 | 4 | 23 |
| 8 | Management of livestock diseases | Livestock manage-ment | 4 | 4 | 3 | 4 | 4 | 3 | 1 | 4 | 27 |
| 9 | Livestock fodder reserve | Livestock manage-ment | 4 | 4 | 3 | 4 | 1 | 2 | 4 | 4 | 26 |
| 10 | Monitoring and control for harmful insects | Pasture | 3 | 2 | 4 | 3 | 2 | 2 | 3 | 2 | 21 |
| 11 | Traditional herding of herders | Training | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 24 |
| 12 | Legislative environment for pasture management | Governance and planning | 3 | 1 | 2 | 4 | 2 | 3 | 2 | 4 | 21 |

## Assessment results of the multi-criteria analysis method

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Monthly and seasonal predic-tion and dzud early warning system | Early warning system and IT | 3 | 20 | 3 | 10 | 15 | 7 | 7 | 7 | 72.9 |
| 2 | Planting of resistant species of forage perennials for fodder production | Livestock fodder production | 2 | 20 | 3 | 10 | 10 | 3 | 0 | 7 | 55.9 |
| 3 | Improvement of livestock breeding | Increase of live-stock productivity | 3 | 20 | 3 | 10 | 15 | 0 | 7 | 3 | 62.7 |
| 4 | Producing supplement feed for fodder production | Livestock fodder production | 2 | 20 | 2 | 7 | 10 | 3 | 7 | 3 | 54.2 |
| 5 | Rain and snow water harvest | Water supply | 2 | 20 | 3 | 7 | 15 | 3 | 0 | 7 | 57.6 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Producing supplement forage with bacterial enzymes for livestock | Livestock fodder production | 2 | 20 | 0 | 7 | 10 | 3 | 7 | 3 | 52.5 |
| 7 | Sustainable pasture management | Pasture | 0 | 20 | 3 | 10 | 5 | 3 | 7 | 7 | 55.9 |
| 8 | Management of livestock diseases | Livestock management | 3 | 31 | 2 | 10 | 15 | 7 | 0 | 7 | 74.6 |
| 9 | Livestock fodder reserve | Livestock management | 3 | 31 | 2 | 10 | 0 | 3 | 20 | 7 | 76.3 |
| 10 | Monitoring and control for harmful insects | Pasture | 2 | 10 | 3 | 7 | 5 | 3 | 14 | 0 | 44.1 |
| 11 | Traditional herding of herders | Training | 3 | 20 | 0 | 0 | 5 | 7 | 20 | 10 | 66.1 |
| 12 | Legislative environment for pasture management | Governance and planning | 2 | 0 | 0 | 10 | 5 | 7 | 7 | 7 | 37.3 |

***Water resource***. The river runoff in Mongolia has been steadily declining since 1993 and the water level of lakes went down and some lakes dried up and glacier area was reduced largely due to its melting. Due to the impact of climate change, the water temperature of rivers are increasing, which in turn increases the surface water evaporation and outflow component of the water balance of water bodies (Table 8.1).

In the water resource sectors, 16 technologies has been listed relating to the reduction of water resource vulnerability and risks, early warning systems, water supply, ecosystem support, integrated water resources management, infrastructure, information technology, disaster risk and training (Table 8.4).

These technologies are ranked according to the multi-criteria analysis methods as follows:

- Water resource forecasting system-81.1
- Dissemination of knowledge on water resources use and ecosystem-based adaptation to climate change-78.9
- Technologies which support decision making processes in Integrated Water Resource Management (IWRM) such as water supply during the drought, water distribution, drilling repair and of wells-72.4,
- Protecting of springs and headwater of river basins-71.1,
- Water metering and production and use of household appliances-55.0

The creation of a forecasting system, increasing the water resources and supplies, saving the environment, preserving natural beauty, integrated water resources management and adapting to climate change based ecosystem-based adaptation to climate change are the main benefiting technology of adaptation in water resource sector. Other adaptation technologies in this sector are ranked in between 7.2-54.6 points.

Low investment cost is to be the most influential or weighted indicators of adaptation technology in the assessment (Figure 8.3).

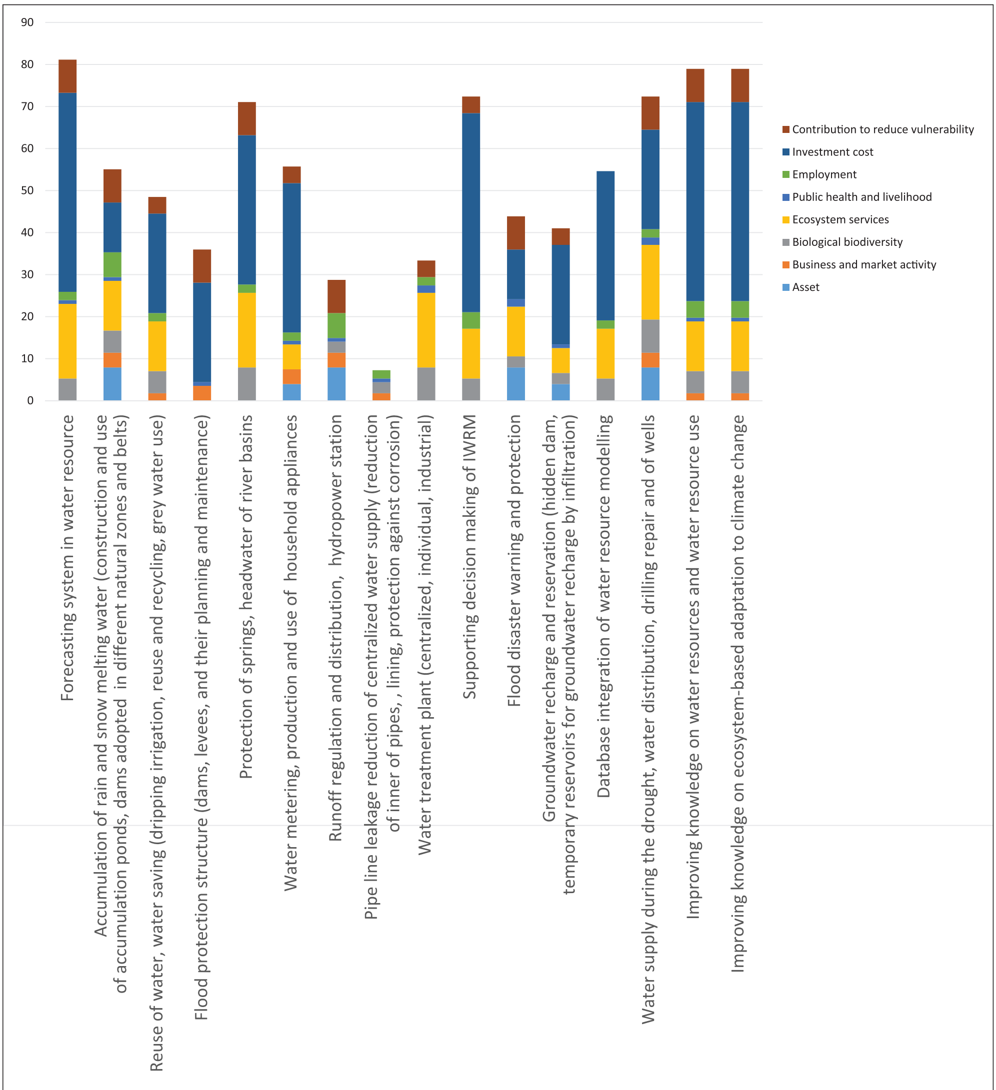


Figure 8.3 Ratio of indicators for adaptation technology in water resource sector

Table 8.4 Technology Needs Assessment on the reduction of vulnerability in water resource sector (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts: Economy: Asset | Benefits and positive impacts: Economy: Business and market activity | Benefits and positive impacts: Environment: Biological biodiversity | Benefits and positive impacts: Environment: Ecosystem services | Benefits and positive impacts: Society: Public health and livelihood | Benefits and positive impacts: Society: Employment | Investment cost | Contribution to reducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Forecasting system in water resource | Early warning system | 3 | 3 | 4 | 5 | 4 | 2 | 1 | 5 | 27 |
| 2 | Accumulation of rain and snow melting water (construction and use of accumulation ponds, dams adopted in different natural zones and belts) | Water supply and supporting ecosystems | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 35 |
| 3 | Reuse of water, water saving (dripping irrigation, reuse, and recycling, grey water use) | Integrated Water Resource Management | 3 | 4 | 4 | 4 | 3 | 2 | 3 | 4 | 27 |
| 4 | Flood protection structure (dams, levees, and their planning and maintenance) | Infrastructure | 3 | 5 | 2 | 2 | 4 | 1 | 3 | 5 | 25 |
| 5 | Protection of springs, headwater of river basins | Ecosystem | 3 | 3 | 5 | 5 | 3 | 2 | 2 | 5 | 28 |
| 6 | Water metering, production and use of household appliances | Water supply | 4 | 5 | 2 | 3 | 4 | 2 | 2 | 4 | 26 |
| 7 | Runoff regulation and distribution, hydropower station | Infrastructure and energy | 5 | 5 | 3 | 2 | 4 | 4 | 5 | 5 | 33 |
| 8 | Pipeline leakage reduction of centralized water supply (reduction of inner of pipes, lining, protection against corrosion) | Infrastructure | 3 | 4 | 3 | 2 | 4 | 2 | 5 | 3 | 26 |
| 9 | Water treatment plant (centralized, individual, industrial) | Infrastructure | 3 | 3 | 5 | 5 | 5 | 2 | 5 | 4 | 32 |
| 10 | Supporting decision making of IWRM | Information technology | 3 | 3 | 4 | 4 | 3 | 3 | 1 | 4 | 25 |
| 11 | Flood disaster warning and protection | Disaster risks | 5 | 3 | 3 | 4 | 5 | 1 | 4 | 5 | 30 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Groundwater recharge and reservation (hidden dam, temporary reservoirs for groundwater recharge by infiltration) | Integrated Water Resource Management | 4 | 3 | 3 | 3 | 4 | 1 | 3 | 4 | 25 |
| 13 | Database integration of water resource modelling | Information technology | 3 | 3 | 4 | 4 | 3 | 2 | 2 | 3 | 24 |
| 14 | Water supply during the drought, water distribution, drilling repair and of wells | Water supply | 5 | 5 | 5 | 5 | 5 | 2 | 3 | 5 | 35 |
| 15 | Improving knowledge on water resources and water resource use | Training | 3 | 4 | 4 | 4 | 4 | 3 | 1 | 5 | 28 |
| 16 | Improving knowledge on ecosystem-based adaptation to climate change | Training and information | 3 | 4 | 4 | 4 | 4 | 3 | 1 | 5 | 28 |

## Assessment results of the multi-criteria analysis method

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Forecasting system in water resource | Early warning system | 0 | 0 | 5 | 18 | 1 | 2 | 47 | 8 | 81.1 |
| 2 | Accumulation of rain and snow melting water (construction and use of accumulation ponds, dams adopted in different natural zones and belts) | Water supply and supporting ecosystems | 8 | 4 | 5 | 12 | 1 | 6 | 12 | 8 | 55.0 |
| 3 | Reuse of water, water saving (dripping irrigation, reuse, and recycling, grey water use) | Integrated Water Resource Management | 0 | 2 | 5 | 12 | 0 | 2 | 24 | 4 | 48.5 |
| 4 | Flood protection structure (dams, levees, and their planning and maintenance) | Infrastructure | 0 | 4 | 0 | 0 | 1 | 0 | 24 | 8 | 36.0 |
| 5 | Protection of springs, headwater of river basins | Ecosystem | 0 | 0 | 8 | 18 | 0 | 2 | 36 | 8 | 71.1 |
| 6 | Water metering, production and use of household appliances | Water supply | 4 | 4 | 0 | 6 | 1 | 2 | 36 | 4 | 55.7 |
| 7 | Runoff regulation and distribution, hydropower station | Infrastructure and energy | 8 | 4 | 3 | 0 | 1 | 6 | 0 | 8 | 28.7 |
| 8 | Pipe line leakage reduction of centralized water supply (reduction of inner of pipes, , lining, protection against corrosion) | Infrastructure | 0 | 2 | 3 | 0 | 1 | 2 | 0 | 0 | 7.2 |

Chapter 8

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Water treatment plant (centralized, individual, industrial) | Infrastructure | 0 | 0 | 8 | 18 | 2 | 2 | 0 | 4 | 33.3 |
| 10 | Supporting decision making of IWRM | Information technology | 0 | 0 | 5 | 12 | 0 | 4 | 47 | 4 | 72.4 |
| 11 | Flood disaster warning and protection | Disaster risks | 8 | 0 | 3 | 12 | 2 | 0 | 12 | 8 | 43.9 |
| 12 | Groundwater recharge and reservation (hidden dam, temporary reservoirs for groundwater recharge by infiltration) | Integrated Water Resource Management | 4 | 0 | 3 | 6 | 1 | 0 | 24 | 4 | 41.0 |
| 13 | Database integration of water resource modelling | Information technology | 0 | 0 | 5 | 12 | 0 | 2 | 36 | 0 | 54.6 |
| 14 | Water supply during the drought, water distribution, drilling repair and of wells | Water supply | 8 | 4 | 8 | 18 | 2 | 2 | 24 | 8 | 72.4 |
| 15 | Improving knowledge on water resources and water resource use | Training | 0 | 2 | 5 | 12 | 1 | 4 | 47 | 8 | 78.9 |
| 16 | Improving knowledge on ecosystem-based adaptation to climate change | Training and information | 0 | 2 | 5 | 12 | 1 | 4 | 47 | 8 | 78.9 |

***Forest resources.*** Degradation of the forest, shrinking of forest areas, an increase of harmful insects and forest fires have been intensified in recent years. Moreover, due to climate change impacts, areas of forest-steppe and high mountain taiga are decreased thus the forest becomes increasingly vulnerable to fires and harmful insects from the intensifying droughts (Table 8.1).

Therefore, five technologies are in the forest resource, which are forest ecosystem management, information technology, governance and planning (Table 8.5).

These technologies have not been evaluated by multiple criteria methods and only evaluated by scores given by researchers and experts.

Table 8.5 Technology needs assessment on the reduction of vulnerability of forest resource sector (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts: Economy | | Benefits and positive impacts: Environment | | Benefits and positive impacts: Society | | Investment cost | Contribution to reducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Protection against forest and steppe fires | Ecosystem management | 4 | 3 | 5 | 5 | 3 | 2 | 3 | 4 | 29 |
| 2 | Forest monitoring and regulation | Information technology | 3 | 3 | 4 | 4 | 3 | 3 | 4 | 4 | 28 |
| 3 | Sustainable forest management | Forest management | 5 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 36 |
| 4 | Protect forest reserves through forestry possession by cooperatives, partnership, economic entities and organizations | Governance and planning | 5 | 5 | 4 | 4 | 4 | 5 | 3 | 4 | 34 |
| 5 | Technology to produce bio-fuels using forest products | Forest management | 3 | 4 | 3 | 4 | 4 | 4 | 3 | 3 | 28 |

***Some biological diversity.*** Mongolia's fauna and their habitats and habitat environment have been impacted by global warming and droughts which occur in a relatively short period and observe shrinkage of relic and distribution area of some mammals, birds, and insects (Table 8.1).

Consequently, five adaptation technologies concerning ecosystem and biodiversity management and research aspects are listed in this assessment (Table 8.6).

Table 8.6 Technology Needs Assessment on the reduction of vulnerability of biological diversity (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts | | | | | | Investment cost | Contribution to reducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Economy | | Environment | | Society | | | | |
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Protected areas and regions | Ecosystem management | 4 | 3 | 5 | 5 | 3 | 3 | 4 | 4 | 31 |
| 2 | Ecological corridors and buffer zones | Biodiversity management | 3 | 3 | 4 | 5 | 3 | 3 | 3 | 4 | 28 |
| 3 | Protection and planning of biological diversity | Biodiversity management | 5 | 4 | 5 | 5 | 3 | 3 | 3 | 4 | 32 |
| 4 | Wetland and peatland protection and rehabilitation | Ecosystem management | 3 | 3 | 4 | 5 | 3 | 3 | 4 | 3 | 28 |
| 5 | Monitoring for biological diversity | Research studies | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 27 |

***Public health***. Climate change, directly and indirectly, impacts people's health and in particular, increases intensity and frequency of atmospheric disasters impact as directly while through air pollution, flood, droughts, water shortages, and transmitted diseases affect indirect way.

The frequency of disasters is expected to increase by 23-60% in the middle of the century and are becoming a key factor to list the five adaptation technologies, which are essential for information technology, early warning, training and research work (Table 8.7).

Table 8.7 Technology needs assessment on the reduction of vulnerability in public health sector (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts | | | | | | Investment cost | Contribution to reducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Economy | | Environment | | Society | | | | |
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Disease registration, controlling system | Information technology | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 3 | 27 |
| 2 | e- health system | Information technology | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 28 |
| 3 | Education on personal health depending on weather and climate | Training | 4 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 37 |
| 4 | Early warning system against multiple natural disasters | Early warning technology | 4 | 4 | 3 | 4 | 5 | 4 | 5 | 5 | 34 |
| 5 | Research studies on climate change and health | Research studies | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 5 | 29 |

***Natural disasters.*** Natural hazards and disasters are facing extreme climatic occurrence and extreme weather events and their intensity and frequency are increasing due to climate change. In the future, the occurrence of atmospheric hazardous phenomena is expected to increase by 23-60% (Table 8.1).

Therefore, these five technologies have been ranked to address early warning system to reduce vulnerability and risks, information technology, training and insurance (Table 8.8).

Table 8.8 Technology Needs Assessment on the reduction of vulnerability of natural disasters (1-very low, 2-less, 3-medium, 4-high, 5-very high)

| № | Technology name | Technology group | Benefits and positive impacts | | | | | | Investment cost | Contribution to reducing vulnerability | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Economy | | Environ-ment | | Society | | | | |
| | | | Asset | Business and market activity | Biological biodiversity | Ecosystem services | Public health and livelihood | Employment | | | |
| 1 | Insurance system on disasters | Insurance | 4 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 29 |
| 2 | Monthly and seasonal forecasting | Early warning technology | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 27 |
| 3 | Disaster response and social media | Training | 2 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 25 |
| 4 | Early warning system against drought and dzud | Early warning technology | 5 | 4 | 3 | 3 | 5 | 4 | 4 | 4 | 32 |
| 5 | Warning system during the disasters | Information technology | 4 | 4 | 2 | 3 | 5 | 3 | 4 | 3 | 28 |

### 8.1.3. Key barriers to adaptation technologies

Above-mentioned climate change adaptation technologies need in environmental, socio-economic sectors have been assessed by basically multi-criteria analysis method based on the assessment of different researchers and experts. Possible obstacles and barriers during the transfer, scale-up and implementation stage has been summarized and analyzed from the common issues for the first five technologies of each sector. Simultaneously, the selected technologies are categorized for determining the measures to eliminate and overcome the barriers. (Table 8.9).

Table 8.9 List of major barriers to introducing adaptation technologies in environmental and socioeconomic sectors, and measures to eliminate and overcome facing barriers

| № | Common barriers and obstacles | Sectors | Measures to eliminate barriers and difficulties |
|---|---|---|---|
| 1 | Lack of finance and economics | Arable farming | • Create an optimal mechanism for the financing of needed adaptation technology<br>• Exemption from import tax of equipment and instruments required for technology<br>• Grant concessional loans to support domestic production<br>• Encourage individuals and enterprises which use climate-related technology |
| | | Livestock | • Increase the investment of foreign donors and government<br>• The attraction of private sector investment and creation of customs and income tax exemptions for private sector investment for the introduction of climate-related technologies |
| | | Water resource | • Establishment mechanisms for implementation, the creation of financial guarantee for a reliable source for water supply, water accumulation, improved water supply and sanitation systems and resource savings system |
| | | Forest resource | • Introduce advanced technology through the centralized budget, international projects, programmes and support from foreign donors, and finance the development of new technologies. |
| | | Some Biological biodiversity | • Increase the share and dividend from using natural resources and hunting income |
| | | Public health | • Clarify sources of funding for climate change-health care activities<br>• Collect a certain portion of foreign donors and donations (up to 5%) |
| | | Natural disasters | • Increase resources for natural disasters and source of financing |
| 2 | Lack of policy and decision making and planning | Arable farming | • Involve international projects and programmes to extend spatial dimensions of introduced and selected adaptation technologies.<br>• Reconsider existing incentive policies in the context of climate change vulnerability and reducing risks<br>• Conduct policies to create an insurance system<br>• Establish a long-term adaptation policy and plan, integrate it into development policies |
| | | Livestock | • Drafting, proposing and approving projects to improve the legal environment for pasture land relations<br>• Improve the legal environment for exporting livestock products<br>• Establish a legal environment for establishing appropriate animal tax (pasture use fees) and livestock ratios (appropriate herd composition) |

| | | | |
|---|---|---|---|
| | | Water resource | • Establish the legal environment for implementing, financing strategic decision-making for projects and programmes on for water supply and water conservation and coordinate with other with national and regional development programmes. |
| | | Forest resource | • Implement the "State Policy on Forest" (2015, Parliamentary Resolution # 49), Medium-Term Plan for the Implementation of the State Policy on the Forest "(2017, Order No. 98 of the Minister of Environment and Nature).<br>• Implementing sustainable forest management that mitigates adverse impacts of global warming and adapts to climate change. |
| | | Some Biological biodiversity | • Make clear the legal environment for income expenditure for use of natural resources and hunting |
| | | Public health | • Develop and approve sectoral adaptation programmes and plans<br>• Increase the knowledge of all decision-makers at all levels<br>• Strengthen management continuity |
| 3 | Lack of Human resource capacity and knowledge | Arable farming | • Systematically raising the climate change related knowledge of agricultural scientists and introduce into the university programme<br>• Developing and introducing manuals for adaptation and adaptation technologies of agricultural specialists |
| | | Livestock | • Provide training in adaptation technology<br>• Conduct training and awareness of traditional livestock and herding practices<br>• Regularly conduct research, meetings, and interviews from other countries |
| | | Water resource | • Implement integrated water resources management, preparation human resource in water resource sector, incorporate climate change, adaptation techniques into re-training programmes, and disseminate knowledge to the public |
| | | Forest resource | • Incorporate knowledge about climate change, adaptive technology, and sustainable forest management into university curriculum, and improve knowledge of forest specialists and administrators.<br>• Provide training within projects implementing in Mongolia. |
| | | Public health | • Increase the knowledge, skills, and attitudes of the population<br>• Train and maintain permanent employment for human resources<br>• Assign a specific person responsible for climate change and provide them with methodological guidance at all levels of healthcare organizations<br>• Providing manuals and promotional materials |
| | | Natural disasters | • Conduct a Bachelor's and Master's Degree studies in Natural Disaster and Risk Management in abroad |

| | | | |
|---|---|---|---|
| 4 | Lack of research studies and data | Arable farming | • Improve capacity building of agricultural training-production centers, experimenting with climate technology and disseminating knowledge to farmers<br>• Inviting foreign researchers and experts specializing in climate technology<br>• Conduct research on the creation of new species to support private and state-owned research |
| | | Livestock | • Conduct research on animal diseases and new breeding<br>• Develop an early warning system against drought/dzud based on information technology-based |
| | | Water resource | • Undertaking research studies on water economics, utilization and conservation technologies, ecosystem services and efficiency studies;<br>• Develop modeling and early warning system against water scarcity, flooding, and pollution ;<br>• Introduce systems on decision-making support, strategic assessment, and integrated water resource management planning |
| | | Forest resource | • Research work on forest above and below ground biomass, carbon resource and establish local emission factor, which is used in GHG inventory<br>• Conduct studies on the development of sustainable forest management, adaptation measures, technologies for forest vulnerability, increasing of greenhouse gas emissions, adaptation opportunities, reduction of forests degradation |
| | | Some Biological biodiversity | • Conduct a detailed assessment of climate change impacts, vulnerabilities, and risks of biodiversity |
| | | Public health | • Create detailed information on human diseases and mortality and Increase the availability and use of information<br>• Prepare human resource in research areas, provide a condition for stable employment<br>• Provide training in research methodology, training in foreign-developed countries, invite experts and trainers and participate in international conferences and seminars. |
| | | Natural disasters | • Conduct research studies on disasters assessment and extreme events, micro-dimensional atmosphere-hydrological modeling |

Natural and socio-economic systems of Mongolia have been adapted to climate variables and its change for long historical periods. It means that any changes caused by natural variation has overcome through its own own adaptable capacities. However, it is becoming increasingly difficult to cope with the present human-induced climate changes and their impacts, which are going very intensive and within a short time. Moreover, damages caused by the changes to our country's environment and socio-economics are increasing year by year as well.

Therefore, researchers and experts from different sectors describe adaptation technology needs and requirements based on the assessment of climate change impacts on forests, water resources, biodiversity, natural disasters, agriculture, livestock and public health sectors in this chapter. These technologies are focused on reducing the vulnerability and risks as well as the positive impacts and outcomes in environmental and socioeconomic sectors. Based on the adaptation technology needs assessment, the following recommendation and proposals are recommended. These include:

- Any adaptation measures to be implemented in above-mentioned sectors are needed to consider assessment result of adaptation technology needs, and necessary technologies are needed to transfer, diffuse and scaling up
- Accurate estimate of cost and benefit of adaptation technologies and better planning of measures to eliminate and overcome facing barriers in diffusing and transferring adaptation technologies
- To develop and approve national adaptation plan and implementation strategy on climate change and incorporate corresponding activities and measures related to diffusing and transferring technologies
- Reflect associated measures of adaptation technology in sectoral policy and plan
- Finally, build and implement monitoring and reporting systems on adaptation activities and measures
- Join the International Center for Climate & Technology (CTCN) as membership country

## 8.2. Mitigation technology needs assessment

This part of the chapter represents findings and suggestions of technologies related to only greenhouse gas (GHG) emissions such as zero or less emitting options. The Mongolian Government has adopted important policies to develop and introduce environmentally-friendly technologies. This includes the Law on Technology Transfer (1998), the Millennium Development Goals-based Comprehensive National Development Strategy (2008), the National Programme of Renewable Energy (2010), the National Programme of Climate Change (2011), the Green Development Policy Concept (2014), the State Policy on Energy (2015) and the Law of energy saving (2015). Advanced technologies are an important part of the successful implementation of the above-mentioned policies. This assessment suggests options of the most important technologies, feasible to introduce to Mongolia in the immediate future to reduce the GHG emissions.

### 8.2.1. Energy sector

The energy sector is a major source of the Mongolian Greenhouse gas (GHG) emission. Sources of the energy and their generation schemes in Mongolia are shown in Figure 8.4.

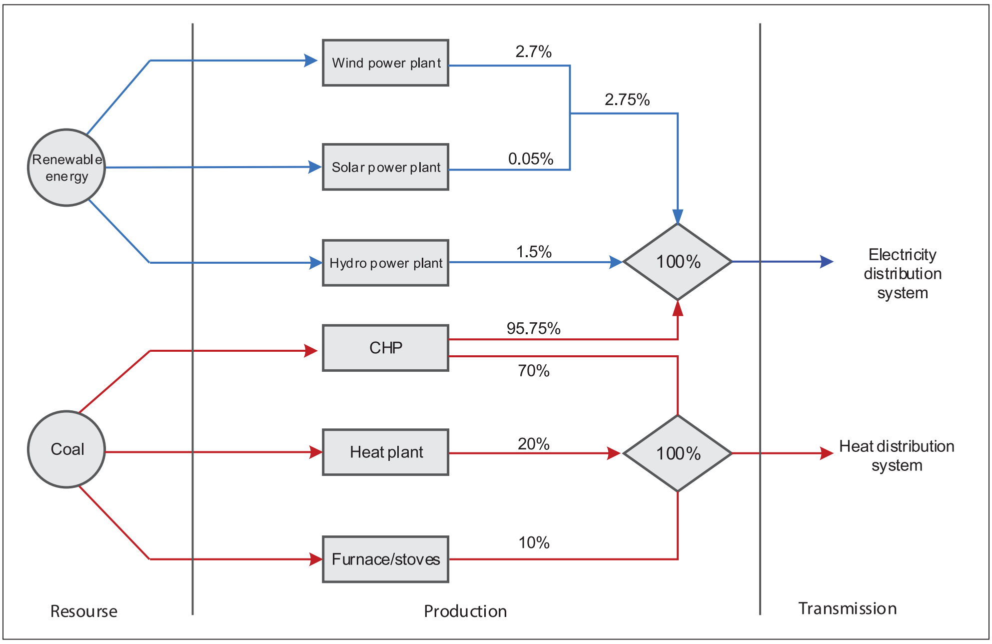


Figure. 8.4 Sources and generation scheme of Mongolian energy sector, 2016

Coal-fired Combined Heat and Power Plants (CHP) produce approximately 95.8% of the country's total electrical power energy (2016). Mongolia is rich in renewable energy sources of wind, solar and hydrology. However, utilization of the sources has not reached an efficient level yet. Small-scale hydrological power plants produce electricity but only in quantities less than 1% of the total energy generation.

### *Electricity Supply*

The CHPs operate by steam with a pressure of 3.5 MPa and 9.0 MPa and these results in a high level of the specific fuel consumption for electricity generation of the CHPs ranging from 370-410 grams CE/kW.h. Specific fuel consumption for electricity generation of Mongolian CHPs is shown in Figure 8.6.

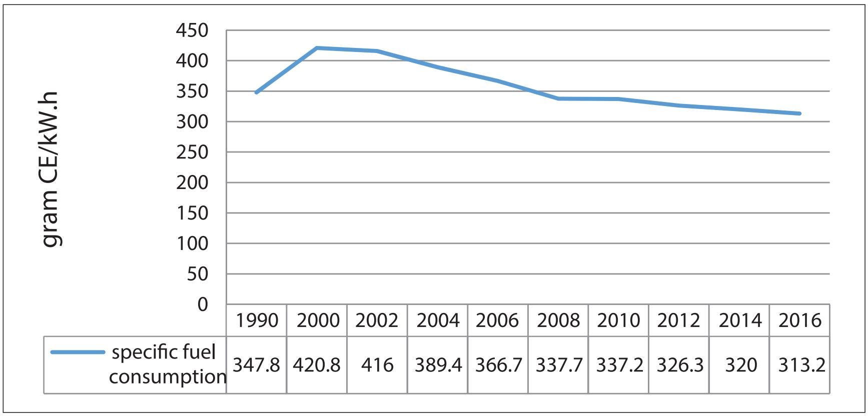


Figure 8.6 Specific fuel consumption for electricity generation of CHPs

In contrast, specific fuel consumption for electricity generation of the CHP-4 in Ulaanbaatar is 300.0 grams CE/kW.h on average, relatively lower than others as its high steam pressure is 13.0 MPa and the relevant temperature is 565°C.

For the energy sector of Mongolia, the main method for increasing the efficiency of electricity production and reducing greenhouse gas emissions is to create an optimal structure of sources for energy system. According to the principle, the installed total capacity of the CHPs should not be more than 60-65 percent of the total capacity of the energy system.

Suggested technology options to be introduced in the immediate future are:

- Implement advanced technology in energy production such as supercritical pressure technology. New large-scale Thermal power plants (TPP) will be constructed at major coal deposits of Baganuur, Shivee-Ovoo, and Tavantolgoi. It will create opportunities to introduce the super-critical technology of steam pressure to these plants and reduce the GHG emissions. In 2018-2020, it is planned to construct TPP with capacity 750 MW at the coal deposit Baganuur.
- Increase renewable electricity capacity from 5% in 2016 to 20% by 2020 and to 30% by 2030 as a share of total electricity generation capacity. In 2018-2020, it is planned to construct 64 MW Hydropower plants either at the Khovd River and 2x50 MW wind park in Tsogt Tsetsii sum of South Gobi aimag and Sainshand city. And also a solar power station with a capacity of 10 MW at the territory of Songino Khairkhan district of Ulaanbaatar city.
- Reduce electricity transmission losses from 13.7% in 2014 to 10.8% by 2020 and to 7.8% by 2030.

Completion of these projects will greatly contribute to increasing efficiency of the integrated energy system and further to the GHG reduction. Large-scale hydropower plants can reduce 897 thou. tonnes of $CO_2$ from one billion kW.h electrical powers generated.

*Renewable Energy Sources*. Mongolia adopted the State Policy on Energy to increase the share of the renewable energy in the total energy generation to 20% by 2020 and 30% by 2030. However, the State Policy implementation is still insufficient and the share of the renewable energy generation accounts for only 4.0%. The share shall increase in the future.

*Small hydro-power plants.* Small-scale hydropower plants categorized by operation period (as of 2016) are shown below:

a. Summer and fall seasons:
   - Bogd River 2000 kW in Zavkhan aimag;
   - Mankhan and Munkhkhairkhan 150 kW in Khovd aimag;
   - Guuling River 400 kW in Govi-Altai aimag;
   - Tosontsengel 380 kW in Zavkhan aimag;
   - Tsetsen-Uul 95 kW in Zavkhan aimag and
b. Year-around:
   - Durgun 12 MW in Khovd aimag;
   - Taishir 11 MW in Govi-Altai aimag

*Wind power generators*. Wind power generators with a capacity ranging between 100-150 kW operate at 10 soum centers of southern aimags of Mongolia. Also, about 30,000 households generate electricity from 50-100 W wind propellers. Wind Park of 50 MW was constructed at Salkhit Mountains in Sergelen soum of Tuv aimag, located at 80 km from Ulaanbaatar city in 2013.

*Photovoltaic (PV) Solar System.* Over half of 135,000 herder households use 50W, and 40% use 20-30W capacity solar panels. The system of 443 kW was constructed in Ulaanbaatar city with Japanese grants in 2011 and is now in operation. And also solar power plant with a capacity of 10 MW was constructed in Darkhan city in 2016. The country has conducted various research to utilise solar energy for the heat supply and has gained significant experience in using solar energy for heating of small-scale buildings and water. Currently, solar panels are widely used by tourist camps to heat water for shower purposes. However, solar energy is not as well used for building heating.

*Geothermal Heat pumps.* Interest in using geothermal heat pumps for buildings heating has increased in Mongolia since 2008. In the past, over 50 heat pumps were installed in Ulaanbaatar city and Zuun Mod city of Tuv aimag; however, those did not operate at reliable regime with high efficiency.

Studies were conducted on the introduction of geothermal heat pumps in the heat supply of some aimag centers. (B.Namkhainyam, Green heating systems analyses for aimag centers of Mongolia, Research report, GGGI, 2016).

### *Heat Supply*

Mongolia is characterized by its sharp continental climate with cold and long winters with drops of air temperature to -30-40°C. About 70% of the country's population lives in four major cities and 330 soum centers of 21 aimags.

Ulaanbaatar, Darkhan, Erdenet and Choibalsan cities and 9 aimag centers are connected to the district heating network. Other aimag centers have small-capacity hot water boilers and soum centers have low-pressure water boilers.

The national heat supply system is divided into three categories by its capacity, coverage, and efficiency:

- District Heating system (from CHP) in Ulaanbaatar, Darkhan, Erdenet and Choibalsan cities;
- The medium-capacity heating system in aimag and urban centers;
- Small-capacity hot water boilers.

*District heating systems of big cities.* CHPs supplying heat to cities generate 70% of heat and 96% of electricity from the country's total. Numerous projects have been implemented to improve the efficiency of outdated steam boilers and install new equipment at the CHPs. The projects resulted in significant improvement of the reliable operation and efficiency of the energy production of the CHPs.

In 2015, a Heat Plant with a capacity of 300 MW was built in Ulaanbaatar. Boilers installed on the Heat Plant burn coal by the technology of a circulating fluidized bed (CFB). And also they have a high efficiency.

Technologies suggested for energy efficiency and saving of the district heating systems and its GHG emission reduction are:

- Speed Controlled Main Pumps;
- Control and monitoring system;
- Heating units at directly controlled by consumers;
- Balancing and blocks valves in residential buildings;
- Individual meters and Heat load control

*Medium-capacity heating systems.* District heating systems in aimag centers and industrial settlements belong to a medium-capacity category. The installed capacity of this category is 20-30MW and the efficiency is not high (0.6…0.65). Currently, Khovd, Ulgii, Ulaangom, Sainshand, Sukhbaatar, Murun, Bulgan, Dalanzadgad, and Baruun-Urt cities have access to the district heating network. In 2012, the Government programme planned to build district heating systems in some cities, such as Zuun Mod, Mandalgobi, Baruun-Urt, Bulgan, Tsetserleg, Undurkhaan, and others. These actions were not carried out due to economic difficulties. In 2018-2020, new heat plants and renovate networks will be built in the Zuunmod, Mandalgobi and Undurkhaan cities.

Taking into account the findings of the desktop review and field study, the following actions are recommended in order to transition to heating systems:

- Currently used boilers do not meet the standards. Boilers of both district heating systems should be replaced with a high-efficiency boiler with circulating fluidized bed (CFB) coal combustion. CFB is a clean process with the ability to achieve lower emission of pollutants by absorbing up to 95% of the pollutants.
- High-efficiency water treatment facilities should be installed at the heat plants and independent quality inspection system shall be set up for water.
- Indoor and outdoor pipelines of residential buildings or costumers should be renovated or replaced with new ones.
- All kinds of consumers shall be installed with heat-meter at their facilities;
- A pilot project to utilize heat pump or electric boiler for heating buildings should be carried out for public buildings such as schools, kindergartens, and airport in remote areas;
- Hot water for some public and private houses should be heated up with a combined solar collector or electrical boiler;
- Old buildings should be retrofitted at a gradual level so that the standard requirements;

One of the main tasks to increase efficiency and reduce greenhouse gas and harmful gases emissions is to reduce the number of small capacity and low-pressure boilers through the development of district heating system. Small capacity and low-pressure hot water boilers strongly pollute the air in cities.

***Small-capacity heating systems.*** *Small-capacity hot water heating boilers with a capacity higher than 100 kW.* Mongolia has over 1700 small-capacity hot water boilers used in all 350 soum centers of the country, and state border sites, villages and ger districts of big cities. As of 2016, Uliastai, Altai, Arvaikheer, Bayankhongor, Mandalgobi, Undurmod, and Zuunmod cities did not have a district heating network. One aimag center at these aimags has 8-12 heating boiler houses, on the average, to generate heat for public facilities and residential buildings. Also, there are approximately 200 boilers in Ulaanbaatar, 50 in other cities with district heating network, and 60 in cities with no district heating systems. The technology used at the above-mentioned small-capacity boilers is very old and the efficiency rate doesn't meet current technical and efficiency requirements. Fuel often doesn't combust completely due to the poor design of the most small-scale hot water boilers and their incomparability with fuel quality and purposes. The efficiency of the hot water boilers ranges between 0.4 to 0.5 and thus, coal combustion of the boilers is very high.

***Low-pressure hot water boilers.*** In recent years, there is an increasing need to heat newly constructed small-scale buildings such as private residential buildings, schools, kindergartens, khoroo hospitals, khoroo administrations, drug stores, police units, canteens, shops, bathhouses and barbershops in ger districts of Ulaanbaatar, Darkhan, and Erdenet cities, aimag and soum centers. Over 3600 low-pressure hot water boilers operate in ger districts of bigger cities of Mongolia consuming 2.4 million tonnes of coal, 20% of the total coal consumption. The boilers don't meet current technological requirements. These boilers are playing a significant role in the pollution of Ulaanbaatar air, Erdenet and aimag centers.

Suggested options for technologies to introduce in the immediate future are:

Increasing efficiency of the small capacity and low-pressure heating boilers is one of the solutions to reduce the GHG emissions. Thus, the following technologies are suggested for that purpose:

- Install newly designed boilers with high efficiency in areas which not connected to the central power grid;
- Replace the boilers located in remote centers (distance over 150 km)

from coal mines but connected to the central power electricity grid, with electric boilers;

- introduction of geothermal heat pumps;
- To resolve this, each boiler house should be installed with water treatment facilities;
- Install oil or gas fired boilers.

*Coal-Primary energy source of Mongolia*

Mongolia is rich in coal resources. Therefore, coal has been the primary energy source and its consumption accounts for 96% of the total fuel utilization. In 2013-2016, coal exploration has increased three-fold and reached 24 million tonnes due to increased export of coxing coal.

Larger coal mines of Baganuur, Shivee-Ovoo, Aduunchuluun and "Shariin" River supply basic coal needs of CHPs of the CES, major industrial cities and other users. Other coal mines provide coal for local heating networks and households. Table 8.12 shows coal consumption of Mongolia for a period from 2000 to 2016 (NSO, 2016).

Table 8.12 Coal consumption of Mongolia, thou. tonnes

| 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 |
|---|---|---|---|---|---|---|---|---|
| 4838 | 5041 | 6824 | 5402 | 5437 | 6905 | 7381.3 | 7793.3 | 8598.6 |

CHPs use 70% of the total coal, medium, and small-scale boilers 20%, and low-pressure and household stoves consume outstanding 10% of the total coal.

About 8.6 million tonnes of brown coal consumed per year (NSO, 2016). However, about 30% of the total consumed coal burned with old technology, in other words, coal put on specific shelves and burned later. In 2016, 53% of the totally explored coal was coking coal, 24% sub-bituminous coal and 23% was brown coal.

***Introduction of coal combustion technology "Circulating Fluidized bed" in thermal power plants planned for construction.*** Larger- capacity boilers of TPPs in Mongolia utilize technology that burns coal after grinding it to dust. This method has been used for many years. In recent years, a new technology of Circulating fluidized bed combustion (CFB) to burn bad quality coal has been introduced. The technology shall be also introduced to large-capacity thermal power plants to be newly constructed.

The air pollution in Ulaanbaatar city reached disaster level because of a large amount of raw coal burned in different types of boilers and stoves during the cold seasons. The level of the air pollution is 6 to 8 times higher than the accepted level and outbreak of pulmonary diseases is very high among residents, especially children and the elderly.

One of the optimum solutions to reduce air pollution in big cities and aimag centers is to utilize coal bed methane as an alternative energy source. Recently, Mongolia started acknowledging the importance of coal bed methane utilization. The geology and exploration also started to take into account coal-bed methane. Utilizing coal-bed methane for hot-water heating boilers would reduce the GHG significantly. Replacement of 1.0 Gcal/hour heat load coal boilers with gas boilers will cut the GHG emission by 7200 $CO_2$ equivalents per year. About 60% of the emission reduction is accounted for by collecting methane gas to be emitted into the air and utilizing for fuel.

### 8.2.2. Energy distribution systems

*Electricity distribution system.* Technology needs assessment of the electricity distribution system is conducted for each of the categories (Figure 8.7).

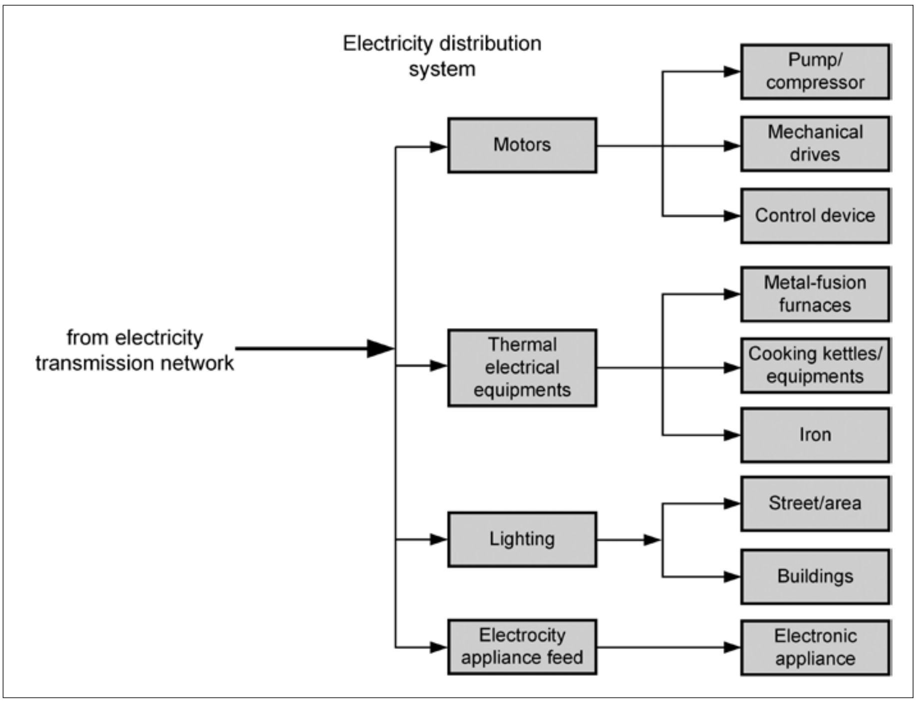


Figure 8.7 Structure of electricity distribution system

Motors and Drives. Motor systems consume about 70% of industrial electricity in Mongolia. Its load level was at 20-30% as identified by audits. Most of the motors have old technologies.

Motor efficiency improvement technologies include:

- energy-efficient motors;
- improvement of power factor;
- variable speed drives.

*Heat distribution system.* Technology needs assessment of the heat distribution system has been carried out by its every component. Thermal energy is utilized for two major purposes:

1. Heating and hot water supply of private and public buildings, and residential buildings;
2. Production of various goods and services and food preparation.

Mongolia is different from other countries in that it uses 90% of the overall energy only for building heating (Figure 8.8). In that sense, introducing technologies that improve the building insulation system is important.

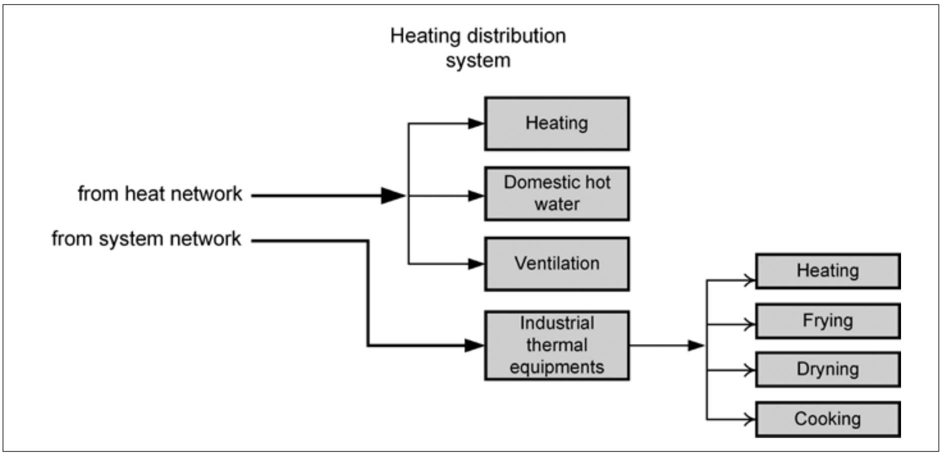


Figure 8.8 Structure of heat distribution system

*Thermal Insulation technology of the buildings*

Thermal insulation in buildings is an important factor in achieving thermal comfort for its occupants. Insulation reduces unwanted heat loss or gain and can decrease the energy demands of heating systems. Heat loss means the heat load of buildings. Buildings have relatively higher heat losses because the heat conductivity level in buildings is lower than the standard level by

2-3 times (Construction Heat Techniques of the Building Norm and Rules (BNaR) 2.0.03-93). It shows that most houses, old houses of 1950-1990 and bad quality houses of the 2000s, in Mongolia have a higher rate of heat loss.

The National Policies on Green Development and Energy aim to reduce the heat loss of building by 20% in 2020 and 40% in 2030. The national statistics data and report of MCUD, the parameters for development of building sector of Mongolia, for example, a total constructed building volume is measured by monetary value, not by the total floor area or its volume. Unfortunately, existing data of construction sector expressed in monetary value cannot be applied for estimation of the building heat losses.

According to above calculation, buildings with about 129.0 million $m^3$ volume or 38.0 million $m^2$ area in total are connected to the district heating system of small, medium and big capacity in Mongolia as of 2014. Approximately, 66% of them are located in Ulaanbaatar city. (B.Namkhainyam, Green heating systems analyses for aimag centers of Mongolia, Research report, GGGI, 2016).

Given city, aimag or soum center shall estimate its actual building heat loss of their buildings and estimate the potential of building heat loss reduction in comparison with the national standard (including, BCM 23-02-09). At the stage of preliminary study and planning, an average amount of the building heat loss reduction can be applied. For instance, it has been estimated that building heat loss reduction potential for pre-cast panel apartment buildings in Ulaanbaatar is 40-50%. (Thermo-technical retrofitting of public and apartment buildings in Ulaanbaatar, GIZ project, 2013).

Additional insulation of the houses at the current standard requirements would increase heat supply system capacity reserves by 400-500 Gcal/hour. In other words, there will be no need for an additional thermal power source in Ulaanbaatar with such increased reserves. This further results in the GHG emission reductions as well.

It has been estimated that additional insulation of concrete residential buildings at the standard level will reduce 1.4 tonnes of $CO_2$ emission per household with 60 $m^2$.

*Control and measuring equipment for heat consumption in residential buildings*

Since 2000, numerous light-industry factories and service entities in Ulaanbaatar, and Darkhan cities have started using heat meters to save thermal energy. However, rural residents are not as strongly interested in thermal energy saving. About 30% of the country's population lives in public residential buildings connected to the district heat network. None of those residential buildings have heat meters and their heating tariff is calculated based on a fixed rate. Also, the residential buildings are not installed with specific technical tools to adjust indoor heat consumption and owners have to open windows when it gets hot inside.

Technology shall be introduced that allows customers of the district heat network to adjust their heat consumption. In other words, each household or an individual customer with a separate financial account would have installed a specific heat adjusting tool.

### 8.2.3. Transportation sector

In 2016, passengers carried 264.0 million, of which 98.5% by road, 1% by railway and 0.5% by air. Carried freight - 40.398 million tonnes, of which 50.5% by road and 49.5% by railway.

Mongolia does not produce any liquid fuel and imports all types of liquid fuel from its neighboring countries of Russia and China.

*Railway transportation.* The fuel consumption of railway is very high due to old diesel locomotives that are already out of production. Also, 1800 km of the new railroad Ukhaakhudag-Tavantolgoi-Sainshand-Khuut-Choibalsan, Khuut-Bichigt will be constructed under "New railway" project. In recent years using new diesel locomotives with low fuel consumption has begun.

*Auto transportation.* Structure of vehicles in Mongolia is shown in Figure 8.9. Numerous infrastructure projects to expand auto road networks and improve road quality have been recently implemented. It increased the length of the paved road from 2830 km in 2009 to 7456 km in 2016. Currently, most of major urban and rural centers are connected by the paved roads; residents greatly benefit. Benefits include reliable and comfortable driving, time-saving, and less mechanical damage to vehicles.

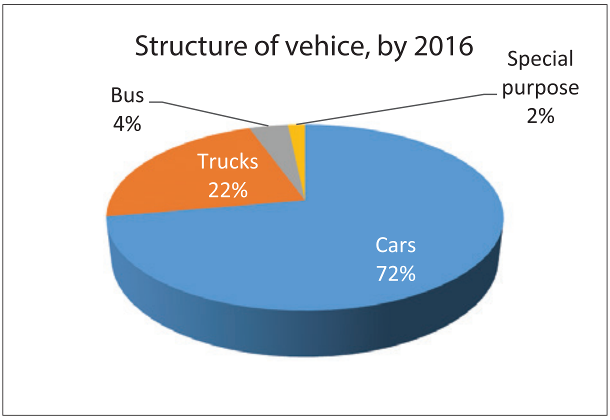


Figure 8.9 Structure of vehicles in Mongolia

Ulaanbaatar city implemented the following measures to reduce the traffic:

- Created only-for-bus lanes and prohibited other vehicles from driving on that lane;
- Increase the share of hybrid private road vehicles;

Procedures that prohibit vehicles to participate in city traffic once a week by car plate number are in place.

### 8.2.4. Industrial sector

The industrial sector does not include all kinds of factories, only ones that emit the GHG during the production process. Cement and lime factories are the only major industrial sources of the GHG emission in Mongolia.

*Cement production*. In 2016 in Mongolia was produced 432.4 thou. tonnes of cement. There are six cement factories operating in Mongolia with the capacity to produce 3.0 tonnes of cement per year (Khutul, Darkhan, Nalaikh, Senj Sant, Khukh tsav, Sergelen soum).

In 2014, Khutul Cement factory started its operation. It has installed capacity to produce 1 million tonnes of cement by dry technology. In 2015, the following cement factories started working.

- Senj Sant cement factory of 0.5 million tonnes;
- Khukh Tsav cement factory of 1 million tonnes;
- Sergelen soum's cement factory of 1.0 million tonnes,

Above-mentioned factories will use dry technologies, as suggested by this report. This dry technology can reduce the GHG emission by two times.

### 8.2.5. Livestock sector

The livestock sector is the primary source of income and a traditional lifestyle of Mongolia. The country's economic development largely depends on that. As of 2016, the agricultural sector accounted for 12.0% of the GDP. The livestock sector solely produces about 84.2% of the agricultural products.

In recent years, the number of livestock has been increasing. The structure of Mongolian livestock is shown in Figure 8.10. Especially, due to strong market demand of the cashmere, the share of goats has increased to 41.6% of the total livestock.

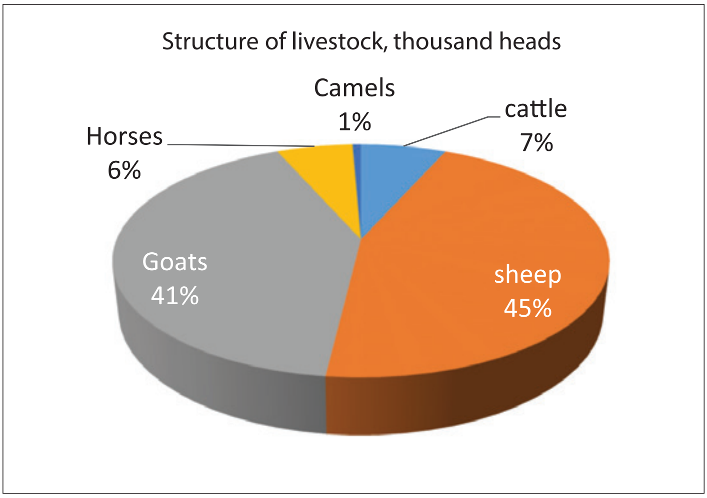


Figure 8.10 Structure livestock, by 2016

Any kind of pastoral livestock products in Mongolia belong to the organic category. Pastoral livestock is exclusively fed by natural pasture plants.

Over the past decade, the country is getting more interested in increasing the quality of livestock rather than increasing its number. One of the solutions for reducing the number of livestock is intensive livestock farming. As of 2016, there were over 1845 dairy and meat farms in peri-urban areas with approximately 170,000 farm animals (MFALI, 2016).

Increasing dairy and meat output will not only reduce the total number of livestock but also cut the GHG derived largely from enteric fermentation. In the future, it is suggested that livestock farming should be encouraged, especially in crop areas, for better food supply and less GHG emission.

### 8.2.6. Land use and forestry

The territory of Mongolia is 1.5 square kilometers, of which 74.0% agricultural lands, 16% state special use land, 6.1% forest resource land, 0.4% land of water resource, 0.3% urban areas, 0.2% roads and networks.

A total agricultural area was 115,400 million hectares as of 2016; 97.7% of which is grasslands, 1.5% is meadows and 0.9% is croplands.

*Grasslands.* Over 80% of Mongolian territory is grasslands. Recent research of the pastureland uses identified that over-grazing and water shortage of grasslands is at serious levels in the countryside. In 2016, 7.8 million hectares of the pastureland was damaged, 2.3 million hectares of which were severely degraded, 2.2 million hectares were damaged by insects and parasites, and 2.7 million hectares were under desertification. In addition to that, an average dry forage yield per hectare is not more than 400 kg.

Two major reasons for the pasture degradations are: (1) climate change and (2) increased the number of livestock, especially goats. Another external factor is the dryness of rivers, springs, and streams. If no preventive measures are taken place, there could be negative effects on the agricultural food supply.

Suggested options for technologies for grasslands protection are:

- Preserve traditional pastoral livestock sector (organic production) and at the same time to improve livestock output (breeding) and cut number of livestock;
- Encourage high-efficiency livestock farming in crop areas;
- Control livestock herding structures, specifically keep the optimum number of goats;
- Implement sustainable grassland management.

*Croplands*. Mongolia has a relatively short period of cropland use. The country had intensively converted grasslands to croplands for agricultural productions during the period from 1958-1980s over 1.2 million hectares became croplands. The sowing area in 2016 is 505,281.9 hectares. This year, 483.5 thousand tonnes of the harvest was harvested. Drop irrigations technology shall be applied for croplands to attain high-efficiency water use and better crops.

*Residential areas.* Buildings and facilities areas, public lands such as streets, mine lands, industrial areas and ger districts belong to this category that occupied about 703.0 thou. ha of land in 2016. Over the past period, the residential area has become larger and consequently, there is less vegetation cover.

*Transportation use land.* Over 435 thou.ha of land are used for railways, auto roads, and another network as of 2016. The country is planning to construct more major auto roads and railways. This would inevitably decline vegetation cover in the country, thus GHG absorption capacity would decline.

*Forestry.* As of 2016, the boreal forest area of Mongolia is 9.09 million hectares, its 78% coniferous forest, 6.6% broadleaved forest, 9.7% mixed forest and 5.7% forest regeneration.

About 440.0 thou. of hectares were degraded in 2016 – 50% by fire, 34.2% from the cutting of trees and shrubs, and 14.6% from insects and parasites Carbon stock of forest is 250 tonnes per one hectare. (Source: REDD+National Forest Inventory, GIZ Project, report, 2015).

*A forestation* As a result of the annual a forestation measures, 8400 hectares in 2012, 6628 hectares in 2014 and 5031.6 hectares in 2015 were afforested. It is suggested that the following technologies be introduced in the immediate future:

- Improve forest protections;
- Intensity the forestation;
- Introduce well-developed irrigation technologies;
- Reduce area of the plantation by increasing yield per hectares.

### 8.2.7. Waste management sector

There are 460 waste-disposal open dumps that cover over 3150 thou. square meters in Mongolia. In 2016, approximately 1.1 million tonnes of wastes were generated; 530-580 thou. tonnes of wastes were generated in Ulaanbaatar and 30 thou. were in Darkhan city. Ulaanbaatar city generates 900 tonnes of wastes daily–65% of which is from households, 23% from construction and industry sector, and 12% from streets and other sources. The city has three final-disposal sites (landfills of Moringiin Davaa, Narangiin Enger, and Tsagaan Davaa) where wastes are transported (UCO, 2016). In 2007, JICA conducted research on Ulaanbaatar waste management and identified that a person living in a ger or private house produces 0.2 kg of wastes a day and 72.9 kg a year. In contrast, one citizen of a city produces 0.6 kg of waste a day and 130.5 kg a year. On the average, a city resident produces 0.34 kg of waste a day and 130.5 kg a year.

Residential waste is a sum of wastes generated by commercial entities and offices and households. A city resident generates 0.84 kg of residential waste a day and 306.8 kg a year.

About 85% of the municipal solid wastes in Ulaanbaatar city are transported to the final waste disposal sites. Other cities and aimags and urban centers do not dispose the waste properly and leave it at open dumps. In that case, methane is almost not emitted.

It is suggested to introduce technologies that generate energy either from producing methane from solid waste treatment or by burning the wastes.

*Domestic wastewater.* Wastewater (WW) management system is divided into three categories of wastewater:

- *Central sewage system and WW treatment plants in Ulaanbaatar, Darkhan and Erdenet city*. Amount of WW in Ulaanbaatar city was increased to 180 000 $m^3$/day in 2012-2016. In the Ulaanbaatar 12 sewerage systems operate, of which the Central WW *treatment plant* is the largest in terms of capacity. The central WW *treatment plant* cannot operate normally because the equipment is very old. Bottom ash disposal is the most critical issue for the WW treatment plants. The plants use the most outdated method of sludge treatment by leaving at open sites to dry naturally.
- *Sewage system of aimag centers*. However, equipment and technologies of the plants are outdated and cannot operate at normal regime for the past years.
- Outdoor pit latrine used by households and commercial organizations in ger districts of Ulaanbaatar, Darkhan, Erdenet cities and aimag centers. All households and commercial entities that are not connected to the central sewage system dig a pit at their land and dispose of wastewater. Soil and water pollution can be mitigated through the establishment of sewage systems in ger areas.

*Renovation of the WW management system* and expansion of its capacity is a high priority issue at this moment of the reporting. Because of the poor treatment of the WW, the Tuul River (Ulaanbaatar city) is far from its boundary of natural recovery and is critically polluted. Construction of the new wastewater treatment plant with large-scale capacity has been discussed in many years but is not yet implemented.

*Industrial wastewater.* Ulaanbaatar has a good number of wool processing, leather processing, and food factories. Even though these factories have its wastewater treatment facilities (khargia), they are no longer in use because of the technology applied. The factories fed wastewater to the city's central sewage system intentionally but in secret caused serious problems. Taking into account the current situation, the city is looking for options to minimize the number of any kind of processing factories within the city boundaries.

Methane is only emitted from wastewater that are generated from by food processing factories, not from the factories that use chemicals for the processing. The food processing factories include meat, dairy, alcohol and beverage productions that generate wastewater composed of organic solutions.

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# Chapter 9

## CONSTRAINTS, GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

## 9.1. The current situation

Since submission to Mongolia's Second National Communication (SNC) in 2010, remarkable advancements were seen in dealing with the challenges that climate change imposed. New framework of policies were implemented, financial and technical possibilities were broader, and the capacity to work with the issue has improved. In Mongolia, during the past years, several projects and activities on climate change issues in different sectors were implemented or are under implementation stage with financial support from multilateral financing institutions. In addition, technical and human capacities in the field of climate change have been improved significantly. The processes for the preparation of the national communication has not only contributed to building and sustaining capacity in the country, it has also helped to highlight important climate change issues that need the immediate attention of key policy-makers and practitioners at all levels.

The latest summary and assessment of activities and undertakings related to climate change were given in the Intended Nationally Determined Contribution (INDC) of Mongolia submitted to the UNFCCC Secretariat in September 2015. These activities and support aimed to maintain long-term ecological balance and to ensure economic streamlining and social development in alignment with climate change through reducing risks and vulnerabilities and improving adaptive capacity. Therefore, necessary adaptation undertakings have been included in National Action Programme on Climate Change (NAPCC) as cross-cutting actions and in strategies and plans, especially for vulnerable sectors.

Given the high priority of adaptation in Mongolia, current and planned undertakings and supports in the most vulnerable economic sectors are summarized within the INDC (Mongolia INDC, 2015, Table 9.1).

Table 9.1. Implementation of climate change adaptation undertakings and supports

## A. Financial Support received in vulnerable sectors

| Sector | Current and planned undertakings | Strategy or Programme name | Current status of implementation | Resource and funding | |
|---|---|---|---|---|---|
| | | | | National | International |
| Livestock and pasture | To coordinate a number of animals and herds composition aligned with pasture carrying capacities at regional levels. | "Mongolian Livestock" National Programme, (2010-2021) | The government has proposed amendments to Law of Mongolia on Land and developed guidelines for pasture land usage taxation based on the number of animals, types and regional contexts. | Government | |
| | To ensure an effective coordination of pasture usage and reserve at least 10% pasture for motor movement at provincial and local levels which can be used during disasters. | "Mongolian Livestock" National Programme, (2010-2021) | There are 7 sites of reserve motor pasture for a special purpose at provincial levels which occupy 679 thou. ha or 0.6% of the total pastureland. At soum (country subdivision) levels, there is 1.8 million ha pasture which can be used as reserve pasture during disasters. | Government | - |
| | To use environment, human and animal-friendly and advanced technologies against pasture insects and rodents. | "Mongolian Livestock" National Programme, (2010-2021) | Every year, the Government budgets 1 million USD and facilitate environment-friendly measures based on monitoring and surveys. | Government | - |
| | To conduct water survey and exploration based on local herders initiatives and establish water wells with water reservoirs. | "Mongolian Livestock" National Programme, (2010-2021) | In the recent years, almost 1000 water wells were established by the Government budget and international projects funding and handed over to herders groups. In the steppe region, renewable energy, like solar and wind, are being used for ground wells operations which are financially efficient to save fuels and environment-friendly. | Government | International projects |
| | To breed high production cattle to increase meat production and ultimately to reduce the number of pastoral animal in winter. | "Mongolian Livestock" National Programme, (2010-2021) | In 2012, meat production cattle and sheep have started to breed in 10 soums and about 1200 cattle of high production were imported from France and Germany. | Government | - |

Chapter 9

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| | To introduce modern, advanced technologies in pastoral animal husbandry and herders' livelihood, to scale up traditional best practices, to implement projects and programmes which aim to advocate for lifestyles and management skills aligned with ecosystem changes and climate changes and to raise public awareness and training. | "National Security Concept", 2010 | Several international projects have been implemented in order to develop climate change adaptation knowledge and skills, to improve pasture management, to encourage traditional best practices and modern advanced methods. As a result one-third of herders' households have joined herders' voluntary groups and attended in training and awareness campaigns. | - | World Bank (WB), Asian Development Bank (ADB), Food and Agriculture Organization (FAO), United States Millennium Challenge Account (US MCA) and Swiss Agency for Development and Cooperation (SDC) projects |
| | To extend pasture and desertification monitoring system, to conduct systematic pasture pests and insects observation and to develop guidelines for pasture health assessment. | The first phase of NAPCC, (2011-2016) | National Agency for Meteorology, Hydrology, Environment, and Monitoring has implemented projects funded by donor agencies and technical guideline for pasture and soil monitoring which is done at about 1500 points of the national monitoring network. The database has been established and National Pasture Status has been reported annually. | Government | 400 thousand USD from international projects |
| | To plan population settlements in accordance with climate change, regional natural resources and their capacities to recover | "Green Development Policy", (2014-2030) | "New soum" project has started to be implemented in soum centers to construct integrated government buildings with central heating and water systems, to provide opportunities to have an access to water and sanitation facilities for households and to establish green gardens and areas. | Government | - |

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| Arable farming | To introduce advanced agricultural and water saving technologies and to establish forest protection strips in order to improve soil fertility and restore soils, to produce and meet national consumption of cereals and vegetables, and to re-use at least 70% of abandoned cropland. | "Green Development Policy", (2014-2030) | As of 2015, the total cropland has been accounted 750 thou. ha including 450 thou. re-used abandoned cropland. There is still a quite big amount of abandoned cropland.<br>The Government though Agriculture Support Fund has given soft loans to farmers for wheat seeds, fuels, soil and crop protection products with repayment after harvesting and agricultural machinery with a repayment term of 3-5 years. | 6.5 mln USD spent for soft loans by the Government | 1.5 mln USD from Government of China |
| | To re-use the abandoned cropland (about 940 thou. ha) in order to increase production of wheat flour, potato, and vegetables to fully meet national consumption demand. | "Third Campaign for Reclamation of crop production", (2008-2010) | As a result of the campaign, farmers and farming companies got a soft loan for fuels, cereal seeds and imported and equipment and paid back after harvests. Consequently, crop production has increased significantly and 100% of wheat and potato have been produced locally and 57% of vegetables are produced. | Government | - |
| | To increase irrigated cropland in order to reduce harvest variation by 20% for cereals, 40% for vegetables by 2015 and to reduce irrigation water consumption by 50% in 2021 through introducing water-efficient technologies. | NAPCC, (2011-2021) | Drip irrigation systems have been started to be used since 1997 and as of 2015, these systems have been applied to 280ha of vegetable farms. Mulches were started to be in practice in 2007 and have been applied to 50 ha of vegetable farms as of 2015.<br>The Government provides household scale irrigation equipment with a capacity of 0.5-1.0ha to farmers free of charge.<br>Projects such as "Mongolian potato" and desertification projects supplied grain producers and household gardeners with drip irrigation systems and plastic mulches. | Government | Government of Switzerland |

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| | -To develop irrigated crop production through increasing irrigation systems, and introducing advanced technologies such as drip irrigation, water reservoirs, and precipitation harvesting.<br>-To conduct water resource survey, exploration for cropland and pasture, design and establish water systems through public-private and individual funding. | "State policy on Food and Agriculture", 2003 | Government funds about 30% of finances to renovate and construct public and private irrigation and water systems for cropland. Irrigated cropland increased by 7.2 thou. ha than in 2005. | 8.75 mln USD in the last 10 years by the Government | 4.9 mln USD |
| Water resource | To forbid mineral exploration and exploitation in 30% areas of upstream of rivers where at least 70% of water and run-off are accumulated. | "Law to prohibit mining exploration and exploitation in areas of upper streams of rivers and water sources and forestry", 2009 | As of 2014, state protected areas reached up to 17.4% of the total land including the upper stream of rivers and water sources in order to maintain wildlife and ecosystems balance. | Government | - |
| | To improve water resource and usage management. | "Water" National Programme, (2010-2020) | Integrated water basin management plan has been implemented for 7 river basins. | Government | International projects |
| | To take ecosystem-based adaptation measures. | A project of "Ecosystem-based Adaptations in highly vulnerable rivers basins", (2012-2017) | The project is being implemented in Kharhiraa-Turgen rivers basin in the western region and Ulz river basin in the eastern region and aims to strengthen national and local adaptation capacity through conservation of riparian and basin ecosystems in the areas. | - | Adaptation Fund for Kyoto Protocol |
| Forestry | To improve forest sector management, structure, and coordination systems. | "National Forestry Programme", (2005-2015) | Community-based forestry resource management was introduced and as of today, about 20% of the forests are under the protection of community forestry groups. | Government | - |

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| Disaster management | To integrate disaster risk reduction into climate change adaptation and sustainable development. | Plan for "State Policy on Disaster Protection" and National Programme for Strengthening Disaster Resilience", (2012-2021) | A certain amount of money is allocated to the Government Reserve Fund from the National budget in every year. For example, 25.7 million USD was spent from this Fund for disaster relief and recovery expenditure in 2013 and 2014. | Government | - |

## B. The capacity of current and planned undertakings

| Sector | Individual level | Institutional level | System level |
|---|---|---|---|
| Livestock and pasture | -Local leaders, herders, and other citizens have started to realize benefits of adaptation undertakings.<br>-Local community participation is the key to the pasture usage, protection, and coordination as suggested by related projects. | -"Pasture usage contract" was initiated by pasture management and herders livelihood projects and is being developed by pasture and livestock specialists. | -"Pasture Law" has been drafted and discussed by related experts and members of the Parliament, but yet has not been passed. The bill was submitted in 2011 to the Parliament and survey poll from 15,060 herders in 118 soums was done according to the suggestion by the Parliament. 68% of the total participants in the survey agreed separate "Pasture Law" is required (18% responded that there is no need and 14% they don't know). But the bill was not discussed at the Parliament. Pasture related articles were included in the Land Law and submitted to the Parliament in 2013. Yet, amendments in the Land Law again have not been discussed.<br>-Pasture law has been under an uncertain condition, pasture related articles such as pasture usage taxation, and using funds for pasture conservation were included in a draft of the "Asset Law" by experts and government officers of related ministries and agencies for the Parliament discussions. |

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| Arable farming | -Due to remoteness from markets and lack of human resource and technical capacities, there is still some abandoned cropland (about 420 thou. ha) in the eastern and the western regions. | -The government provides support to farmers through Agriculture Support Fund of the Ministry of Food and Agriculture, however in remote regions; access to the fund support is limited due to lack of structure and capacities. | -In remote regions, lack of infrastructure, distance from markets, science and research centers and low factory capacities for cereals and vegetable production hinders arable farming development and extensions. |
| Water resource | -There is a lack of knowledge and skills related to climate change in the curriculum of colleges, institutes, and universities. Training and re-training are not sufficient. | -Dissemination of climate change study is limited; therefore, information and research on economic benefits of adaptation options are insufficient. These hinder efficient implementations and monitoring of adaptation options. | |
| Forest | -Training private inventory companies to pursue better forest management practices, and forestry units and environmental agencies to conduct efficient monitoring of forestry measures. | -Piloting a comprehensive training system for sustainable forest management, and advising the Ministry of Labour on ways to improve the vocational training system for foresters. | - |
| Natural disaster management | - | -In Mongolia, there is 1 meteorological station per 11.8 thou. $km^2$ and the distance between observation stations are 200-300km from each other. There is only one radar station in Ulaanbaatar city which was set up by Japanese Government funding in 1998. These geographical gaps in observation network make a prediction and early warning of atmospheric disastrous phenomena difficult. Even though irrigated cropland is increasing, irrigation and water application are not being done based on research and scientific bases which reduce the benefit of irrigation. Numerical weather prediction, especially for precipitation, is not sufficiently accurate; river run-off forecast is based on flood wave transfer methods. Weather stations are located in settlements, so there are challenges to predict forest and steppe fires and river floods. | -Disaster management is carried out by the National Emergency Management Agency (NEMA) of the Government according to Disaster Management Law. However, implementation is inadequate at provincial and local levels due to lack of knowledge and skills and dependency mindset of people.<br>-Early warning of rapid onset hazardous and disastrous phenomena is delivered to people through public media in general ways. |

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| | - | -Meso-scale model of numerical weather prediction has been introduced in the Meteorology Agency since 2006 and prediction accuracy has improved significantly. But the forecast of extreme events (atmospheric hazardous and disastrous phenomena) is not sufficient. Especially slow onset phenomena such as drought and dzud are challenging to predict even in objective ways. | - |
| | - | -Currently, risks of natural disasters are not being done due to lack of monitoring information of atmospheric hazardous and disastrous phenomena as well as unaccounted economic and natural losses. There is no integrated database, which includes information about human-animal epidemic sources. Each institution has separate databases, which makes management and decision-making challenges. | - |

## C. Current and planned technological undertakings

| Sector | Adaptation technology needs | Current status |
|---|---|---|
| Livestock and pasture | Seasonal to inter-annual prediction and livestock early warning system | -There is a lack of coordination and integration between monitoring, assessment, usage, and management of pasture and soil. Information and conclusions are different, information is not exchanged and pasture issues are not sufficiently resolved at the policy level.<br>-Early warning actions need to be improved through clarifying functions roles of related institutions. Information and dissemination structure should be clear and regular based on pasture condition and whether long-term forecasts.<br>(Implementation status is medium) |

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| | Selective breeding of livestock | -Currently, the building of the National comprehensive center for animal genetics fund is being constructed in Khongor soum and Darkhan-Uul aimag. As a result, laboratories for livestock production, genetics, biotechnology and animals breeds will be established according to international standards.<br>-In the framework of maintaining genetics pool of breeds of livestock, National livestock genetics center has replenished the fund with 7,429 portions of genes in 2012, 9,549 genes in 2013, 6,128 genes in 2014 and the total 20,402 genes according to technical standards.<br>(Implementation status is medium) |
| | Livestock Disease Management | -Current practice is to develop a plan and budget for livestock health and prevention measures for every year. Within such practice, provincial governors and Ulaanbaatar city mayor approved plans and budgets for a number of animals, required veterinary medicines products to prevent epidemics and parasites.<br>-In order to effectively diagnose epidemics and infections, four fully equipped laboratories costing 295 thousand USD have been handed over to veterinary departments of Arkhangai, Khovd, Dundgovi and Khentii provinces.<br>(Implementation status is medium) |
| | Sustainable Pasture Management | -In order to appropriately manage pasture for winter and spring, information about drought, summer pasture production, pasture capacity, local context number of animals and predicted winter weather needs are analyzed. Associated risks should be assessed and based on that public information, recommendations should be disseminated. These roles are required to be systemized, clarifying functions and responsibilities. Herders and local community participation should be ensured in pasture management at all levels.<br>(Implementation status is medium) |
| | Producing supplement feed for winter and spring | -Fodder storages with a capacity of 100 tonnes were built in the western region Zavkhan and Gobisumber aimags.<br>(Implementation status is good) |
| | Planting of forage perennials resistant to drought and cold winter for fodder production | (not implemented) |
| | Rain and snow water harvesting for herder groups | (not implemented) |

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| | Producing supplement forage with bacterial enzyme for livestock | (not implemented) |
| Arable farming | The system of wheat intensification through conservation tillage | Minimizing or zero soil tillage was piloted in the 1980s for cereals and forage plantations. Since 2008 this technology has been applied intensively and about 140 thou. ha of the fallow field has had zero-tillage and round-up herbicide against weeds as of 2014. This technology helps to minimize expenses, reduce soil moisture losses and wind erosion because the soil is still covered by straws. Farmers are lacking the financial capacity to buy imported machinery and herbicide.<br>(Implementation status is medium) |
| | Vegetable production system with drip irrigation | Since 1997, drip irrigation system has been applied and as of today, about 280 ha of the vegetable field are using the technology. Farmers have limited financial capacity to buy drip irrigation and knowledge to apply the technology.<br>(Implementation status is medium) |
| | Potato seed production system using aeroponics | (not implemented) |
| | Proper rotation system of cereals planting | Before the 1990s, livestock fodder was centrally planned and managed by the Government, so planting of forage plants such as barley, beans, and other plants was higher than wheat and a rotation of "wheat – fodder plants" were used at least 33% of fallow fields.<br>During the transition period after 1990, livestock was privatized and herders could not buy fodder for their animals. Therefore, rotation shifted to "wheat-fallow" turn which means 50% of cropland was under fallow processing. In the recent years, rye and oil plants have been planted and exported due to incapability to process in factories.<br>(Implementation status is medium) |
| | Crop planting under plastic mulches | In the framework of international projects started in 2007, usage of plastic mulches was piloted for vegetables and potato fields. As of 2015, about 50 ha of a vegetable field has been applied with plastic mulches which help to save labor and water cost for irrigation. Farmers cannot afford imported products due to lack of understanding the benefits and financial capacity.<br>(Implementation status is medium) |
| | Integrated Nutrient Management | (not implemented) |
| | Forest strip protection of agriculture land | (not implemented) |

Chapter 9

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| | Planting winter crops | During 1970, research and experiment on winter crops such as wheat and rye were done in agricultural regions, but winter cropping is very limited in the country due to its low precipitation and very cold weather.<br>Warming and expected winter precipitation increase after 2030 can give more opportunities to pilot some varieties of winter wheat and rye. |
| | Harvesting winter snow water to increase soil moisture | Currently, winter snow is very low which is limiting factor to test and apply snow harvesting. However, technologies to increase snow density through making delay in snow melting and reserving more snow in cumulative ways can be piloted and applied.<br>(Implementation status is medium) |
| | Breeding of new varieties of the crop using marker-assisted selection (MAS) | (not implemented) |
| Water resource | Ecosystem-based adaptation | Project "Ecosystem-based adaptation approach to maintaining water security in critical water catchments in Mongolia" is implementing in mountain and steppe ecosystems by internalizing climate change risks within land and water resource management regimes, (2012-2017)<br>(Implementation status is medium) |
| Forest | Biodiversity and adaptation of key forest ecosystems to climate change | Improvement of the legal and administrative framework' is contributing to the creation of suitable conditions for sustainable forest management, (2012-2018)<br>(Implementation status is medium) |

## 9.2. Legal, institutional, financial, technical and capacity constraints and gaps

Assessments conducted to identify key constraints and gaps of the implementation of climate change activities and ways to improve the continuous and timely preparation of the national communications to UNFCCC show that barriers such as financial resources, technology, research, development and human capacity belong to high priority external barriers for all sectors. At the same time, insufficient legal environment, lack of coordination and integration, weak law enforcement and absence of detailed research are in the category of high priority domestic barriers.

These constraints and barriers are mainly related to:

(a) Legal and policy enforcement and planning of climate change actions,

(b) Uncertainties related to research on climate change projections, its potential impacts, and consequences of implementation of climate change response actions,

(c) Sufficiency and sustainability of financial resources for addressing climate change challenges,

(d) Adequacy of technical and technological support and knowledge,

(e) Capacity building support and availability for climate change action,

(f) A national system to implement climate change activities envisaged to support the convention,

(g) The efficiency of institutional arrangements for climate change action and for preparation of national communication on a continuous basis.

(h) Human and technical capacities to develop project proposals for funding GCF and other climate funding organizations,

(i) Mainstreaming and integration of climate change issues into national, subnational and sectoral development programmes and plans.

(j) Coordination among the government ministries and agencies, as well as among the international financing and project implementing entities,

Currently, Mongolia does not have specific laws on climate change that regulate the cross-sectoral and nationwide activities to address climate change challenges, but some amendments of existing laws reflect climate change concerns and challenges and promote climate change related activities. Thus, these issues are not well coordinated in the various related laws and the main national development policy documents which include the basic concepts, principles and legal framework of climate change have been compromised. In 2012 the amended Law on Air includes an Article on climate change that guided to establish the Climate Change Office responsible for the management and coordination of activities under national law and regulation documents, action plans and national programmes, fulfillment of reporting and other obligations and provisions under international multilateral agreements.

In order to do that there is a need to develop a new law on the coordination of all climate change related activities. Existing environmental regulations, sectoral development policy documents, and other related laws need to be amended if this is required for adaptation or mitigation actions. Passing new laws or amending existing laws, particularly policy or development programmes or plans guiding different economic sectors, and development of improved strategy documents should be carefully reviewed, revised and implemented for the protection and preservation of the unique Nature and Cultural heritage of the country.

*The National Action Programme on Climate Change (NAPCC),* while formulating legal policy framework and addressing challenges relevant to climate change, was approved by the State Great Khural (Parliament) in 2000 and updated in 2011. The action programme includes the national policy and strategy to tackle the adverse impacts of climate change and to mitigate greenhouse gas emissions. The NAPCC is aimed not only at meeting the obligations and provisions received under the UNFCCC and its Kyoto Protocol, but also at setting priorities for action and to 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 to mitigate GHG emissions. The NAPCC will be implemented in two phases over the periods from 2011 to 2016 and 2017 to 2021. The implementation plan for the first phase (2011-2016) of NAPCC was approved by the Government on November 9, 2011.

The other national development policies such as *The Millennium Development Goals-based Comprehensive National Development Strategy (MDG-based CNDS)* of Mongolia, *The 21st Century's Sustainable Development Action Plan, the Green Development policy*, *The Sustainable Development Vision 2030* and other policies include concrete considerations and recommendations on adaptation on Climate change and mitigation of GHG emissions. The goals and strategic objectives of Mongolian Green Development Policy are directly coherent with the goals and measures identified in National Action

Programme on Climate Change in addressing climate change challenges. Thus, the implementation of Green Development Policy of Mongolia will play an important role in reducing greenhouse gas emissions and improving natural carbon sequestration.

Mongolia faces with serious challenges and difficulties in implementing the goals and targets of the policy documents on climate change, which are mainly related to financial and economic possibilities, available advanced technologies, technical and human capacities. Currently, climate change concerns and challenges are not fully reflected in national and sectoral development plans and programmes.

Regarding the institutional arrangements, at the local level there is no entity or officers that are directly responsible for the implementation of the NAPCC as well as other climate change related strategies and plans, but currently the local agencies of the Ministry of Environment and Green Development, Development of Policy and Planning departments of Local Governor's offices, and in some case the Centers of Meteorology, Hydrology and Environment Monitoring are monitoring and are responsible for implementing these activities.

There are numerous uncertainties as to the research on climate change projections, potential impacts on the biophysical environment, natural resources, social life and economic sectors, as well as its consequences of implementation of climate change response measures in both mitigation and adaptation fields. Adaptation technology normally requires a large initial investment. In addition, the results of an adaptation measure are not immediately visible. Therefore, effective adaptation requires considerable time and effort.

The adaptation options are beneficial even if the climate does not change as predicted. These measures that need to be taken in different sectors present complicated, multifaceted and absolutely necessary issues for decision and policy makers. For instance, measures such as controlling and regulating or limiting the number of livestock according to land degradation, pasture availability and changing watercourse are costly and have less social acceptance, thus are harder to implement. Long-term research is needed to ensure sustainability of the economy, society, technology, and environment, to alleviate uncertainties and to develop future adaptation strategies. Extensive and detailed scientific research on understanding and projecting changes in climate parameters will play a vital role in supporting effective decision making on climate change issues.

It is necessary to evaluate possible challenges when implementing climate change response measures. It is clear that numerous challenges can arise when implementing adaptation and mitigation measures depending on the country's socio-economic development and geographic and climate features. There are certain challenges and constraints in implementing response strategy and measures at different levels, which are as follows:

*At the institutional level:* Challenges and constraints in some socio-economic sectors have been analyzed and certain actions to meet those challenges have started. In 2012, the status of MEGD has upgraded as one of the core ministries of the government which presents an important step to lead and coordinates climate change policy at the national level. Nevertheless, due to a weak coordination and information, conflicts occur among different ministries and agencies. Some measures and activities are ineffective and inefficient because of unclear mandates and responsibilities for undertaking climate change response measures, especially adaptation actions. Coordination and cooperation among diverse stakeholders are very important in implementing adaptation measures. The right and responsibility to make decisions and implement activities related to climate change lie with the ministries for agriculture, environment, energy, health, infrastructure and local government organizations and thus, they are responsible for the final result. Therefore, climate change is not the responsibility of one sector or organization. Instead, it relies on cooperation among all stakeholders, mutual assistance, and distribution of responsibility. During the implementation of the planned activities, it is important to take measures such as improving the coordination among government organizations, monitoring their effectiveness and efficiency, determining adaptation measures for the present and future, and increasing the efficiency of the funding.

*In relation to funding:* It is obvious if the funding for adaptation measures is insufficient, the results would be ineffective. The difference between planning and implementation, for instance, the high cost of adaptation measures will put pressure on the implementation process. The effectiveness and success of activities will depend on reliable sources of funding. Thus, it would be effective to devote international sources of funding and investment for adaptation measures as the possibilities to build a sufficient reserve in the national budget, which is limited due to the current economic situation of Mongolia. It will be necessary to extend international cooperation with different countries and financial organizations in order to attract foreign investment and promote the transfer of technology.

There are certain barriers and constraints for implementation of mitigation measures in the energy and industrial sectors. The common economic and financial barriers are inappropriate financial incentives; the high cost of capital; the high transaction cost; the lack or inadequate access to financial resources; and uncertain macroeconomic environment. Common barriers regarding the policy are the legal and regulatory aspects; the lack of long-term political commitment and uncertain government policies (political risks for investors); the lack of government control for implementation of laws and regulations; and the government or utility monopoly of the energy sector. Moreover, common barriers regarding the market and network aspects are underdeveloped competition and insufficient coordination between relevant ministries and other stakeholders.

*In respect of social life:* Lack of knowledge and information, misconceptions, an old-fashioned mentality of individuals and the public will pose challenges for the implementation of adaptation measures; therefore, these challenges need to be addressed. The adaptation measures implemented by herders and others in the agricultural sector should be compatible with the tradition and culture and they should be based on concrete life experience. Since the end beneficiaries' actor of adaptation policy is the public, their participation should be ensured already at the adaptation policy formulation and planning stages so that the public becomes aware of their benefits and responsibilities. It is impossible to implement all adaptation measures at the same time at any given time. Therefore, by meeting challenges that occur during a certain implementation period, the opportunity could arise for evaluation and mitigation of potential challenges that could occur for other activities. It is thus important to identify ways to meet challenges so that it will allow saving time and resources.

## 9.3. Financial, technical and capacity needs

The adaptation and mitigation goals and targets have their origins in the National Action Programme on Climate Change and the Green Development Policy of Mongolia, which is an over-arching and comprehensive approach delivering low-carbon economic growth taking into account national circumstances in the context of its sustainable development. This ambitious strategy mainstreams both mitigation and adaptation in a way to reduce social and environmental vulnerability and enhance its resilience. To achieve these adaptation goals and targets, there are great needs for Financial, technical and capacity support in Mongolia.

Adaptation: As one of the most vulnerable countries in the world to climate change adverse impacts, in Mongolia adaptation has high priority in the country's development agenda. Based on current adaptation undertakings and gaps, the needs to achieve adaptation goals and targets for 2021-2030 are given in Table 11.2 (Mongolia INDC, 2015).

Rough estimations of adaptation measures are listed in Table 11.2, shows that in the near future Mongolia will need around 3.4 billion USD for funding in technology and capacity building. Up to 80% of total need expected to be financed from international sources and donor institutions.

Table 9.2 Adaptation needs (2021-2030)

| Sector | Adaptation goals | Adaptation targets | Needs | | |
|---|---|---|---|---|---|
| | | | Capacity | Technology | Financial (interna-tional, invest-ments), million USD |
| Animal husbandry and pas-ture | -To implement pasture sustainable manage-ment. | -Reduce the rate of degraded pasture,<br>-Regulate headcounts and types of animals including wild animals to match with pasture carrying capacities. | -To create legal regulation for pasture use,<br>-To set up taxation system for pasture use,<br>-To increase community participation in the proper use of pasture, its monitoring and conservation. | -To build up an early warning system for drought and dzud to prevent animal loss,<br>-To improve livestock quality and breeds,<br>-To improve livestock health (epidemic and infectious diseases) management. | 46 |

| | | | | | |
|---|---|---|---|---|---|
| Arable farming | -To increase irrigated cropland, reduce soil water loss and decrease soil carbon emissions. | -To reduce bare fallow up to 30%,<br>-Crop rotation system with 3-4 routes and 3-5 species crops will be introduced,<br>-Irrigated cropland will be expanded by 2-2.5 times. | -To create legal regulation on soil protection (soil texture and moisture). | -To diffuse zero tillage technology,<br>-To increase species of crops and rotation,<br>-To transfer effective drip irrigation technology reducing water loss by 2.5-5.0 times. | 150 |
| Water resources | -To maintain the availability of water resources through protection of run-off formation zones and their native ecosystem in river basins. | -30 % of the territory will be state protected by 2030 and the sustainable financial mechanism will be introduced. | -To implement Integrated water resource management systems,<br>-To coordinate multi-stakeholder relations through improved legal policies and efficient management,<br>-Strengthen human resource capacity to deal with technical issues. | -To implement ecosystem-based technologies,<br>-To support ecosystem services through hydrological monitoring, construction of water diversion canals to drying lakes located in floodplains and re-forestation actions. | 5 |
| | -To construct reservoirs for glacier meltwater harvesting,<br>-To regulate river streams and flow. | -To create water reservoirs at rivers and at outlets of lakes, and to construct multi-purpose systems of water usage. | - To enhance hydrological monitoring and research for river flow regulation,<br>-To construct water reservoirs and water diversion facilities to transfer water resource to dry regions. | - | 1800 |

| | | | | | |
|---|---|---|---|---|---|
| | -To introduce water saving and water treatment technologies. | -To find solutions for sustainable water supply of Ulaanbaatar city and industries and mining in the Gobi region, and subsequently implement. | - To conduct a study and introduce sustainable water supply with closed systems preventing evaporation loss. | -To introduce new technologies for water saving and treatment. | 605 |
| Forest resource | -To increase the efficiency of reforestation actions. | -Forest area will be increased to 9% by 2030 through reforestation activities. | -To build the capacity of community forestry groups to conduct modern technologies for forest seedlings and tree plantations. | -To introduce technology to plant seedlings. | 11 |
| | -To reduce forest degradation rate. | -To reduce forest degradation rate caused by human activities, fires, insects, and diseases. | -To set up fully equipped stations fighting forest fires and insects' outburst and capacity building. | -To use airplanes to fight fires,<br>-To introduce biological technologies against insects and pests. | 13 |
| | -To improve the effectiveness of forest management. | -Resilient forests which are adapted to climate change, highly productive and have appropriate composition and structure will be created. | -To provide equipment and machinery to carry out forest cleaning activities,<br>-To train human resources for forest management practices. | -To improve the efficiency of forest cleaning technologies. | 7 |
| Natural disaster management | -To enhance early warning and prevention systems for natural disasters. | -Strengthening early warning system for natural disasters. | -To establish early detection and prediction system,<br>-To conduct disaster risk assessment in the local area. | -To improve forecasting quality through increasing supercomputer capacity,<br>-To establish Doppler radar network covering the entire territory of the country. | 65.4 |

*(Mongolia's INDC, 2015)*

***Mitigation:*** Mongolia has a low responsibility for climate change mitigation in terms of its historic emissions, and limited capacity due to relatively challenging environmental conditions including a long lasting heating season, a coal-based electricity production system, a lack of access to cleaner fossil fuels and a highly dispersed population particularly in remote areas (lack of access to the electricity grid). This has led to a high emission per capita ratio. Mongolia is committed to the decarbonization of its growing economy and intends to reduce its emissions intensity by implementing the proposed measures. Parliamentary approval of the most significant energy measures and corresponding commitment to implement an important part of the mitigation actions with domestic means demonstrates the ambition of the Mongolian Government.

The goals and strategic objectives of Mongolian Green Development Policy are directly coherent with the goals and measures identified in National Action Programme on Climate Change in addressing climate change challenges. Thus, the implementation of Green Development Policy of Mongolia will play an important role in reducing greenhouse gas emissions and improving natural carbon sequestration.

Needs for GHG mitigation actions are focused on the implementation of the following actions:

*(a) Set up an institutional framework and ensure organizational cooperation:* As previously mentioned, the energy sector is the main source of greenhouse gas emissions, and as energy issues are getting multi-sided, mitigating policies require a special inter-sectoral coordination. Ministry of Energy (MoE) bears the main responsibility for implementing and making decisions on issues relevant to the energy sector, while Ministry of Environment and Green Development (MEGD) is a leading entity for coordinating mitigation activities. Hence, enhancing inter-organizational coordination for developing policies and implementing projects and measures directed at GHG mitigation is important.

*(b) Set funding priority:* GHG mitigation measures require a great amount of investment. Having limited economic resources or capacity, determination of spending priority or sequence of potential financing sources at a national level, and allocation of the sources by technical and economic criteria, is vital for Mongolia. Particularly, the funding should be directly transferred to the organization that performs an operation; and for cooperative organizations, funding should be allocated per organization.

*(c) Set legal framework:* As an organizer and supporter of climate change

response measures, the Government is responsible for creating legal and institutional frameworks. Generally, mitigation projects require a huge amount of initial investment and climate-friendly technologies; hence, certain economic and policy mechanisms are important for the implementation of GHG mitigation measures. For instance, one of the economic mechanisms to overcome some investment barriers could be a tax, tax concession and other compensations. In this case, more efficient technology, low carbon sources of energy and the best resource management should be implemented. Tax concession is especially important when buying energy-saving applicants by import and leasing.

Climate-friendly technology diffusion initiatives are important for improving energy efficiency in the energy supply and its consumption. Public education and close cooperation between producers and consumers are important factors for the implementation of mitigation measures. In order to implement these initiatives, it is necessary to use a wide-range of education and information tools including efficient labeling of the applicants, promotional brochures for owners of buildings, and radio and TV broadcasts. In addition, measures including the expansion of energy networks, development of hydropower plants and the use of solar and wind power systems play a significant role in reducing greenhouse gas emissions and are also important for enhancing sustainable development in rural areas.

Major outcomes and indicators of the GHG mitigation strategy identified in the NAPCC are focused on the reduction of carbon or energy intensity and an increase of renewable energy share in total energy generation. For instance, specific fuel consumption of electricity generation in power plant will be 330 g J/kW h and specific fuel consumption of thermal energy production will decrease by 30 kg/gCal compared to 2010 in the country. Renewable energy will cover 20% of the total energy production by the end of the NAPCC implementation period.

In achieving these mitigation goals and ambitious targets, there are urgent needs for sufficient financial support and investment, technical and capacity building assistance in Mongolia.

## 9.4. Capacity building and enhancement

Building institutional and technical capacity is essential to address climate change challenges in Mongolia. It considers advancing the development and strengthening of professional skills and expertise of relevant agencies, institutions and private entities that advocate climate change mitigation and adaptation.

There is no rigid framework which must be adhered to. However, there is an emerging understanding about what types of capacities and processes might be expected and Mongolia will need to ensure it has these capabilities. However, MET recognizes that there are further opportunities for Mongolia to access international funds, particularly from GCF. Advantages were perceived in facilitating alignment with national policies, as national ownership, can harmonize with national development plans. It should also be noted that one single coherent organization (MET) could also provide a 360-degree view of opportunities public, private, multilateral and innovative sources of funding and, assuming the relevant capacity, could make choices about the selection of the most appropriate fund. For that, it needs strong technical and institutional capacity.

Mongolia's Sustainable Development Vision 2030 reassures the importance of capacity building and indicates that to establish the national capacity to cope with climate change and climate change related disasters. Moreover, Mongolia's National Action Plan on Climate Change (2011-2021) indicates the significance of capacity building of employees at the national level to reach the NAPCC overall objectives. The key capacity building needs for climate change in Mongolia are prioritized and described as below:

- Enhance human capacity, institutional capacity and assure the stability of the relevant institutional arrangement
    - Although policy framework of climate change is relatively well established in Mongolia, one of the key challenges is to ensure the institutional sustainability and sufficiency of staff. There are need to increase the number of personnel who has extensive expertise on climate change policies, international treaties, and climate finance. Stability of institutional arrangement is one of the key challenges. There are need to enhance the knowledge of climate change policy of decision-makers and policymakers.
    - Enhance the capacity of negotiation skill both for the domestic and international level is crucial for Mongolia. At the domestic level, it considered that the capacity to coordinate and communicate the involvement of stakeholders to make robust decisions on climate change. At international level it considered that to negotiate and create opportunities and to attract funds for climate change issues.
    - There are needs to enhance the capacity of expertise of climate change in sectoral and city level and local (provincial) level. There

is lack of general understanding of climate change mitigation and adaptation policies and measures among sectoral agencies and local authorities when it comes to reporting.

- There is a strong need to provide technical capacity for certain issues of climate change namely MRV, NAMA, the readiness of climate finance, climate change adaptation, and vulnerability and M&E, GHG inventory, reporting, research, and technology transfer.
  - Enhance and support training of technical, research and managerial personnel based on the certain needs of above-mentioned climate change topics at national and local level.
  - Enhance the implementation and monitoring of climate change mitigation and adaptation strategies and policies in long-term perspective
  - Need to establish climate change resource center and climate change database to mainstream the services on climate change.

# Chapter 10

## OTHER RELEVANT INFORMATION

## 10.1. Climate change research studies and regular monitoring of the climate system

### 10.1.1. Climate change research studies

Climate change research studies in Mongolia has significantly improved over the last 20 years such as dynamic downscaling of global climate model results into on a regional scale using dynamic models, assessment of interaction between atmosphere and land cover, defining climate change risks in various socio-economic and natural components, technology needs assessments for adaptation, development of adaptation policies and strategies to climate change and assessment of paleoclimate using tree ring growth and geological sediments.

Downscaling results of global climate model using regional climate model reveals climate patterns detailisation in particular regions and also more accurately evaluates future climate changes projection of the Mongolian regions (Gomboluudev P, 2007). Downscaled results of future climate change are used to assess impact and risk of water resources for some selected river basin (Buyant, Khovd, Kharkhiraa-Turgen, Ulz river basins) and proposed necessary measures of management (Davaa et al., 2012).

Impacts of intensifying desertification or land cover changes during last 30 years in Mongolia and its feedback mechanism to the regional climate has been significantly interested. In this regard, some study results have been published on how climate regime changes under given the change of land cover types in East Asian regions as well as in Mongolian (Gomboluudev P, 2011). Numerical modeling results show that if desert steppe regions of Mongolia changed into desert and steppe regions into desert steppe type, then air temperature of the summer season is expected to increase by 1.0°C, the land surface temperature is expected to increase by 1.5 °C and precipitation amount will be decreased by 14 percent. In terms of atmospheric circulation, west and northwest flow will be weakening, latent heat defined by evapotranspiration will reduce, then moisture convergence becomes less and air sinking will enhance due to surface radiation cooling. Also, some Chinese scientists have studied the effect of future possible change of pasture on the climate of Mongolia (Fan Zhang, et al., 2013).

Livestock numbers have increased by almost 3 times since 1990s of last century, traditional structure of livestock is lost and percentage of goat numbers among total livestock which previously took about 20 percent has increased twice and this situation much-increased pressure on pasture and in combination with climate dryness became main cause of pasture degradation (worsen of land cover productivity).

The Asian Development Bank (ADB) jointly with the Swiss Development Cooperation Agency (SDC) have conducted a field survey on the changes of the mechanical structure and fertility of soils depending on degree of pasture degradation in the territory of Tariat soum of Arkhangai aimag, which is located in the forest-steppe region, and estimated changes of soil nutrient by Century 4.0 model (Wang S et al., 2014). This study for the first time shows that only plant cover condition is not enough in the assessment of pasture degradation and but also it is important to consider and control changes of soil fertility, namely change of organic carbon.

Certain progress was achieved in the assessment of climate change impacts and consequences. Since 2003, by conducting field survey and permanent observation in the Altai Mountain glaciers Mongolian scientist G.Davaa have been estimated that glaciers are reduced by about 30 present since 1940 (Konya K et al., 2010, 2013), (Kadota K et al., 2011),(Davaa G et al., 2013).

Considerable amount of works have been done on assessing impacts of climate extreme condition such as drought and dzud on pastoral livestock (Tachiiri K et al., 2008), (Natsagdorj L, Sarantuya G., 2011), (Altanbagana M, 2013), (Troy Sternberg, 2013), (Shinoda M et al., 2010, 2014), (Nandintsetseg N, Shinoda M., 2013).

Ch.Dulamsuren (Dulamsuren Ch, 2010, 2011), (Khishigjargal M et al., 2014), from the German University of Gцttingen and other scientists (Davi N.K et al., 2006, 2010) from Columbia University of USA and National University of University of Mongolia have studied the impacts of climate change on the forest ecosystem.

L. Natsagdorj, Ts Büjinlkham, A. Khaulyenbyek have revealed certain dependence between seed quality, pest spread forest areas and drought intensity and have attempted to identify their future trends. Comparing data and information on the annual growth of tree ring in the Kharkhiraa-Turgen region and also other regions of Mongolia may have observed some improved climate conditions for forest growth since 1940$^{th}$ of last century in Mongolian Altai (CCI, 2013).

Assessments on adaptation technology requirements were done first in some most vulnerable sectors to climate change. Moreover, cost estimation and efficiency of introducing the selected technologies were developed by the United Nations Environment Programme (UNEP) (TNA, 2013). In the technology assessment, the ideas, options, and measures for reducing greenhouse gas emissions were included. Monograph of research work in this field has been recently published (Namkhainyam B, Tsolmon N, 2014).

Up to now, Mongolia uses greenhouse gas emission standard factor which were recommended by the methodology of Intergovernmental expert group on Climate Change (IPCC) and amendments were made for the first time in pastoral livestock sector (Namkhainyam B et al., 2013) in the pastoral livestock sector within Government project of Mongolia in 2012-2013.

Measurement results were carried out at the Ulaan-Uul station (UUM) of greenhouse gases monitoring network. It showed an increase in the minimal value of CO2 in the atmosphere during summer that were caused from desertification or degradation of vegetation in Mongolia. It further implies that minimum value of CO2 during summer outweighs the maximum value of CO2 in spring because of anthropogenic activities around the globe. (Natsagdorj L, 2012). Due to this situation, amplitude of carbon dioxide in the atmosphere is reducing significantly in Mongolia.

Climate change risk assessment was done by Department of the Environment, Food and Rural Affairs (DEFRA) of the Government of the United Kingdom of Great Britain and Northern Ireland covering water resources, biodiversity, ecosystem services, forest agriculture/animal husbandry, public health and infrastructure sectors and combined assessment of the different sectors done by methods of multi-criteria analysis. The mentioned assessment indicates that animal husbandry, biological resources, pasture, infrastructure, and agriculture sectors are to be most vulnerable sectors to climate change (CCPRA, 2012).

Climate change adaptation strategies have been developed as generally in 2010 and goals, objectives and implementation measures of biodiversity, forestry, animal husbandry, agriculture and water resources were included in the strategies. While in 2013, detailed strategies were developed that include cost-effectiveness estimates of each measure of the forest, water and agriculture/animal husbandry sectors covering the 2014-2021 period.

In 2015, Mongolia has developed the Intended National Determined Contribution (INDC) and has delivered to the Secretariat of the UNFCCC.

### 10.1.2. Monitoring network for the climate system

*Climate observation networks.* At present days, 135 meteorological stations are operating in Mongolia and carrying out permanent observation in accordance with the standard programme of the World Meteorological Organizations (WMO) (Figure 10.1). Another 180 meteorological posts which only conduct observations during the daytime by the single observer are operating in the center of soums, which are the primary administrative unit of Mongolia (totally nearly 330). The meteorological posts conduct observation for air and soil surface temperature, relative humidity, wind, weather phenomena at 00, 06 and 12 h of the Greenwich hours (GMT).

Meteorological 40 stations of the Mongolian observational networks included into the reference stations of a synoptic network of the WMO and another 10 stations are included in the list of reference stations of Global Climate Observation System (GCOS). Since 1993, began to install Automatic Weather Stations (AWS) in the meteorological observation network and today the network consists of 90-95 of AWSs and some of them combined with human observation and AWS. However, AWS network of Mongolia consists of different countries and companies such as CAMS620 from China (about 20 stations), from Vaisala, have two types of stations as AWS MAWS301 and AWS330 and SK4100 from Japan and even stations which mounted in Mongolia. This condition barriers to maintaining measurement homogeneities in terms of metrology.

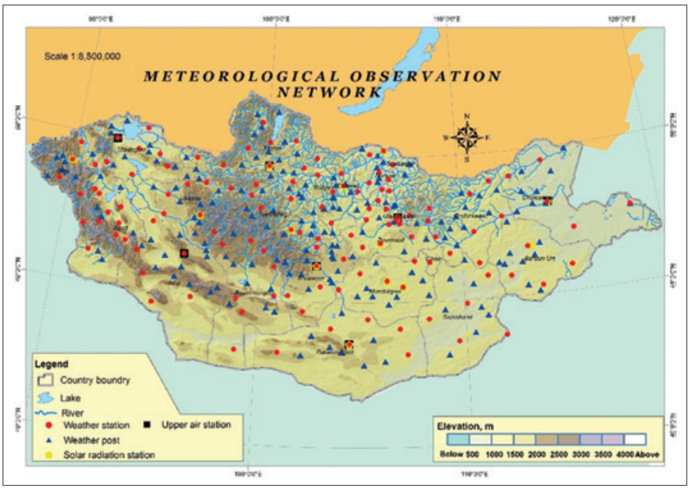


Figure 10.1 Hydrometeorological observation networks

Before, soil depth temperature measured at depths from 20 to 320 cm at 40 meteorological stations. Nowadays, it reduced up to 20 stations and only conducting measurements up to 1.0 m depth. Previously, the intensity of liquid precipitation was recorded at 20 meteorological stations (paper tape recording method) today additionally at 50 stations conducting intensity measurement using automatic rain gauges.

***Solar radiation observation.*** The solar radiation observation network in Mongolia was established in 1961. Since the 1970s until 2004-2005, Mongolia had 19 points to measure solar direct and indirect radiation, long and short wave radiation balance and surface albedo. Since introducing AWSs in the observation network, some of the old solar radiation stations are dismantled and currently, except 5 operational stations which are included in WMO's actinometer network, another 6 stations still use old instruments (Russian made) to sum of radiation and radiation balance.

Previously, sunshine duration was recorded at 32 meteorological stations, since 2008, after introducing AWS, sunshine duration continue to measure only at 8 solar radiation stations.

*Greenhouse gas monitoring.* In 1991, Mongolia established greenhouse gas monitoring station at Ulaan-Uul site ("Red Mountain") of Erdene soum of Dornogovi aimag, which is included global greenhouse gas observation network of National Oceanic and Atmospheric Administration (NOAA) of USA for the first time in Central Asia. Since 1991 up to now, based on the data, the atmospheric greenhouse gas concentrations are defined in the Climate Monitoring Diagnosis Laboratory (CMDL) of NOAA in the USA. The observation data are published and is archived in the world greenhouse gas database in Tokyo Centre, Japan.

*Dust storm monitoring in Mongolia.* With the start of instrumental observation for climate and weather in 1936, also have been started visual observation for dust storm and with the development of meteorological observation network also dust storm observation have been expanded and developed. Nowadays, synoptic visual observation for dust storm is conducting at 135 meteorological stations and 191 meteorological posts (by 2014).

Today many countries in the world use satellite techniques for monitoring for sandstorms, fugitive dust to the atmosphere and volcanic ash and detected results apply for different research purposes. Such activities started in Mongolia since the 2000s.

Also, ground truth or ground level observation with the use of devices for sandstorms, fugitive dust to the atmosphere is rapidly progressing around the world since the 2000s. Such observations allow determining size distribution dust storm and mass concentration, chemical composition, and optical properties. Also the vertical distribution of dust storm measure of lidar installed at ground level.

Under requests of China, Japan, South Korea and Mongolian governments, the Asian Development Bank (ADB) and Global Environment from the United Nations Environment Programme Environment Fund (GEF) have developed regional master plan named as "Prevention and control of dust storms in

Northeast Asia" in 2003 in order to develop and improve early warning system against dust storms, improve model performance, elaborate studies on remote inputs, vertical distribution, concentrations of dust in soils and sources of dust emissions.

Issue related with establishing dust storm monitoring network of Mongolia is included in the master plan above. Since 2006, this plan has started activities as establishing newly dust measurement, monitoring, and warning system within Meteorology and Environmental Monitoring Network of Mongolia.

By 2013, the number of new dust monitoring station has reached 11 and already established new monitoring network for dust storms. Figure 10.2 shows the location of monitoring stations for dust storms


Figure 10.2 Location of monitoring stations for dust storms

***Agrometeorological observation network.*** The meteorological stations and posts (consisting of 44 units) in the agricultural regions of Mongolia observe phenology phases, heights, density, thickness, damage rates, causes and harvest of wheat, potatoes, and vegetables. In some sites, precipitation and other crop productivity observations are conducted (e.g. weight of 1000 seeds).

***Landcover monitoring.*** Since 1960$^{th}$, monitoring for pasture condition had been conducted within state hydro-meteorological network which distributed in the 329 soums (sites). Pasture land observation is monitored using three types of observations including pasture plant phenology dominant insect, pests and rodents, overgrazing and desertification (since 2001).

***Zoo (livestock) meteorological observation.*** Observation for impacts of environmental factors to animal organism had been conducted in 10 soums representing different natural zones from 1976 till 1990th and at present days, this observation continued for cattle, goat and sheep herds at 7 sites of 3 soums representing desert, steppe, and forest-steppe zones. Where:

- grazing performance
- fatten or live body weight (for young animals and mature animals)
- micro-climate offense, shelters for animals,
- morbidity and mortality and its causes etc. are being observed.

*Soil moisture monitoring.* In Mongolia, the moisture of the soil layers of pasture and crop fields are measured up to 1.0 m depth every 10 days at 54 sites by weighing method. Also, determines the moisture in the soil of the fallow field.

Before determining soil moisture, determines agro-hydrological parameters of soil by field and laboratory methods and parameters and indicators of the soils are updated every 10 years. Also soil moisture measures during soil freezing and thawing periods at 135 points by weighing method. Since 2014, began to measures the soil's moisture by automatic measuring devices at sites 26 in some selected pasture and crop fields.

*Surface water monitoring.* Surface water monitoring network operates within the National Hydrometeorological service of Mongolia. Hydrometric observations for river and lakes resources and regime started in 1942. At present, 132 hydrological stations are measuring daily water level, discharge, water temperature and also ice thickness and phenomenon. A number of observation stations sample sediment for further analysis. Also water level and other lake parameters are measuring at 18 big and small lakes of Mongolia (Figure 10.3).

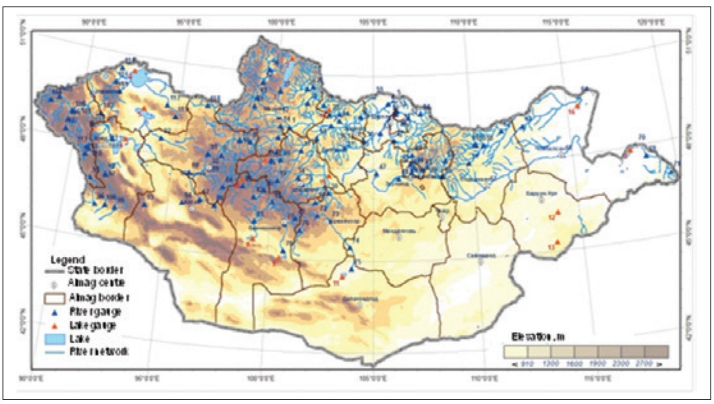


Figure 10.3 Location of hydrological stations at rivers and lakes

In addition, samples of water plankton, benthos species of aquatic organisms and plants are collected at 106 hydrological stations and carrying out further analysis. Samples for water chemistry and pollution are collected at 177 points and conducting research analysis for water chemical composition, nutrient pollution, and heavy metals.

Concerning groundwater network, there 25 sites, boreholes for groundwater level and spring yield measurement at 11 sites are still operating within surface water network. Moreover, at 11 sites conducts observation for open water evaporation and evapotranspiration.

***Permafrost monitoring.*** Historically, research studies and monitoring for permafrost and cryosphere began at the Institute of Geography of Mongolian Academy of Sciences with the support of former the Soviet Union by mid-1950th. Although, the first observation borehole for permafrost monitoring had been installed by mid of 1950th and almost absent continuous measurement results supported by the unified methodology.

However, in connection with climate warming, succeed to establish permafrost monitoring network within consists of 120 sites within the national programme on "Water" of Mongolia and joint Mongolian-Japanese project implemented at Institute of Hydrometeorology and Institute of Geography with support of some international programmes such as Global observation network for terrestrial permafrost (Global Terrestrial Network for Permafrost /GTN-P/), circumpolar active layer monitoring of the polar region, thermal state of permafrost etc. Monitoring boreholes belong to the Institute of Geography, Institute of Hydrology, Meteorology and Environmental Monitoring (see Figure 4.18).

***Glacier studies and monitoring.*** Glacier mass balance observation conducts since 2003 in the Tavanbogd, Tsambagarav, Munkhkhairkhan ranges: a melting and accumulation of glaciers, glacier area and thickness and flow regime of glacier originate rivers, and climate and weather observation at glaciers (Figure 10.4).

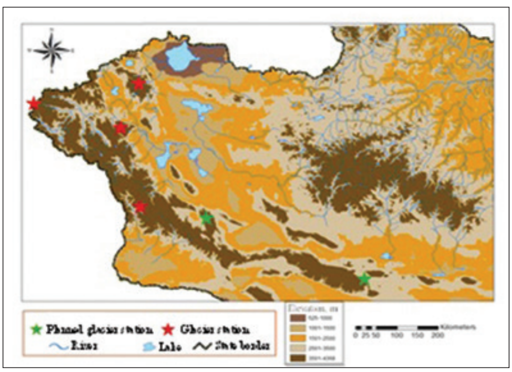

Figure 10.4 Location of glacier monitoring stations

## 10.2. Cooperation on climate change

### 10.2.1. In-country cooperation

Countries as Mongolia which are extremely vulnerable to adverse impacts of climate change that are unable to resolve challenges and issues related to climate change without the robust inter-governmental cooperation as well as the technological and financial support of international cooperation, organizations and developing countries. After the ratification of UNFCCC (30, September 1993), Kyoto Protocol (1999) and the Paris Agreement on Climate Change (2016) by Mongolian Parliament, the Government-wide opportunities expanded for developing the national and multilateral cooperation in the areas of climate change.

After the reorganization of the government structure composed in 2012, Ministry of Environment and Green development has become one of the core ministries among four other Mongolian Ministries. This enables a wider cooperation with other sectoral ministries. In terms of the climate change governance, the Ministry of Environment and Tourism is the main central government body responsible for climate change issues at the national level including the state policies and strategies development on climate change, implementation of the legal requirements on environmental protection, strengthen environmental monitoring networks and research studies and capacity building and etc. However, due to the complexity of the issue itself, a robust coordination mechanism is necessary at the national scale, rather than one sector-sided system. Therefore, in accordance with the Law on Air (2012), the government has established an inter-sectoral National Climate Committee (NCC), responsible for coordination between sectors, regulation and management of measures on adaptation to climate change and reduction of greenhouse gas emissions, and Climate change coordination office (CCCO) within ministry of Environment and Green development (MEGD) and responsibilities of this unit was to ensure activities of the national committee, implementation of the UNFCCC and its Kyoto Protocol's obligations, coordination between different sectors, based on the relevant laws and resolutions.

However, in 2015 the CCCO was dissolved due to the political turnover. At the same time, there was the strong need to develop Intended Nationally Determined Contributions (INDCs), Mongolia's Third National Communication and Biennial Update Report and submit these on time. With these important responsibilities at hand, the Minister of Environment, Green Development and Tourism approved an order for establishing another unit, Climate change project implementing unit (CCPIU) under the Environment and Climate Fund (a former Nature Conservation Fund) based on the former staff of the CCCO in March 2015. Since then, the CCPIU has been caring out activities in areas of climate change on behalf of the MET; those are not limited to GHG inventory, development of INDCs, the management of bilateral cooperation such as Japan's Joint Credit Mechanism and capacity building. Furthermore, in 2017 a former International Cooperation Division of the MET has restructured as Climate Change and International Cooperation Department (CCICD) yet, this newly formed department has a limited capacity to carry out its responsibilities effectively in areas of climate change with the only 1-2 officers responsible for climate change. Moreover, there are no local units established or even specialist responsible for ensuring the implementation of national climate change programme and follow-up the plan of the strategy at local level. Some provincial offices, services or departments such as provincial development planning department, department for environmental policy or local hydrometeorological services are dealing with climate change issues at local levels.

Additionally to Ministry of Environment and Tourism, the Ministry of Finance responsible for control of the state budget, international grants and loans, and international relations, and the National Development Agency which is responsible for ensuring the economic and development priorities coherent with Mongolia's Sustainable Development Vision 2030, play an important role in climate change issues. Moreover, other ministries, agencies and private sectors namely the Ministry of Energy, Ministry of Construction and Urban Development, Ministry of Food, Agriculture and Light Industry, National Emergency Management Agency, local governments, and businesses are core partners for the effective implementation of policies and measures.

Upon the approval of Paris Agreement, the operationalization of Green Climate Fund (GCF) and demonstration of JCM funded private sector mitigation projects, there is a certain degree of momentum, awareness, and interest of partnerships in the climate change adaptation and mitigation built among local stakeholders and partners. Mongolian Bankers Association together with the Ministry of Finance and Ministry of Environment and Tourism has started a process of establishing Mongolia's Green Credit Fund to leverage the private sector investments in low carbon and green development. As XacBank accredited by GCF in December 2016, Mongolia has achieved a great milestone for encouraging private businesses and attracting financial resources for climate change measures. Since then two investment projects of XacBank, namely the Greenhouse gas reduction loan programme for MSMEs and 10 MW solar power plant have approved by GCF.

Through the successful private-public partnerships, robust cooperation and collective impact, the Government of Mongolia could achieve the key milestones on climate change in the future and while create enabling mechanisms for the transparency and transformative change.

### 10.2.2. International cooperation with organization and partner countries

The Global Environment Facility (GEF), the Government of Japan and Germany, Asian Development Bank (ADB), World Bank (WB), the United Nations Development Programme (UNDP), and The UN Environment (UNEP) are key partners of Mongolia in the areas of climate change cooperation. In addition, it is crucial to cooperate and to receive technical and financial support from the Adaptation Fund, Green Climate Fund and Technological centers and network within the UNFCCC and its Kyoto Protocol.

Also should emphasize the contribution of countries such as Australia, the Netherlands, Luxembourg, the United States and the Government of Switzerland in implementation different climate change projects and activities in Mongolia in the past.

*The Global Environment Facility (GEF).* Mongolia receives a total of 32 million USD grants from the GEF and by joint funding implements totally 27 national projects for 342 million USD and 9 of them were related climate change projects. Also, Mongolia has participated in regional and global projects related to climate change funded by the GEF. For example, have been involved in 13 projects for 827 million USD and two of them relate to climate change.

According to the 5th phase defined by the GEF (from July 2010 to June 2014), have been allocated climate change projects and programmes for approximately 3.2 million USD allocated for Mongolia.

*The Asian Development Bank (ADB).* Since 1991 when Mongolian became a member country of ADB, the ADB is the largest source of official aid for development of the country and has been played an important role in the transition period to a market economy.

There were has implemented 10 projects on climate change with the support of the ADB at national and regional levels and six of the implemented under technical assistance, two projects by the grant and another two projects by loan, respectively. Currently, jointly with the Ministry of Environment is now implementing two projects at national level. Where: a) Rural Livelihoods Project adapted to climate change (Grant) and b) Enhance the urban environment by improving energy efficiency projects (loans). Further, ADB plans to focus on transport, energy, water supply, infrastructure, health, access to education and regional economic integration sectors.

*UN's support.* Financial and technical support of United Nations has been providing a significant contribution to our national economy and social development. Mongolia has received technical assistance under a grant of more than $ 200 million dollars since 1963. Financial support which is one of four priority support of UN for the development of Mongolia (2012-2016) is defined as following: improving the immunity of vulnerable ecosystem, populations under changing the climate, improving natural resource management and providing sustainability.

And the UN agencies operating in Mongolia have been providing assistance such as technical advice based on an assessment of the need to ensure the implementation of a comprehensive national development policy based on the Millennium Development Goals (MDGs) and to introduce the general macroeconomic model for Mongolia.

*The UN Development Programme (UNDP).* Mongolian Government had signed the agreement to receive the support of UNDP on 28th March of 1976. Since 1973, it has been past dozens of successive years of cooperation, when the UNDP first time opened its doors in Mongolia.

The UNDP assists and supports to ensure implementation of national programmes to combat desertification, NAMA or measures of reduction of greenhouse gases emissions adopted for the national situation and to strengthen the capacity of national authorities responsible for climate change within the framework of climate change adaptation and mitigation measures.

Also, plans to implement measures on reduction of GHG emissions by reducing air pollution and improving the energy efficiency of buildings and constructions. Because in our country with harsh and long winters a certain portion of household income spent to preserve the heat of buildings houses. The UNDP provides supports to improve energy efficiency by introducing advanced insulation materials for buildings and improving capacity building of building norms and standards. Also, focusing on the development of policy and strategy in the energy sector aims to support the low-income family.

Besides the above measures, implemented mitigation and disaster preparedness, response and pasture land, water and forest management measures to support livelihoods of herders at the local level.

The following climate change projects are implementing at the national level with the support of UNDP. Greenhouse gas emission reduction measures in the construction sector with consideration of national features NAMA's problem; b) Implementation of ecosystem-based adaptation measures to climate change in critical river basin; c) Projects on disaster risk reduction management, improvement of coordination capacity at the local level.

The World Bank (WB). Since November 2, 1991, when the country became a member of the World Bank, Mongolia has received $ 701.7 million. By the 1st April of 2014, investment volume of the Bank is the US $ 160.39 million, where: 7 measures funded by the International Development Association for 95.05 million USD and 12 measures for about US $ 65.34 million from 14 trust funds.

Projects are implemented mainly in infrastructure development, economic management, and the mining sectors to strengthen the institutional capacity building.

Since, 1991, then the International Development Association supports projects and measures in rural education and development, habitat improvement of Ulaanbaatar city, environmental controls in the mining sector, sustainable infrastructure development in southern Mongolia, policy development on environmental protection and reduction of air pollution areas.

The World Bank redirected its activities into climate change within the UNFCCC activities. But this is not yet the real measure in Mongolia.

For the Bank, climate change is not the priority issues. However, the WB supports measures on mitigation of climate change such as projection energy efficiency and climate change adaptation projects. Also, has appointed to support establishing national institutions (DNA) of the Clean Development Mechanism.

Currently, the World Bank is implementing land management, sustainable livelihood projects, and at the end of these projects is planning to implement the project in soil carbon management based on climate investment funds. Currently, Clean Air Project (loan) project is being implemented by the WB to mitigate climate change.

***UN-REDD programme.*** Mongolia has become the Partner country of UN-REDD programme on October 6, 2011. Minister of Environment and Green development has issued an order to establish a working group to develop a plan for "Prepare National REDD + of Mongolia" and has been developed National REDD + programme with the support of UN-REDD programme.

Mongolia has been invited to the 12th Policy Committee meeting of UN-REDD Programme which was held on November 4, 2014, in Lima, Peru to introduce own plan of National REDD + programme.

The plan to prepare the Mongolia National REDD + has been adopted by the parties in the policy committee meeting.

***Global Green Growth Institute (GGGI).*** Mongolia became a member of the GGGI in Incheon, the Republic of Korea on 10-11 of June of 2013. The Memorandum of Cooperation to promote cooperation in promoting green growth established between the Ministry of Environment and Green development and GGGI in 2011.

As a result of initial talks and consultative meeting which held on November 2, 2012, has been determined priority sectors such as energy, road, and transport sectors and were launched first projects in 2012. As a result of projects, strategies of Green energy system and Green Public Transport system were developed in 2013.

GGGI expressed their willingness to support the governmental policy of Mongolia to implement green growth strategies adopted by the Parliament. The South Korea as a donor country has supported real help to implement "Green Belt"(Green Wall) program of the Mongolian Government.

### 10.2.3. Bilateral cooperation

*German Society for International Cooperation (GIZ).* Since 1991, GIZ runs their mission and has opened it's a representative office in Ulaanbaatar in 1998. Leading areas of the cooperation include sustainable economic development, environmental policy, especially energy savings.

The GIZ jointly with Ministry of Environment, Nature and Green Development implements technical cooperation project for 2.4 million euros on the national forest inventory consistent with the requirements of the GIZ REDD +commissioned by the German Federal Ministry for Economic Cooperation and Development.

Presently, the following projects are being implemented to mitigate climate change by GIZ are a) Energy efficiency projects b) Projects on climate change adaptation of the forest ecosystems. Also, technical and financial supports were provided to build up Climate Office of Climate Change of the MEGD before.

*Mongolia-Japan Low Carbon Development Partnership.* Mongolian Minister of Environment and Green Development and Japan's Environment Minister made a joint statement at the 18th UNFCCC Conference of the Parties, held in Doha of Qatar. The joint statement has included the development of joint crediting mechanism in environment and climate change cooperation. As a result, the Mongolian and Japanese Governments signed the letter for "Low Carbon Development Partnership" on 8 of January of, 2013. Mongolia became the first country of signatories to cooperate with Japan under the joint credit mechanism (JCM). As a result, conducted a joint research to improve the efficiency of thermal power plants and studies of NAMA within the power supply.

By 2017, has implemented fifteen projects with the support of the Ministry of Environment, Ministry of Economy and Trade and Ministry of Industry of Japan under the Joint Credit Mechanism. Where: 8 feasibility studies, 2 projects on planning research and 5 model project.

*Cooperation with non-governmental organizations.* In addition to aforementioned climate change official cooperation within the mitigation and adaptation measures of climate change, to be noted that various initiatives and cooperation projects are being implemented by the research institutions, non-governmental organizations, foundations and the private sectors.

Some examples of the cooperation with some non-governmental organizations and private sectors are: the European Bank for Reconstruction and Development initiated the wind farm in Salkhit, energy efficiency loans by the XacBank, the Swiss Development Agency supported green gold/ disaster management and response prevention measures project and others. Some additional projects like hydropower projects in Durgun and Taishir, as well as other projects related to clean development mechanism, biomass, and energy efficiency also have been implemented.

*Barriers, challenges, and future prospects.* Past experiences show that have made substantial progress in combating climate change through efforts of state and non-governmental organizations and jointly implemented project, programme, and measures.

However, efforts of the government to develop multilateral and bilateral cooperation are not only ways in this regard, but it is vitally important to provide participants of other non-governmental organizations as jointly.

The successful implementation of measures on climate change within the framework multilateral and bilateral agreements of Mongolian Government with donor countries faced certain obstacles and challenges. Necessary funding and coordination mechanisms and also lack of high-level political support still are lacking for implementation of the official multilateral and bilateral agreements.

Even stagnation of implementation of projects happened due to lack of a secure financial support of the donor's programmes in the environmental sector. Another problem which limits highly effective development and advanced integration is a lack of human resources.

The bilateral and multilateral cooperation in climate change is just in the beginning of way and development in our case.

The Mongolian Government has taken positive steps on adaptation to climate change, responses, and implementation projects to improve the development of a low-carbon renewable energy and energy efficiency.

## 10.3 Integrating climate change actions into development policies and plans

One of the important preconditions of successful implementation of national strategies aimed to address climate change challenges and risks is to integrate adaptation and mitigation actions with national and sectoral development strategies and actions plans.

Climate change impacts such as ecosystem changes and degradation, drought, dzud, floods and severe weather are likely to result in production decrease, food shortages, increases in vector-borne diseases, loss and damage of infrastructure, properties and economic sectors and the degradation of natural resources upon which livelihoods are based. The negative impacts of climate change will hit socio-economic sectors, local communities, herders and farmers and poor people disproportionately. Development choices made today will influence adaptive capacity and also determine future greenhouse gas emissions. In other words, climate change threatens development objectives and is in turn affected by development choices. Furthermore, the impacts of climate change are likely to become progressively more significant and aggressive in the years and decades beyond the 2015 target date for the achievement of the Millennium Development Goals as well as national and sectoral development goals of the country.

In principle, a range of development activities could help reduce vulnerability to many climate change impacts at all levels. In some cases, however, "development as usual" may inadvertently increase vulnerability. The risk of inadequate and not-timely response measures to the need for the country to systematically assess climate risks and vulnerabilities, and to include potential adaptation and mitigation measures in development policies, plans, and activities at all levels.

Yet, many development policies, plans, and projects currently fail to take into account climate variability, let alone climate change. While efforts to integrate climate change adaptation and mitigation into development will be led by the governments, partner countries and donor agencies have a critical role to play in supporting such efforts as well as in integrating such considerations within their own organisations.

The process of mainstreaming adaptation and mitigation into policy and planning documents of the country includes the following important steps:

- *Understanding the challenges and risks associated with climate change*. Within this step human-induced climate change places it within the context of weather and natural climate variability and discusses its implications in key economic and social sectors, sub-regions and local communities should introduce. In addition, it introduces the concepts of adaptation and mitigation, and the need to integrate climate change responses into regular development activity.
- *Integrating climate change adaptation and mitigation at national, sectoral and activity level plans.* Within this step, national and sectoral circumstances and perspectives should be considered. Also, discussions in detail how to assess and address climate risks and opportunities, and how to integrate adaptation and mitigation responses within development at key decision-making at national, sectoral and activity levels should be conducted.
- *Integrating climate change adaptation and mitigation at the local*

*level.* Within this step, the specific challenges and opportunities arising from climate change in urban and rural contexts and discuss how to incorporate adaptation and mitigation considerations within government- and community-level processes in both contexts should be examined.

Legal framework, policy, and planning background at the national level are described in the above chapters. In particular, the Green development policy and Sustainable Development Vision 2030 include basic ideas of integration of climate change considerations into national development goals and strategies.

Many climate adaptation and mitigation measures and investments will be undertaken by sector-level authorities. In the case of "public service delivery" sectors, this may primarily involve strengthening the monitoring of key climate-relevant variables, which have an impact on their activities and factoring in the consequences, as well as ensuring that facilities which are established under their sectoral authorities' responsibility are not located in particularly vulnerable areas or are capable of withstanding climate conditions. In the case of sectors which primarily undertake physical investments, the key will be to ensure that planned infrastructure investments are designed and located so as to withstand future expected climatic conditions. Particular emphasis should be placed on sectors or domains where investments or decisions have long-term consequences and that would be very costly to modify later. At the sector level, climate change adaptation and mitigation can be integrated at several stages along the policy cycle. A climate lens can be applied at the sectoral policy formulation and sectoral planning stages. Applying a climate lens to sectoral strategies and policies and to the corresponding sectoral plans is critical to avoid maladaptation risks and to allow for the identification of new opportunities emerging from climate change. In Mongolia, several interventions have also been identified at the different stages of the policy cycle. At the planning stage, the intervention involves building in necessary adaptation and mitigation related specific activities.

The local level is important for mainstreaming climate change adaptation for certain reasons. For instance, climate change impacts are manifested locally, affecting local livelihood activities, economic enterprises, health risks, etc. Also, vulnerability and adaptive capacity are determined by local conditions. In addition, adaptation activities are often best observed at the local level. Decisions about livelihood strategies and investments can represent real-life demonstrations of adaptation. The process for integrating climate change adaptation into development policies and activities is broadly the same in urban and rural settings.

Adaptation actions will be implemented mainly in livestock, arable farming, water, forest, and other environmental sectors as well as Emergency Management Authority. Generally, mainstreaming adaptation actions into policy and planning documents of these sectors are also weak.

Mitigation measures will be implemented mainly in the sectors of energy, mining, industry, construction, road, and transportation, urban development, etc. Therefore, mitigation measures should be included in the development strategies and action plans of these sectors. Currently, measures to mitigate greenhouse gases reflected some extent in the Law on Energy, Law on Renewable energy and other policy documents. However, consideration of mitigation measures is weak; therefore it is necessary to improve the reflection of concrete mitigation measures in respective areas of sectors of the country.

### 10.4. Information, knowledge sharing, and networking

The central government administration authority responsible for climate change information and knowledge sharing and networking is the MET and its agencies:

- National Agency for Meteorology and Environment Monitoring (NAMEM)
- Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE),
- Environmental Information Center (EIC).

NAPCC includes the article on disseminating information about policies, decisions of the government, science and advanced technologies to the public regarding the climate change. There are efforts and initiatives to develop online platforms to ease the access to climate change related information and promote networking and knowledge sharing. For example: in 2013, Climate change coordination office (CCCO) at MET has established a website (http://climatechange.gov.mn) to provide information and to share knowledge for all type of audiences. However, the web is no longer available due to an unstable institutional arrangement. Below are some efforts and initiatives aimed at enhancing information sharing and promote access to information:

- Online database on GHG inventory – undertaken by CCPIU
- Environmental Information Center (EIC) (http://www.eic.mn/) – provide meteorological information and climate change projection
- UN-REDD programme www.reddplus.mn - MET with collaboration of UNREDD to promote REDD+ actions.
- JCM web (www.jcm-mongolia.com) in English only.

The common gap to keep the web access actively for the public is the lack of staff and its capacity that are responsible to manage information and communication. There is strong need to establish a National online platform for climate change mitigation and adaptation in Mongolia that can link, coordinate and provide information for all type of audiences.

## 10.5. Education, training and public awareness

It is crucial to introduce climate change related issues to the public and individuals to give them an adequate understanding of the matter, and to have these issues reflected in formal and non-formal educational systems. Climate change should be considered an important part of this country's knowledge for sustainable development education. Activities towards climate change mitigation and adaptation are not only the environmentalists' duty to implement, but also it needs everyone's efforts and participation. In other words, climate change directly or indirectly affects people's daily livelihood. Therefore, being knowledgeable about climate change will help people to choose how to adapt their ways and actions.

### 10.5.1. Legal frameworks, policies, and programme

Rio de Janeiro's 1992 of "Global Sustainable Development Agenda 21" Declaration, Article 6 of the UN Framework Convention on Climate Change Convention, Article 13 of the UN Convention on Biological Diversity, the UN "Education for Sustainable Development for 10 Years" Strategy Plan, ensuring that the information on the environmental decisions are made available on documents such as the "Community Guidelines for the European Communities" and other international conventions to which Mongolia is a party and also to the public to access this information as this issue that is addressed are an internationally responsible issue.

The legal framework for Climate Change is the Constitution of Mongolia; so far, the Law on Air (1995, 2012); the Law on Environmental Protection (1995, 2007); and Disaster 2003 have been approved by the Parliament.

Our country is in an agreement with these international documents and in accordance and regulations with the laws of our country, the "State Policy on Ecology", "National Programme of Global Ecological Education" or its continuation "National Programme on Global Sustainable Development Education", in addition to developing and implementing the "National Programme on Biodiversity" and also "Green Development Action Plan", the Sustainable Development Concept of Mongolia (2016-2030) has been approved, and "Sustainable Development Programme XXI for Mongolia" is being developed and implemented.

From these policies: "State Policy on Ecology", "Green Development Policy" to implement "Green Development Action Plan", "National Programme on

Climate Change", "National Programme on Global Sustainable Development Education" as well as Ecological and Sustainable Development (SD) and the issues on Climate Change Education (CCE) as a specific objective is being implemented.

However, in other environmental and educational laws and legislation, and major government policies and programmes, there is a clear set of provisions for the education and public awareness on the matters of ecological and sustainable development; which are the following regulations. These include:

- Ecological education, and providing knowledge on this matter;
- Conservation of natural resources, sustainable use;
- To protect the nature, restoring the environment;
- To enjoy the aesthetics of nature, to learn from traditional upbringing.

### 10.5.2. Curriculum

The National Programme on Ecological Education for the public started being developed and implemented since 1997. Therefore, environment and nature protection and conservation were part of the compulsory curriculum at primary and high schools levels.

Scientific groups of Mongolian State University of Education (MSUE) and National University of Mongolia (NUM) have done research and evaluated the reflection of climate change issues on policy documents, books, brochures, textbooks of general education schools and knowledge level of the teachers, as well as the coordination between the governmental and non-governmental organizations of the climate change sector in 2014. Even though the general education school's textbooks focus more on knowledge and theory, it is insufficient to build the knowledge for applying it to the real conditions.

*Schools*: With the recent education system reform in Mongolia, there is a shift from the 2008-2009 academic year to a general 12-year education system, the curriculum has been upgraded to include ESD in general secondary school programmes rather than in independent learning. In 2010, with the support of technical and financial support from the Swiss Agency for Development and Education, "Coping with Desertification Project in Mongolia" a new programme starting a 4$^{th}$ and 9$^{th}$-grade curriculum for the Education for Sustainable Development (ESD) has been approved under the framework of the project. Under the "Sustainable Development Education" project that is being implemented since 2015 by the GIZ which is funded by the Government of Mongolia and Swiss Agency for Development and Cooperation, Sweden Uppsala University and the Swiss International Education Cooperation Institute, the notion is being reflected in the curriculum of 628 general education schools. Currently, ESD has included ideas for all class programmes in general education curriculum. The assessment of the implementation of the concepts of ESD that is reflected in general education curriculum, textbooks, and other training activities. Improvements will take place based on the evaluation of the results. Also, ecological education for children's summers' camp programme was developed.

*Universities:* Moreover, about 800 students are majoring in the environment and nature conversation in degree courses at state and private colleges and universities. Researchers and experts on climate studies are trained by the National University of Mongolia (NUM) and Agriculture University of Mongolia, Darkhan. In addition, students of the University of Science and Technology study energy-saving technologies, nature conservation and impact assessment on nature and the environment.

The development of "Climate Change and Ecosystem Adaptation Education Curriculum" starting 2015, 2 credits or 16 hours of lecture in a 32-hour seminar on environmental education at a bachelor level class is taking place in the University of Education. In the future, other university programmes are expected to be introduced.

### 10.5.3. Media coverage

The Media's role is essential in disseminating the government's strategy and policy on adaptation to climate change and the mitigation of GHG emissions in the context of national development goals.

According to a public survey, the main sources of news for respondents were as follows: television (33%), newspapers and magazines (9%), the internet (21%), social media - Facebook, Twitter, YouTube, (8%), and others (29%) [Mongolian Media Today, 2013]. It is, therefore, necessary to include promotion activities to integrate ESD/CCE principles into the policy of national print and broadcast media institutions. Currently, there are 135 newspapers, 99 magazines, 84 radio stations (including 77 FM stations), 166 television channels, 24 cable channels, and 68 news websites actively operating in Mongolia. Among these, 15 television channels and 3 radio stations broadcast nationwide, while 16 daily newspapers and 7 weekly magazines are circulated nationally. Although there is small coverage on environmental issues in national and local print and broadcast media, there is almost none pertaining to sustainable development. With 51% of respondents to a survey on the access to information on the environment [Press Institute, 2011] state that information access is non-satisfactory, we can infer that comprehensive, public information on environmental issues is not being disseminated effectively.

Climate Change Education and Training Programme will promote actions such as: saving water and electricity, public transportation usage, cycling and walking, planting trees and shrubs, to protect forests, prevention of land degradation, the proper handling of the environment, to introduce more parks, sustainable usage of natural resources, to introduce advanced technology, the prevention of forest fires, the use of low fuel consumption cars, the reduction and management of waste and to discard the use of incandescent lamps. Although this programme is broadcasted on "Bongo Broadcast" on Education channel TV, "Green Future Broadcast" on channel 25, "Green Music Broadcast" on Mongolian National Radio and Television channel, National Geographic 25.0, special subscription programme on Eco TV channels, on FM radio and magazines such as the "Green Quest" and "Natural Sciences", and on the websites and Facebook pages of governmental and non-governmental organizations, the majority of the public does not understand that these counter-response actions for climate change are a part of the training for sustainable development, green economic development and education on ecology.

This is evident when keywords related to climate change are searched online, in recent years, the content of this matter has increased but it is evident that access to this kind of information is not much significant for non-professionals and students.

### 10.5.4. Local governments and cities activities

Our action of today will determine the future of Mongolia. The majority of citizens' attitude towards climate change issues refer to the politics, decision makers and environmental specialists who work in the field. Research shows that 1% of the Mongolian population has a deeper knowledge about climate change or is studying and working in the climate change and environmental sector. Even if the 3000 people who work in this sector collaborate, it is not enough to mitigate greenhouse gas and to prepare the other 3 million people for the climate change adaptation. Therefore, providing climate change education to the public and preparing citizens with sustainable development knowledge is the only way to tackle this issue. Everyone should be required to learn about the climate change mitigation results and negative impacts instead of doing nothing. Responsive actions consist of two issues, including adapting to the climate change, which has been already begun, and to learn mitigation approaches for potential changes and apply these experiences to the daily lifestyles.

The Ministry of Environment and Tourism announced 2013 as the "Year of Environmental Education Support", and with the participation of the Environmental Protection Fund, with 1 billion MNT to organize children and youth forum, to publish books and guides and to broadcast science-related programmes on TV for the promotion of ecological education. Also, the year 2014 was announced as the "Year of Transparency of Environmental Information" and based on this event; the database of Environmental Information Center was expanded. Also, information and communication centers were established at 29 Special Protected Area Administration Offices.

The National Forum on Sustainable development was organized in 2015. At this forum, it was important to emphasize the key policies of SD and ESD involving local representatives and also the importance of ESD to combat climate change.

Also, in 2017 a second National Forum "Youth on in the action of Climate Change" was organized. At this forum, topics on matters such as international practices on climate change mitigation, the different ways of mitigation and adaptation of climate change, innovatory youth participation and to share information on climate change online were discussed and on this forum, the Declaration of "Ulaanbaatar against Climate Change" was adopted.

*Local decision-makers.* In order to introduce climate change policy documents to the local environmental and other related sectoral specialists nationwide, regional seminars were organized in 2012, and 2013 to provide sufficient information and knowledge about greenhouse gas mitigation, about climate change adaptation, about mitigation activities on the negative impact of climate change and about policy implementation at a local level, and to coordinate implementing a "National Action Plan for Climate Change" and it's first phase plans, "Climate change policy and mitigation actions." Also, teacher training reflecting climate change adaptation in local development policy planning was organized and two people from each province have been trained and certified.

Awareness among leaders and the public on ESD/SD/GD/ is increased, and selected companies and organizations are certified with ISO 14001 and key environmental standards in 2015.

"Climate change and policy" regional workshops were organized to the local environmental and other related sectoral specialists nationwide in 2017.

*Young people between the ages of 15-24:* Translate into Mongolian and distribute the guidebook, "Climate change and lifestyle," which is a smart consumer and lifelong education guidebook for youth aged 15-24, that has been translated into 18 different languages worldwide, and is for organized discussions among the university and secondary school students.

A small survey was taken with ten questions for the young people using Facebook. There were 508 in the (A) group which were active participants officially provided with sustainable lifestyle information and there were 207 in the (B) group which were inactive participants who were not provided with sufficient information. 97.04% of the (A) group of people who participated in the questionnaire responded that they worry about climate change while 35.26% of (B) group participants responded the same. To mitigate climate change 95.86% of (A) group and 31.4% of (B) group responded that their active participation is important. Regarding the reasons for climate change, 99.21% of (A) group and 32.36% of (B) group responded that greenhouse gas is anthropogenic. Despite that, most of the (B) group participants responded that this is a naturally oriented issue caused by air pollution, environmental execution, and mining use.

(A) group participants precisely determined impacts caused by climate change on the environment, while the (B) group participants wrote only that desertification and water shortage are obvious climate changes.

Most of the participants from (A) group responded that disposing of waste in open areas, protecting the trees and greens, sufficient energy supply, reducing paper supply, recycling, green trade, restoration, saving freshwater, and using public transportation were climate change mitigation actions. Most of the participants from the (B) group responded that disposing of the waste in the open area, protecting the trees and greens, sufficient energy supply, reducing paper supply, recycling, and green trading were climate change mitigation actions.

According to the above micro research which included the questionnaire and discussion results from the students who participated in green lifestyle survey, knowledge is still higher for students who were given the sustainable lifestyle information than for the students who did not have proper information. However, students from both groups had the ecological knowledge to protect water and forests.

Organizing activities such as using social media to provide information, publications, sustainable lifestyle television programmes for students and children, essay and drawing competitions themed, “What can we do to mitigate climate change?” and “Traditional ways to adapt climate change” are important in order to increase climate change knowledge and understanding. This will also encourage people’s participation in climate change mitigation actions. However, these activity frequencies and framework will still not be enough.

*Journalists and media specialists:* One of the most important tools to disseminate rational and accurate information to the population is media and press. Therefore, the ESD project organized training for journalists and media specialists in several phases during July-Sep in 2016.

The first phase aimed to prepare trainers in the media field and involved a total of 44 participants from Ulaanbaatar and all aimags. The second phase aimed to build the capacity of the journalists and media representatives on SD, GD as well as the use of ESD when writing about SD, GD. The training involved over 200 journalists and media specialists nationwide.

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Climate Change Project Implementing Unit
Environment and Climate Fund under
Ministry of Environment and Tourism
Apt. 22-7G, Amar Street, 8th khoroo
Ulaanbaatar-14200, Mongolia

+ 976 - 7000 0743

+ 976 - 11 - 310 743

www.ecfund.mn, www.mne.mn