GOVERNMENT OF MONGOLIA

MINISTRY OF ENVIRONMENT AND TOURISM

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UNEP

FOURTH NATIONAL COMMINICATION OF MONGOLIA

Under the United Nations Framework Convention on Climate Change

April 2024

This **Fourth National Communication (FNC) of Mongolia** has been prepared in accordance with the UNFCCC Guidelines for National Communications for Non-Annex Countries.

The development and publication of FNC under the UNFCCC were managed and supervised by the Climate Change Project Implementing Unit of Climate Change Research and Cooperation Centre, Ministry of Environment and Tourism of Mongolia.

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ABBREVIATIONS

AR5	Assessment Report 5
AR6	Assessment Report 6
AFOLU	Agriculture, forestry and other land use
AGB	Above-ground biomass
ALAMGaC	Agency for Land Administration and Management, 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
CCRCC	Climate Change Research and Coordination Centre
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
ETF	Enhanced Transparency Framework
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
GHGI	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
NDC	Nationally Determined Contribution
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
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
WMO	World Meteorological 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 (1 Gg = 1000 t)
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

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 COP21 in 2015. Upon an operationalization of its principal provisions, including article 6 as outcome of the non easy discussions during the last two COP 27 and COP28 in Sharma-Sheikh and Dubai, the momentum has built and awareness has risen domestically to accelerate the implementation through collaboration work across government, business, non-government, international organizations and citizens to achieve the integrated climate and development objectives.

In Mongolia, most of socioeconomic sectors are adversely affected by natural disasters including harsh winter (dzud), drought, snow and dust storms and flash floods and thereby climate change has tremendous impacts on livelihood of the communities. Last summer severe floods occurred in different part of the country, particularly in region of the capital city-Ulaanbaatar caused significant damage to infrastructure and residential areas. Heave snowfall in most part of the territory and cold waves replaced by warm ones led to form impassable snow coverage, affecting heavily transport sector business and pasture based livestock. Number of livestock lost because of this dzud situation by only the April month was exceeding 6 million head and many herding members of local community were losing income source for daily life. Observed data at meteorological stations in Mongolia have shown that an annual mean air temperature increased by 2.5˚C since 2040 and seasonal distribution of precipitation is changing not in favor for pasture based livestock and rainfed crop production.

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 Nationally Determined Contributions under the Paris Agreement (2015-2030), the State Policy on Renewable Energy (2015-2030), and Mongolia's Long-term Development Vision 2050. Recently National Committee on Climate change approved the National Adaptation Plan (NAP), which was developed as ab part of continued process toward the low carbon and climate resilient development.

In terms of the national policy implementation, through the international and bilateral cooperation, number of solid demonstration projects implemented and initiatives are in place in line with the national and sectorial development goals to address both mitigation and adaptation issues

The Fourth 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 acknowledgements 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 be served as a solid basic information resource for the domestic and international communities and will be utilized as the platform for the sectoral policy development, and international cooperation.

Mr.Bat-Ulzii BAT-ERDENE

Member of the Government Cabinet, Minister of Environment and Tourism

FOREWORD

The Ministry of Economy and Development (MED) in the structure of the Government is mandated to be in charge of formulation and implementation of the national short-med-long term development plans in order to ensure that they lead to economy and social progress in sustainable and inclusive manners. In this regard, this Ministry is responsible for addressing the emerging challenges like climate change, desertification, land degradation and water resource depletion, which are mostly affecting negatively on the national development pathway.

The Paris Agreement indicates that all parties should strive to formulate and communicate to the UNFCCC Secretariat mid-century Long-Term Strategies (LTS). These strategies have great potential to guide countries on a path to limit global temperature warming to 1.5 - 2°C by the end of the century while ensuring that climate plans align with efforts to pursue strong, sustainable, balanced and equitable growth.

Accumulating global practice and identifying lessons learnt from already developed LTS of benchmark countries Mongolia is developing a comprehensive national pre-LTS scoping document that integrates the goals of the Paris Agreement into Mongolia's broader development strategy, including the "Vision-2050", "New Revival Policy", and upcoming "Targeted Development Programs".

Mongolia has been pledging Net Zero or Climate Neutral commitments, responding to the Paris Agreement call for submission of LTS, and subnational governments and companies also are preparing to move to the similar commitments as well.

There is a need to identify the priorities, direction and the extent of Mongolian interventions related to LTS development as well as to lay out the specific stepping stones to advance the LTS agenda in the country. In order to move forward, Mongolia has to identify what Mongolia can leverage from its existing and planned long-term developmental strategies and policies and where the country currently stands in the LTS development, their barriers, binding constraints and opportunities.

MED is undertaken, jointly with other relevant ministries and agencies, background analysis of the current situation to ensure the effective alignment of diverse policies, development of long-term climate action and comprehensive plan to reach the long-term goal and promotion of low-emissions development across different stakeholders nationwide, secure credibility of international commitments, and attract additional support through effective ways of partnership, building scenarios and narratives of decarbonization in a transparent way and socioeconomic benefits of climate change policy measures.

I believe that this Fourth National Communication Report will be used as a scientific platform for development of the current and further long-term decarbonization efforts of Mongolia and the MED will be actively cooperating with all stakeholders engaged in this essential exercises.

Mr. Gantumur TUVDENDORJ, Vice Minister of Economy and Development

ACKNOWLEDGEMENT

Mongolia's Fourth national communication (FNC) has been completed with financial support from the Global Environment Facility (GEF) and implemented through United Nations Environmental Programme (UN Environment). All members of the national team for preparing of the report are wishing to express their sincere gratitude for the support in development process of this report and more important for promotion to improve the national capacities necessary for undertaking the relevant analysis, assessments and studies.

Great efforts were made by more than 40 national experts from different sectors to collect data and conduct relevant assessments, GHG inventory and future scenario development. A special credit goes to the thematic working groups led by Dr. Gomboluudev Purevjav (adaptation) and Dr. Erdenesukh Sumiya (mitigation). A special recognition goes to every organization, which have been involved and dedicated its time in the FNC development process by providing valuable data, information, feedback needed and technical advice at the all stages of the exercises: National Statistics Office (NSO), National Agency for Meteorology and Environmental Monitoring (NAMEM), the Information and Research Institute for Meteorology, Hydrology and Environment (IRIMHE), Ministry of Energy (MoE), Ministry of Food, Agriculture and Light Industry (MoFALI), Ministry of Construction and Urban Development (MCUD), Ministry of Road and Transport Development (MRTD), Ministry of Mining and Heavy Industry (MMHI), Agency for Land Administration and Management, Geodesy and Cartography (ALAMGaC), Energy Regulatory Commission (ERC), Forest Research and Development Center (FRDC), Mayor's office of Ulaanbaatar city and other stakeholders.

The development of FNC has involved not only the national experts and agencies but also number of experts from international organisations provided technical assistance and support. Thus, special thanks are extended to Nairobi Office of United Nations Environmental Programme (UNEP), 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 go to the Ministry of Environment and Tourism and Climate Change Project Implementing Unit (CCPIU) of the Climate Change Research and Cooperation Center (CCRCC) which mobilized a dedicated team of national experts and the scientific advisor to ensure the quality and effectiveness of works. This core team of hardworking experts, namely, Ms. Kh.Undarmaa, as a project coordinator, Dr. Sh.Gerelmaa, as an expert on Agriculture and Waste sector, Dr. B.Bujidmaa, as an expert on LULUCF, Ms. D.Davaasambuu, as an expert on IPPU, Ms. B.Tegshjargal, as an expert on Energy sector have successfully managed the whole process, despite the challenges and barriers, associated with COVID-19 and other organizational matters, completed in timely manner the national GHG inventory in accordance with IPCC 2006 guidelines, and have compiled the work on the report, as required internationally agreed rules and procedures.

Throughout the entire process of FNC development, the every engaged expert and government officials were able to learn from each other, gain new technical skills, in accordance with the progress in the international cooperation activities on climate change. This made a cooperation and coordination among attributed stakeholders more effective, even though having limited man power and needed support. Without the collaboration and dedication of the team members and all relevant stakeholders, this report would not possible to have succeeded. In this sense I would like to wish for the next step of work to develop more effective cooperation mechanism mobilizing both experienced experts and newly coming professionals in order to keep the level of work quality have not been compromised, due to modern days policy fluctuation because of both internal and external factors.

Dr. Zamba BATJARGAL

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EXECUTIVE SUMMARY

1. National circumstances

Climate of Mongolia is harsh and continental due to its unique geographical location in the center of Eurasian continent such as highly elevated position above sea level, surrounded by high mountains and long distance from the seas. Therefore, climate of Mongolia is characterized by high seasonality with very distinct four seasons, high amplitude of temperature and low precipitation. Latitudinal and altitudinal spatial distribution of climate variables could be clearly distinguished in any part of the territory. Pasture based livestock and rainfed crop production as the key sectors of the national economy, as well as the traditional livelihood based on these and other sectors greatly exposed to natural hazards are making local communities in Mongolia more vulnerable to the global climate change with notable regional impact. Fluctuation of climate parameters like air temperature, precipitation and wind speed etc. which exceed the span of the regular climate variabilities is a great concern in respect of time needed for effective adaptation to new climate condition.

Climate: Mongolia has a severe continental climate with long-lasting cold winter and relatively hot and short summer. The annual mean air temperature ranges between minus 6 and minus 10°C in the Altai, Khangai, Khentii and Khuvsgul mountains ranges, in the depressions between mountains ranges, also along the valley of big rivers, while less than -10°C in near mountain peak, warmer than 2.0°C in desert steppe and warmer than 6.0°C in south Gobi region. The warmest place was indicated in Shinejist soum of Bayankhongor province, where at Ekhiingol meteorological station (978 m above sea level) annual mean air temperature was 9.1°C.

Annual precipitation exceeds 400 mm at high mountain belts, but in generally 300-400 mm in the Khangai, Huvsgul, and Khentii mountains and the Khalkh river basin in the Eastern region, 250-300 mm in Mongol Altai and forest-steppe, 150-250 mm in the eastern steppe region, and 50-150 mm in Gobi and desert region. In the southern, inner-facing side of the Altai Mountain range, annual precipitation is typically less than 55 mm. In Mongolia, 85% of the total precipitation falls in the warm season; no more 3% of participation is the snow that falls during the winter.

Sunshine is abundant in Mongolia with clear sky days range about 230-260 days in a year. The total duration of sunshine during a year is about 2,600-3,300 hours. Mongolian steppe and desert-steppe regions are very windy with the annual average wind speed of 4-6 m/s. Therefore, the possibility to use solar and wind as an energy resource is relatively high.

Land resource: Mongolia’s total land area is 1,564,116 km^2. The distance between the most western and most eastern points is 2,392 km, and between northern to southern points is 1,259 km and the total length of the national border is 8,252.7 km. Mongolia, in term of territory is the seventh largest country in Asia and the 19th largest in the world.

According to the revised in 2002 Law on Land, the land in Mongolia is classified into six categories:

agricultural land; land of cities, villages and other urban settlements; land under roads and infrastructure networks; land for special needs or purposes; land with forest resources, and land with water resources.

Based on this classification, as of 2022, 72.6% of the territory of Mongolia is agricultural land, 16.7% is land for special needs, 9.1% is land with forest resources, including bush and shrubs; 0.6% is urban areas, 0.4% is land with water resources and 0.5% is land under roads and infrastructure. Land category changed recently, and depending on definition and classification terms, the percentage of forest cover appears to be different in some sources (ALAMGaC, 2023).

Land use: According to the report by the Agency for Land Administration and Management, Geodesy and Cartography, a total of 4.8 million ha area were degraded nationwide by 2022. A 4.7 million ha of pasture land and 81.5 thousand ha of cultivated area were degraded. Also, 10.5 thousand ha of settlement land, 56.8 thousand ha of forested area, and 0.2 thousand ha of water reservoirs were affected by some degree of degradation. A part of 14.3 thousand ha from these areas were affected heavily or damaged by digging and other form of land use.

As of 2020, there are a total of 120 specially protected areas (31 million ha), including 21 strictly protected areas (13.8 million ha), 37 national parks (13.5 million ha), 48 nature reserves (3.6 million ha and the Government decision to confirm an additional 1.68 million hectares is awaited), and 14 monuments (0.098 million ha and the government decision to confirm an additional 0.002 million hectares is awaited) contributing to the preservation of the nature, and ensuring the ecosystem balance. In addition, as of 2023, there are 1,401 locally protected areas covering 24.5 million ha and 15.7% of the total territory of Mongolia (EIC, 2024).

Mongolia is a country with scarce water reserves and the most of the bigger rivers have outgoing flows. Precipitation is the only source for surface water and groundwater. Therefore water resources depend mostly on rivers flowing out of the country.

Mongolia has three watersheds. The rivers belong to the inland catchments basins of the Arctic Sea, the Pacific Ocean and the Central Asia Inland Basin. In the north and west mountains, the water network featured by relatively high density. The south, central and south-east parts have a fewer rivers and other water resources, as a rule, available in depressions with no outflow.

Annual water resources are estimated at around 564.8 km^3 out of which 500.0 km^3 (88.5%) accumulates in the lakes, 34.6 km^3 (3.4%) forms in river systems, 19.4 km^3 (6.1%) is in glaciers, and 10.8 km^3 (1.91%) in groundwater.

An average river runoff is estimated to be 34.6 km^3/year where river runoff 30.6 km^3 forms within Mongolian territory and remaining 4 km^3 of river runoff forms in the neighboring countries and flows through Mongolian territory, and the reachable groundwater resource is estimated to be 10.8 km^3. The surface water census covered 6,356 rivers, 584 mineral water, 13,222 springs, and 4,057 lakes and ponds in 2020 (NSO, 2021a).

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

The new Constitution of Mongolia was adopted on January 13, 1992, and legalized the democratic form of government with a one-tier parliament and a presidential institution in Mongolia. Mongolia adopted a new democratic constitution and election law. In accordance with this new legal system Mongolia has a parliamentary democracy, with an election held every 4 years to elect 76 members of the Parliament. In accordance with the new amendment to the Constitution, however, starting 2024 election the Parliament will have 126 members. The President of Mongolia is a constitutional institution that plays a unique role in Mongolia's political system and governance structure.

Population: As of 2023, the population is reached 3,504,741 people and scattered across the country, making Mongolia as one of the least densely populated regions in the world, with average density of 2 people per square kilometer. The population increased by 1.36% in 2023 compared to 3,457,548 in 2022. Mongolia is ranking 135th in terms of total population and 66th in terms of population growth rate. There were 66.8 thousand births, 19.0 thousand deaths, and an average life expectancy of the country is 71.5 year in 2023.

An average life expectancy according to gender diversity, for women is 76.9 year and for men is 67.6 year. As of 2023, 70.8% of Mongolian population living in urban areas. A high migration stream to the Ulaanbaatar city is becoming a cause of rapid growth of population in capital city, with associated challenges related to air pollution, waste management, social services, traffic congestion etc.

Legal Framework: Mongolia 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. The ratification of UNFCCC and its Paris Agreement enables Mongolia to contribute to the global response in mitigating climate change and protecting the humanity from its adverse impacts and risks, while creates an opportunity to cooperate and access the financial and technological sources from international organizations. Within the global goal for climate change, Mongolia submitted its “Intended Nationally Determined Contributions (INDC)” on September 24, 2015, communicating its efforts to mitigate greenhouse gas (GHG) emissions from its BAU scenario by 14% compared to 2010 by 2030, and to implement adaptation measures in the most vulnerable economic sectors.

As the Paris Agreement calls upon all Parties to prepare an updated NDC by 2020, Mongolia has enhanced its mitigation commitments in 2020 which has a target to reduce greenhouse gas emissions by 22.7% (excluding LULUCF) below the business-as-usual scenario (BAU) in 2030, equivalent to an annual reduction of approximately 16.9 Mt CO_2e of economy-wide emissions. Mongolia’s NDC outlined a series of policies and measures that the country has committed to implementing through 2030 in energy production, energy consumption (transportation, construction, industry), agriculture, industrial processes, and waste sectors.

In addition to the unconditional efforts, Mongolia's NDC identified conditional measures e.g., carbon capture and storage and waste-to-energy technology, as well as the carbon removal potential in the forest sector. If these additional measures are implemented, the total GHG reduction target could reach 44.9% by 2030, compared to the BAU baseline of 2010.

At the World Leader's Summit organized as part of the UNFCCC COP 27 which was held in November 2022 in Egypt Mr. KHURELSUKH Ukhnaa, President of Mongolia has announced for the first time about the GHG "Net Zero" target of Mongolia which should reached by 2050. Mongolia also has joined to the "Global Methane Pledge".

Mongolia does not have a specific law on climate change that regulates cross-sectoral and nationwide climate change actions. The objectives, priority actions, and implementation principles of climate change mitigation, adaptation, and cross-sectoral actions are reflected in the long-term development policy Vision-2050 (PoM, 2020), the Nationally Determined Contribution (NDC, 2019), the Government Action Programme (GoM, 2020), and a New Revival Policy of Mongolia (PoM, 2021).

Macroeconomy: Mongolia's economy is primarily based on mining, quarrying, and agriculture. The country is rich in natural resources, but despite government efforts, have been made very modest progress in respect of industrialization and diversification of economy. Over 80 percent of Mongolian exports are mineral products, such as copper ores and concentrates (31.0%), bituminous coal (29.9%), unwrought or semi-manufactured gold (10.9%), iron ores and concentrates (10.3%), crude oil (3%), and others. The second largest export from Mongolia is cashmere, representing around 3% of the total exports. Mongolia's economy grew by 5.6% in 2019, and due to the pandemic the GDP growth was minus 4.6% in 2020 and little progress as the plus 1.6% in 2021. The average annual growth of GDP per capita for 2016-2021 was 1.1%, while the average annual growth of GDP per person employed was 3.1%. In 2022, the economic growth of Mongolia reached 5.0% and in 2023, GDP at 2015 constant prices was MNT 30.5 trillion, which is increased by MNT 2.0 trillion (7.0%) compared to the previous year. GDP per capita at current prices reached 5.9 thousand US Dollars in 2023, an increase 15.7% from the previous year. In 2023 the mining and quarrying sector's share in GDP was 28.2%; agriculture, forestry and fishing 10.2%; manufacturing 6.9 %, constraction 3.0%, electricity and water supply 1.8%, and service sector's share was 49.8% (NSO, 2024).

Industry: Mongolia's industry sector is divided into the mining, quarrying, and manufacturing sub-sectors. The industry sector's share in GDP was 35.1%, which is mining and quarring accounted for 28.2% and manufacturing for 6.9% in 2023. In terms of the total production structure of the industrial sector, the mining industry dominates. Mining and quarrying accounted for 16.1% of the total industrial production in 1990, and increased to 57.7% in 2022. However, the share of manufacturing industry in industrial sector decreased from 71.8% in 1990 more than halved and is now down to 31.4% in 2022, it is mostly due to not adequate way of transition to market economy, specifically, issues related to privatization of state owned enterprises. Total industrial output increased by 24.4% compared to the previous year, mainly due to increased output of the mining and quarrying production and the manufacturing production.

Mining and quarrying sub-sector. Mining and quarrying have rapidly developed in recent years to become one of the leading sectors in the economy of Mongolia. This is largely due to the start of mining activities at the largest mineral deposits of a strategic significance, such as Oyu tolgoi and Tavan tolgoi. The coal production has increased from 7.2 million tons in 1990 to 37.3 million tons in 2022, which was increased 5 times. The coal production since 2020 to 2023 was increased 2 times. In 2023, 81.2 million tons of coal were extracted, of which 69.6 million tons were exported; 14.9 tons of gold were extracted, of which 11.7 tons were exported.

Manufacturing sub-sector. At present the industrial processes and activities during the cement production and metal industry considered as a contributors of GHG emissions of Mongolia. In terms of cement production, Mongolia has only two remaining cement plants built before 1990's and some technology improvements were made for the improved efficiency. In 1990, 440.8 thousand tons of cement were produced, and in 2022 production tripled to 1,373.5 thousand tons. Although production amount is not sufficient to the demand, there are needs to increase production in future. Metal industry, on the other hand, steel production with electric arc furnaces (EAFs) and a direct reduced iron (DRI) production facility is currently active.

Agriculture sector. The sector is one of the priority sectors for the country's economy and cultural heritage. The food and agriculture production compounds 10.2% of the national GDP, 24.9% of total Mongolian work force. The share of agriculture in total GDP peaked at 36% in the mid-1990s, but output shrank in the early 2000s amid rising industry and services growth, the share was 27.4% in 2000 (ADB, 2020b). At present the agriculture's share more than halved and is now down to 13.0% in 2021, compared to 2020.

Livestock production comprises 82.5% of the total agriculture production. In particular, 21.9 thousand tons of meat, 113.6 million litre of milk, 938.8 thousand tons of combed down, 2.2 thousand tons of scoured wool were produced in 2022. Cashmere is considered key export items and is triggering an uncontrolled increase in goat numbers, causing pasture overgrazing and land degradation. Simultaneously, the increased dust and aerosols in the atmosphere creating land degradation and desertification. This leads the industry to face major challenges such as sharply rising land degradation, leaves animals with the lowest survival rate in unfavorable, extreme weather conditions; therefore, policies that prevent overgrazing are recommended and could have an effective and lasting impact on the sector for the future economic diversification apart from the mining sector. The massive migration is triggered by the climate-induced impacts on citizens' livelihoods, especially for herders. Most of the residents moving to the capital's outskirts are former herders whose income sources were depleted due to harsh climate impacts, leading to major urban issues. Climate change must be addressed through policies as it has multiple, cascading, and interconnected impacts. Clear demonstaration of this trend has been happening in the winter of 2024 when total livestock lost was exceeding 6 million head ben the end of April month despite the fact that the summer grass condition was tolearable (NEMA, 2024).

Energy resource and energy production: Coal, mainly lignite, comprised 80% of the primary energy supply. Energy loss is estimated to be 49% of the total energy supplied, mostly lost in conversion processes and 11% in power station transmission, distribution, and operation. Thus, 40% of the heat is lost in distribution via above-ground due to leaking and poorly maintained pipes. The net result is that only about 25% of the energy from coal was finally consumed as heat and electricity.

As of 2022, Mongolia produced 8,178.6 GWh (79,1%) of electricity and imported 2,161.5 GWh (20.9%), with 90.8% of total demand supplied by CHPPs, 8.4% by wind and solar power energy sources, 0.8% by hydropower and 0.01% by diesel power generators, respectively, and the demand is showing trend in increasing.

The current situation in Mongolia is that demand exceeds installed electricity production capacity and causes inconsistency with NDC targets, while the sector is the main contributing sector to Mongolia's GHG emission. Development policy documents proclaim the use of renewable energy, but due to energy tariff issues; the government has been inactive in supporting ancillary activities, investors, and technology-based solutions, further fueling the barrier. Cheap energy tariffs have also been criticized as a sign of unsustainable energy regulation, and the same is true of green hydrogen, a potential new energy source.

Transport: There are four subsectors of transportation operating in Mongolia: road, railway, air, and water transport. It is essential that transport and logistics in Mongolia cope with increased demand for their services.

In 2023, 29.5 billion tons km of freight was transported, with 63.9% by rail, 36.0% by road, and only 0.1% by air. The amount of transported freight increased 76.6% to 107.4 million tons, driven by a 50% increase in mining and 21% in total exports. 78.4 million tons or 98.7% of exported goods were mining products. 7,088.0 million tonne freight and 146.5 million passengers were carried by all types of transport. The freight turnover was 25,963.3 million tonne-kilometers, and passenger turnover was 6,492.7 million person-kilometers.

In 2023, 6,492.7 million person km were traveled, with 59.8% by air, 27.9% by road, and 12.3% by rail. Air passenger turnover doubled compared to the previous year. In the year 2023 and 2024 the number of tourists visiting Mongolia was increased rapidly, but it can not be regarded to climate factor only.

2. National Greenhouse Gas Inventory

The GHG inventory has been conducted for key economic sectors that support Mongolia’s economic development. The emissions/removals have been estimated from five sectors which are energy, industrial processes and product use, agriculture, land use, land use change, and forestry and waste, defined by the 2006 IPCC GLs.

In 2020, total GHG emissions of Mongolia were 43,081.62 Gg CO_2e (excluding LULUCF). This represents 82.17% increase from the 1990 level of 23,648.79 Gg CO_2e and 6.20% decrease from the 2019 level of 45,927.72 Gg CO_2e. Net GHG emissions in 2020 were 12,909.10 Gg CO_2e (including LULUCF). This represented a 340.02% increase from the 1990 level of -5,378.40 Gg CO_2e and 17.92% decrease from 2019 level with 15,726.84 Gg CO_2e.

In general, emissions/removals from each sector are shown an increase in 2020 compared to the base year and changes are listed in Table 1 as absolute values and percentages.

Table 1 Mongolia's GHG emissions/removals by sectors in 1990 and 2020

Sector	*Emissions and removals, (Gg CO_2e)*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
	1990	*2020*		
Energy	12,086.55	19,292.48	7,205.92	59.62%
IPPU	284.98	1,147.75	862.77	302.75%
Agriculture	11,221.64	22,390.57	11,168.93	99.53%
Waste	55.62	250.82	195.20	350.95%
Total (excluding LULUCF)	23,648.79	43,081.62	19,432.82	82.17%
LULUCF	-29,027.19	-30,172.52	-1,145.33	3.95%
Net total (including LULUCF)	-5,378.40	12,909.10	18,287.49	340.02%

In 2020, GHG emissions from agriculture sector were 22,390.57 Gg CO_2e accounting for 51.97% and from energy sector were 19,292.48 Gg CO_2e for 44.78% of the national total emissions. IPPU and waste sector emissions contributed 1,147.75 Gg CO_2e (2.66%) and 250.82 Gg CO_2e (0.58%), respectively.

Compared to 1990, the amount of increased emissions for the energy sector was 59.62%, for the IPPU sector was 302.75%, for the agriculture sector was 99.53%, for the waste sector was 350.95% and removal for the LULUCF sector was 3.95% in 2020.

Two main sources of the total emissions were agriculture and energy sectors for the entire inventory time series. However, the share percentage of emission sources have been varied year by year depending on economic and climatic factors such as enhanced energy demand in the energy sector and natural disaster frequency in the agriculture sector.

Direct gases, namely CO_2, CH_4, N_2O, HFCs and indirect gases which are NO_x, CO gas emissions estimated in the inventory. The most emitted gas in Mongolia was carbon dioxide (CO_2) without removals accounting 42.40% of national total in 2020, primarily from fuel combustion activities in energy sector. The second dominant gas was methane (CH_4) and it contributed 33.82% to national total GHG emissions which mainly originated from enteric fermentation, manure management and solid waste disposal. Followed by nitrous oxide (N_2O) emitted from agricultural soils contributes 22.46% of national total and then the remaining 1.33% attributed to HFCs emission from utilization of refrigeration, air conditioning, fire protector, and foam blowing equipment.

3. Present climate change and future projection

The monitoring of GHG concentration was started in 1992, in Erdene soum, Dornogobi province of Mongolia. According to the monitoring, the CO_2 concentration was increased from 354.6 to 413.3 ppm (16.5%), and CH_4 concentration was increased 1808 to 1968 ppbv (8.8%) as respectively, for the period of 1992-2020. Annual near surface temperature over Mongolia has been increased by 2.46°C between 1940-2022 periods and warming intensified since 1988. In terms of climate extreme indicies, daily maximum temperature and minimum temperature over Mongolia were increased, while number of cold days are decreasing and number of hot days are increasing.

Annual precipitation is slightly increasing during this period. However, if comparing recent dry period 1996-2011 with 1977-1983 period, the length of dry period has been increased. The cold season precipitation (Oct-Apr) is increased by 19%. Daily maximum rainfall and its 54% was observed in 2000-2020 period. It means high intensity rainfall is increasing due to climate change. Dryness is intensifying due to increasing of evaporation, especially severe dry long lasting years were occured during 1997-2011 period, when dryness index value was ranged from minus 0.5 to minus 1.0.

According to climate change projection of AR6, IPCC under low, medium and high GHG emission scenarios, all seasonal temperature project to increase by 0.7-1.4°C in 2030, 1.1-2.9°C in 2050 and 1.2-6.5°C in 2080, respectively. In terms of projection of seasonal precpitation change over Mongolia, winter precipitation will be increased relatively high (8.7-55.4%) and spring and autumn precipitation is little high, and summer rainfall is projected to have almost no change.

Climate extreme indices, such as maximum temperature of summer season is projected to increase by 1.6-5.3°C and minimum temperature of winter season is projected to increase by 1.4-5.3°C, while frost day will be decreased by 8.8-36.9 days, annually. Heat wave duration in summer will be increased by up to 2.8 days, while cold wave duration decreased by up to 2.6 days, as respectively.

4. Assessment of climate change impact, vulnerability and risk

As result of assessment conducted during this report, climate change impacts, vulnerabilities and risks are increasing in all natural and socio-economic sectors except tourism. In other words, the negative impact of climate change is likely to dominate in the future. For tourism, the risk will decrease slightly due to the increase in favorable climate conditions, especially, in winter season. For other sectors, it will move up to the risky level by 1-2 degree categories. In comparison of future and present risk indexes, the relative highest value of 0.23-0.30 is projected in pastureland, forest resources, permafrost, glacier, animal husbandry, arable farming and infrastructure. Details of each assessments are discussed below:

Water resource. The annual total river flow since 1978 varied by gradually increasing to its maximum value of 78.4 km^3 in 1993. However, from 1996 to 2017 due to the long-lasting low flow period (23 years) it is continued steadily, and reached its minimum of 16.7 km^3 in 2002. Lately, an increasing trend of the river flow have been observed from 2018. The total flow norm of the rivers of Mongolia was revised for period of 1991-2020 and it was a 30.6 km^3/year, which is 10% less compared with the previous norm of 34.6 km^3/year. The river flow in the Arctic ocean basin is projected to increase by 8% and the Pacific basin decreased by 40%. If compared with 1945, the number of lakes was decreased by 16.1% and its total area decreased by 7.79%.

Glacier. The total area of glaciers in Mongolia was 535 km^2 in the 1940. However, total area of the ice coverage spread over 42 mountains was 470 km^2 in 1990, 451 km^2 in 2000, and 338 km^2 in 2019, respectively, showing a rapid decline. The melting of the ice-caps and glaciers of Turgan, Potanin, Tsambagarav, and Sutai Khairkhan mountains is expected to be 40-86% by 2050 with an average of 65%, mostly occuring in the lower skirt of the glacier.

Permafrost. The potential area for the spread of permafrost has decreased by 33.7% in the last 45 years (1971-2016). Also, the southern boundary of permafrost was shrinked by 178 km in the Khentii mountain range, by 94 km in the Khangai mountain range, and by 240-900 m in the Altai range. Mongolia's permafrost area is expected to be decreased by 33 - 61% by 2050.

Pasture and soil degradation. Based on the assessment of the State of pasture report in Mongolia as of 2020, the composition of plant species changed by 70% of total grassland area compared with the reference level. Also, 76.9% of Mongolia's total territory has been affected by desertification with a certain degree, with an increase of desert area by 2.4%, steppe area by 2.6%, and dry steppe area by 13.9%. In addition, it is expected that the soil organic carbon will continue to decrease by range of 18 - 28% in the middle of this century and it will be different depending on the natural zone areas throughout the country.

Forest resource. The area covered by forests reduced by 729 thousand ha or 5.5% between 2006 and 2020, meanwhile, forest burnt area increased by 939 thousand ha or 133%. The area of insect infestation in the forest has increased by 76 thousand ha or 127% between 2010 and 2015. Total change in forested area due to fires and insect infestation is expected as a decrease by 723.1 km^2 (72.3 thousand ha) or 0.32% by 2050.

Wild animal. Climate change has both a positive and negative effects on the habitats and core habitats' areas of some different species of animal groups of Mongolia. For example, the habitat area of the Grey long-eared bat (Plecotus austriacus) will expand by 14.7% and the habitat area of the Demoiselle Cranes (Grus virgo) by 7.1%, meanwhile the area of the Mongolian ground Jay (Podoces hendersoni) will decrease by 6.8% in 2050.

Livestock. The number of goat herds has been constantly increasing since the 1990s, and it accounts for 41% of the total herd of Mongolia in 2020. The decrease in the live-weight of mature Mongolian ewes observed in the forest and steppe natural zone. Due to the warming of climate, the timing of goat's cashmere shedding period has been delayed by 5-10 days in the spring. There is a tendency to increase the number of days the animals to be showered. It is expected the decrease in the winter live-weight of grazing sheep by 4.47 kg by 2050. In general, the decrease in live-weight of animal is greater in the steppe zone. Due to the increasing intensity of drought and dzud, the mortality of livestock will be increased 5.5% compared with the number of animal of beginning of the year in middle of this century. According to this estimation, the mortality is projected to be incerased by 50% in the middle of this century.

Arable farming. In Mongolia, 80% of agricultural land located in the central region, 11% in the eastern region, and 9% in the western region as of 2020. These are mainly non-irrigated crops and are directly dependent on agro techniques and weather conditions. According to the long-term trend of wheat and potato yield per hectare, although their fluctuation depends on the weather conditions of actual year, and it had increased until 1990, then decreased drastically, and then gradually start increasing from 2003. According to the projection, wheat yield is expected to decrease by 26.1% in the western region, 36.0% in the central region, and 11.0% in the eastern region, with an average of 24.4% by 2050.

Tourism. Over the past twenty years, the number of tourists visiting Mongolia has been continuously increasing. Mongolia received a maximum of 577.3 thousand tourists in 2019, but in 2020 and 2021, the number of tourists dropped sharply by 95% due to the COVID-19 epidemic. According to the average value of tourism climate index (TCI), Umnugobi, Ulaanbaatar, Bayan-Ulgii, Uvs, Khuvsgul provinces belonged to suitable or good category and the TCI was 61.3. The tourism climate index is expected to increase by 3.4% in the future by 2050.

Infrastructure. In Mongolia, the land area covered by roads and its network had increased from 407 ha in 2010 to 477.2 thousand ha in 2021. In 2021, the 69.2% land area was covered by roads, 7.5% of railways, 2.0% of air transport, and 21.0% of network line, respectively. In the last 20 years (2000-2020), the frequency of disasters on the roads has doubled mostly due to flooding and heavy precipitation. After 2000, intense rainfall accounted for 54% of all cases. Furthermore, the maximum daily rainfall will be increased by 41% in Ulaanbaatar and 19.2% in Mongolia. This indicates that loss and damage on the road and railway, and construction is projected to increase. One positive impact in this sector due to climate warming is a shorthening of the heating season by 12 days for buildings and apartments between 1975 and 2018, and its projected to continue reduce by 2 days, 8 days, and 20 days in 2030, 2050 and 2080, respectively.

Natural disaster. The last 30 years or 3 decades, the number of natural disaster occured 29 times in 1989-1998, 53 times in 1999-2008, and 80 times in the last decade, and it has a tendency to increase. In Mongolia from 2001 to 2021, 539 people lost their lives and 29.773 million animals were killed, costing 681.8 billion MNT due to extreme weather and disasters. The estimation based on future projections up to 2050 have shown that frequency of drought will increase by range of 5% - 45%, and the frequency of dzud will increase by range of 5-40%. Under the conditions of the flood case in 1966, an area of 24.9 km^2 is likely to be use inundated, and this area is projected to increase by 20.8% in 2050, with an increase in maximum daily precipitation projected for future. The risks of fire area is expected to increase by 9% in 2050.

Public health. Climate change most likely causes an increase of diseases in the cardiovascular system, which is the third cause accounts for 11.1% of all diseases. The duration of summer heat waves will be increased by 3.5 days in 2050, indicating the increased risk for the population. Other diseases such as the West Nile fever, Japanese encephalitis, and Dengue infection and diseases caused by mosquito-borne infections to human have been reported in Mongolia.

Policy issues for reducing socio-economic impact and vulnerability. There is two historical cases of drought and dzud which covered more than 80% of the total area of Mongolia between 1995 and 2013. Around 122.1 thousand people were migrated to Ulaanbaatar city due to dzuds, which is 29% of the total migrants. The industrial production of the agricultural sector was decreased from 37% to 20.7% after the 2000-2002 dzud in 1999 and 2002, respectively, which was a 44% decrease, and it decreased by 35% after the dzud of 2009-2010. These chain events had the potential to ultimately hinder the implementation of Mongolia's sustainable development goals.

To strengthen climate change adaptive capacity in the vulnerable sectors and social community of Mongolia it is essential to 1) increase climate change resilience and to decrease vulnerability and risk, and maintain preparedness against natural disaster, and 2) to focus on consistency of planning for vulnerable sectors and social community, at the national and the local government levels, improving related legal structures covering adequately the challenges at aimag and soum levels.

5. Policy of climate change, adaptation starategy and project proposal

This chapter presents Mongolian laws, regulations, long, medium, and short-term policies and measures, their coordination, possible technological solutions suitable for policy measures, and proposals for feasible projects.

Prior to the launch of "Vision-2050," the national long-term development policy, the Government of Mongolia has been proactive in implementing long—and medium-term policies and a national-level action plan. These include the 2008 Millennium Development Goals-based Comprehensive National Development Strategy, the 2010 National Security Concept of Mongolia, and the 2011 National Action Program on Climate Change (NAPCC). The NAPCC, in particular, focused on environmental sustainability and reducing socio-economic vulnerabilities and risks through strengthening the national climate change adaptive capacity. The program was implemented in two phases, with the final phase ending in 2021. The government monitored the implementation of both phases, although no special evaluation was conducted.

Since the completion of the implementation of this program, the tasks necessary to determine the National Adaptation Strategy and Measures, to ensure their implementation at the policy level, and to reflect them in the next level of policies and strategies have been carried out within the framework of the National Determined Contribution (NDC), approved by the Government Resolution No. 407 dated 2019 and the National Adaptation Planning process (NAP), the finalised plan as an outcome of which was endorced by the National Climate Committee in April 2024.

The Mongolia's NDC under the Paris Agreement, specifically addressed the most vulnerable sectors, demonstrating Mongolia's proactive stance in climate change adaptation, such as livestock, arable farming, water resources, forest resources, biodiversity, natural disasters, public health, livelihood and social protection. Based on the identified vulnerable sectors, an Action plan for the implementation of the NDC was developed to ensure the implementation of UNFCCC and its Paris Agreement in line with the Mongolia's long-term development policy Vision 2050 and Government Action Plan 2020-2024.

In 2019, Mongolia started refining its adaptation planning process at the national level to strengthen the government's institutional and technical capacity and advance the process of formulating and implementing a National Adaptation Plan for future climate resilience. One measure connected with the NDC action plan was to develop and approve the National Adaptation Plan (NAP) under the target "Improvement of Climate Change legislations, policies, regulations, and overall implementation systems and framework." As part of this work, the "National Adaptation Plan of Mongolia" was completed between 2019-2024. Subsequently, the National Climate Committee officially approved this plan in March 2024 as a list of actions, as mentioned above. According to the summary of the approved version of Mongolia's climate change adaptation plan, it consists of 3 main sections with 10 overarching Targets, 27 goals to facilitate their achievement, and a comprehensive set of 107 specific measures identified in the 8 high-priority vulnerable sectors for the period 2023-2030.

Currently, there is no specific law regulating the issue of climate change in Mongolia. Since climate change is an interdisciplinary issue, it is regulated by the laws of the relevant sectors. In the framework, the Mongolian government has started the initiative of drafting the Climate Change Law, which is currently under discussion by the national working groups of experts. The objective of the law is to create a national regulatory framework to promote colective work through close cooperation among all relevant stakeholders to address emerging issues arising from climate change, promote climate change mitigation and adaptation measures, support climate change research and innovation, fulfil Mongolia's obligations under international agreements; towards managing and creating climate finance.

Adaptation and technology needs assessments and project proposals. For Mongolia, the deforestation and deterioration of forests due to climate change, in combination of other factors, have become major problems that need to be solved, requiring urgent actions. Due to the high risks and dangers facing forest resources in Mongolia, it is important to implement adaptive technologies on a large scale to prevent pests and fires, improve forest growth through planting, afforestation, maintenance, and thus increase carbon sequestration in forests. The first Mongolian technological needs assessment (TNA) of adaptation was conducted in 2013, and the assessment result showed the prioritized technologies for the most vulnerable sub-sectors, such as arable farming and livestock. Ten years have passed since the release of the technology needs assessment report, and technologies used in vulnerable sectors to reduce the negative impact of climate change have been updated and improved to a certain extent. Within the framework of the Third National Communication of Mongolia (TNC), some updates to conduct technology needs assessments have taken place based on the latest impacts, vulnerabilities and risk assessments on water resources, permafrost, forest resources, pasture-soil, wildlife, natural disasters, agriculture, livestock and human health sectors. Although some improvements have been made, the technology needs assessment on climate change adaptation was not conducted comprehensively compared with the previous assessment in 2013.

This time, some outputs on climate change adaptation assessment, prioritizations and ranked technologies and measures were listed for each socio-economic sector. Following adaptation technologies and measures have been updated for the livestock, arable farming, and forest sectors:

Livestock. Expanding the health zone from livestock infectious and highly infectious diseases: (i) improving the surveillance and control system to prevent highly contagious and infectious diseases in livestock, fully introducing tracking technology in the national network of livestock movement control and verification of the origin of livestock and livestock products, and expand meat production for export from protected areas. (ii) strengthening the resilience of pastoral livestock: the introduction of modern, advanced technologies in livestock breeding to breed more livestock that are more resistant to climate change while maintaining the gene pool and resilience of pastoral livestock adapted to climate change.

Arable farming. The use of synthetic film and straw mulch in agricultural production, the introduction of drip and seepage irrigation technologies, the introduction of reduced and zero irrigation technologies, and the establishment of forest strips have been included. For example, technologies on soil treatment, crop seeds, and sorts/varieties with drought and disease resistance, as well as those that are ecologically adaptable and short-maturing, produce quality seeds and increase supply; straw mulching, plastic film mulching, drip irrigation, sponge and pond for sustainable harvests, forest strip expansions, crop rotation.

Forestry sector. The action plan for implementing NDC and the "Billion Tree Campaign" objective proposed some adaptation technologies, such as the introduction of bio-pesticide technology and technology for early detection of wildfires (by quantity) as part of the monitoring system. Following the technologies and measures reflected in the policy documents and plans, technology “Reforestation technology of planting containerized seedlings” is highlighted as a detailed project proposal.

6. Policies and measures to mitigate GHG emissions

This chapter provides a comprehensive overview of Mongolian laws, regulations, and a range of long-, medium-, and short-term policies and measures and also details the coordination of the policies considered. Following the submission of the Third National Communication to the UNFCCC, the Mongolian Parliament and Government approved the “Vision-2050” (2020), “Mongolia’s New Revival

Policy" (2021), "Mongolia's Nationally Determined Contribution (NDC)" (2019), "Action Program of the Government of Mongolia" (2020), "Mongolia's five-year development guidelines for 2021-2025" (2020), "Mongolian National Program for Reducing Air and Environment Pollution" (2017). The COVID-19 pandemic has caused difficulties in implementing mitigation policies and measures outlined in the previous report. Therefore, adopting the New Revival Policy to reduce the effects of the epidemic and ensure the implementation of the first phase of the long-term policy, "Vision 2050", shows the government's short-term measures and initiatives to ensure coherence of the development policy.

Based on the above changes regarding the policy and plan updates, the current assessments on implementing policies and programs were updated between 2015 and 2020. In this, the current situation and planned policies in four sectors: (i) energy, (ii) industry, (iii) agriculture, forest, land use change, and (iv) waste, measures, and information on its implementation are combined at three levels. However, a detailed estimation was not conducted, particularly for the development of measures to reduce GHG emissions and their impacts.

Energy. Most GHG emissions are generated from the burning, mining, and transporting coal and liquid fuels. According to future economic and social development trends, GHG emissions in the energy sector are expected to increase sharply. The main measures taken to reduce GHG emissions in the energy sector are divided into two main groups: increasing the use of renewable energy and improving energy efficiency which measures indicated in the NDC is consistent with.

Industry. The industry sector plays crucial role in the Mongolian economy and as economy developing and industries shift to more modern, GHG emissions from production and consumption are expected to arise. The measures such as introducing technologies, productivity inclination while supporting the supply demand in domestic production where highlighted on the previous reporting period, while the cement production and improved efficiency in cement plants were considered under the NDC. The policies and measures and their implementation status were generated based on the measures covering the introduction of standards, technologies that increase efficiency and raw material processing.

Agriculture, forestry, and land use change (AFOLU). The increasing number of livestock is one of the leading causes of overgrazing and pasture degradation. Forests are the main removals of GHG and are subject to depletion due to improper use associated with human activities, the impact of forest fires on pests, and grassland degradation. In the AFOLU sector, the main measures were (i) reducing the number of livestock, supporting exports, and improving livestock health; (ii) abandoning the traditional technology of overturning soil and protecting against soil erosion; (iii) reducing deforestation, increasing the number of forested areas through restoration and afforestation, and creating sustainable management and effective implementation.

Waste. Simultaneous growth in population, urbanization, and industrialization is leading to an increase in waste generation and the change of components; the average volume increased by 500 thousand tonnes annually in Mongolia. In terms of waste composition, solid and liquid waste data are the most prominent and estimable. The main measures taken to reduce GHG within the framework of the waste sector are divided into four main groups: waste reduction, reuse, recycling, and reduction of waste disposal in nature, mostly considering the standard enabling processes and establishment of facilities on waste treatment and recycling.

Certain provisions have been repealed in the government's policies, national programs, and plans in the above-mentioned sectors, but policy coherence has been ensured by integrating the relevant provisions into the necessary policy and action documents.

7. Baseline scenarios for climate change and potential options for mitigation measures

The estimation for the future projection of GHG emissions and removals in Mongolia was based on population growth, economic developments, and their demands if no additional actions are taken (BAU) and mitigation scenario GHG emissions based on related policy measures at the national and sector-level using international guidelines, methodologies, and models (LEAP, COMAP and Ex-Act models).

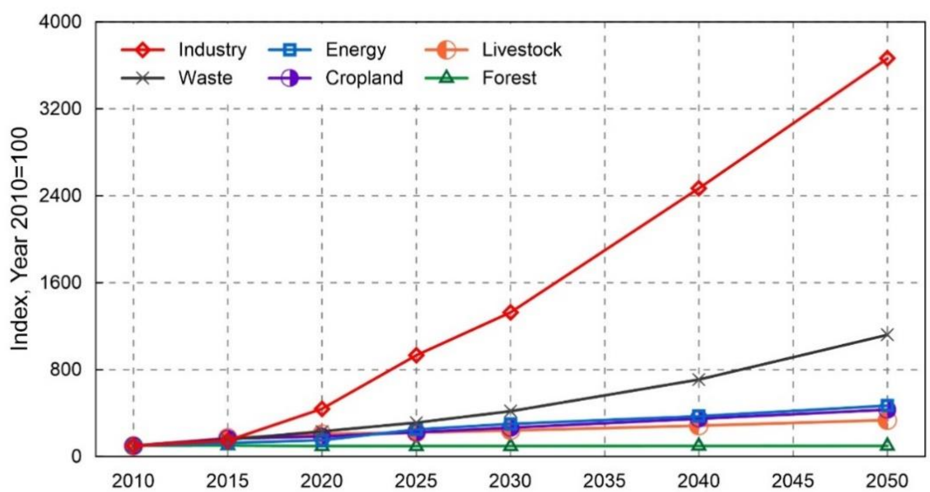


Figure 4. Future projections of GHG emissions and removal in Mongolia by sector

Future projections to 2030 and 2050, using the year 2010 as the base year and assuming no action is taken (BAU), show that emissions from the energy sector are expected to increase by 3.0 and 4.7 times, cement production in the industrial sector by 13.3 and 36.6 times, the livestock sector of 2.4 and 3.4 times, the agricultural sector of 2.7 and 4.3 times, and waste sector 4.2 and 11.2 times, while the carbon sink potential of forests will rise by 14.0% and 31.0% respectively (Figure 4).

Carbon dioxide (CO_2) emissions will rise by 3.2 and 5.3 times, methane (CH_4) emissions by 2.4 and 3.5 times, and nitrous oxide (N_2O) emissions by 2.1 and 3.2 times in 2030 and 2050 compared to the base year 2010.

As seen from Table 2 the mitigation scenario could reduce total GHG emissions by 24.3%, 26.4%, and 27.4% in 2030, 2040, and 2050, respectively, if it completely implements the measures outlined in the policy and plans and programs of sectors that produce GHG emissions.

Table 2. Comparison of the baseline and mitigation scenarios of GHG emission in Mongolia

Year	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU), Mt CO_2e	20.9	29.3	36.1	51.9	61.4	77.2	97.4
Mitigation scenario, Mt CO_2e	20.9	29.3	36.1	43.3	46.5	56.8	70.7
Total GHG emission reductions, Mt CO_2e	-	-	-	8.5	14.9	20.4	26.7
Total GHG emission reductions, %	-	-	-	16.5	24.3	26.4	27.4

However, including land use, land use changes, and forest sinks, GHG emissions could be reduced by 32.1%, 35.4%, and 36.7% in 2030, 2040, and 2050, respectively.

Considering all the possible policies and measures taken in the field of reduction of GHG emissions in Mongolia, it is expected to reduce GHG emissions by 8.5 Mt CO_2e, 14.9 Mt CO_2e, 20.4 Mt CO_2e, and 26.6 Mt CO_2e 2025, 2030, 2040 and 2050, respectively, by each emission sectors, based on the baseline scenario. Considering the removals by forests, it is possible to reduce by 10.6, 19.4, 26.8, and 35.2 Mt CO_2e in the mentioned years (Table 3).

Table 3. Reduction of greenhouse gas emissions by sector in Mongolia

		2025	2030	2040	2050
Total emission reductions, Mt CO2e					
Total emission reductions Mt CO2e		**8.535**	**14.938**	**20.369**	**26.650**
1	Energy	5.900	9.300	11.500	14.000
2	Industrial Processes and Product Use	0.053	0.099	0.193	0.286
3	Agriculture	2.525	5.446	8.451	11.898
4	Waste	0.058	0.093	0.225	0.466
Total emission reductions/removals Mt CO2e					
Total GHG emissions accounting removals from forest		**10.642**	**19.356**	**26.835**	**35.156**
5	Enhancement of forest removal	2.428	4.791	6.944	9.097

8. Technology needs assessment

There are measures reflected in the New Revival Policy (2030) that aimed enhance the energy capacity and efficiency in terms of increasing the production of the electircity and heat supply and demand with the least increase in GHG emissions. These activities relate to the new energy sources and transmission lines to be established, renewable energy facilities shall be developed in accordings with country's need, indexing prices and tariffs in energy sector, connection the transmittion lines with the network within the Northeast Asian integrated energy grid.

In energy sector, Mongolia faces following issues:

1. In total 39 entities received the special licenses for building the renewable energy generation facilities (wind, solar, hydro and others) with total capacity of 1,528.8 MW, since ratified the Renewable Energy Law (2015). However, current capacity of the centralized energy supply grid of the country cannot tolerate this level of input from unstable energy sources.
2. Another issue is related to the power transmission capacity (Bavuudorj, 2018). Assessment show that with the commissioning of Naranteeg 15 MW solar PV plant and Sainshand 55MW wind farm the summer time transmittable capacity of the overhead lines is reaching maximum level.
3. Revision needed in the Renewable Energy Law that requires a certain provision in respect to control the tariff for renewable energy. There is expected a financial instability of energy sector if renewable energy tariff will increase up to 136.37 MNT/kW/h.

Hydropower is the largest source of renewable electricity in the world and it is particularly suited to providing system flexibility. Seasonality of Mongolia's climate with long-lasting winter and variation on runoff due to drought limits hydropower development to only in medium and small scales.

Next potential sources in energy sector of Mongolia are bioenergy technology collaboration programmes (TCP) (started 1980s), and the Geothermal TCP which currently operating in small-scales, however, upscaling requires adoption of the newest technologies and an international collabration. Finally, combination of renewable energy technology with other systems (e.g., the solar heating and cooling power system) will be a potential increase in energy sources.

Technology issues related to adaptation

The adaptation technologies identified were regrouped under different categories:

- sustainable water use and management: use of treated water, water-smart technology, water ponds, and improve the efficiency of water delivery system;
- planning for climate change variability: information exchange and early warning system;
- soil management: soil fertilization using agricultural waste composte;
- sustainable crop management: conservation of the locally adaptive or indigenous varieties and their seed productions;
- sustainable livestock management: livestock insurance, conservation of the locally adaptive or indigenous breed;
- sustainable farming system: climate-smart farming and agroforestry;

- land use management: management of watershed and agroforestry, afforestation and monitoring of the land use change;
- capacity building and stakeholders: capacity building of research and adopion of environment friendly technologies/indigenous technologies for dissemination to farmers and other relevant stakeholders.

Most of projections on future climate in Mongolia based on Global Climate Models (GCM) show that at least by the mid of the century in Mongolia will dominate drier climate with prolonged droughts, having at the same time, frequent floods due to short but intensive rainfall. Property owners and farmers in vulnerable areas will increasingly interested to use technologies that can help them to minimize those potential risks. The best solution for climate-resilient agriculture could be optimal combination of inherited adaptive capacity of local community and modern know-how and technologies. For example:

- Water scarcity: more cost effective and environmental sound new approaches, like use of natural setting;
- Farming: introduce climate-smart technologies such as 'drip irrigation' systems to aviod loosing water by evaporation;
- Reuse: gray water and harvesting rain water are may become an additional water sources by employing an appropriate and non-expensive technology in crops, agroforestry and others.
- In Mongolia, insurance in agriculture sector has not been fully developed, mostly because this sector is at high risk caused by uncertainties in extreme weather conditions and lack of solid motivations based on clear benefit evidence. Currently, Index based livestock insurance (IBLI) is an insurance applied in agriculture sector, yet no insurance for small farmers and stackholders.

At present Mongolia has well developed network of meteorological and hydrological stations which is serving as the basic infrastructure for climate monitoring and the latest satellite meteorology and remote sensing technologies in place with bilateral and multilateral cooperation. Mongolia is receiving new supercomputer within adaptation project supported by Green Climate Fund (GCF). It will substantially extend the capacity of the national agencies to be engaged more productively in climate change adaptation activities.

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

This section covers constraints and gaps in accelerating climate actions in Mongolia, as well as the support needed to address the existing challenges in terms of climate change coordination, monitoring, reporting, and verification (MRV), climate finance, and capacity building.

Institutional arrangement and multi-stakeholder coordination. According to the current regulations, the Ministry of Environment and Tourism (MET) is responsible for designing, developing, coordinating, and reporting on climate change policies and measures at the national level. The Department of Climate

Change, established within the MET, has increased its climate change positions, but it has not been able to function at its full potential due to staff turnover and other administartive management issues. The National Climate Committee (NCC) plays a role of an intersectoral coordination body; it is headed by the Deputy Prime Minister of Mongolia, and the members include a wider scope of officials. The powers and responsibilities of the committee are limited to monitoring and evaluating the implementation and making recommendations within the scope of the mandate, which is not well defined yet as well. At the technical level – the Climate Change Research and Cooperation Centre (CCRCC) is to support both the MET and NCC. But a status of this center as a self-funding state proferty entity is not promoting the well functioning regime, due to lack of guaranteed financial support and administrative micromanagement intervention. At present at the policy level there is no any national level strategy on climate change in addition to the NDC. The Government of Mongolia has dealt with setting up the coordination system within the government institutions and with the international partners to a certain level, but not much done to attract and engage the private sector stakeholders.

Mongolia joined the NDC Partnership (NDCP) in 2017. For the effective facilitation of the work of the NDCP, four focal points are appointed for key ministries. Through the NDCP's support, MET has developed an online NDC coordination platform to enhance coordination to achieve NDC targets by tracking financial flows among partners and stakeholders. Yet, due to the lack of dedicated staff to run the platform, the platform has fewer updates, involvement, or input from stakeholders.

Monitoring, reporting, and verification (MRV). CCRCC is responsible for the MRV implementation including the estimation of the national GHG inventory, and the preparation of the implementation reports and communications under the UNFCCC and its Paris Agreement. There is no dedicated monitoring system in place for climate change planning, implementation, evaluation, and reporting. The environmental databases are mainly managed by the National Agency for Meteorology and Environmental Monitoring (NAMEM) and National Statistics Office (NSO). These data sources are utilized for the preparation of the national communications, biennial update reports, and the GHG inventories. The validation is organized by CCRCC, particularly, the core team of the former Climate Change Project Implementation Unit (CCPIU) before the UNFCCC submission, through multistakeholder consultations in order to consolidate and validate the findings and recommendations. For the GHG inventory report, the quality assurance (QA) is overseen by the GHG inventory team (as part of the CCPIU) at the CCRCC, but the actual and direct technical work is conducted by the third-party or external consultants.

Gaps and Challenges. Mongolia has been facing the following main gaps and constraints in addressing climate change. These include weak legal frameworks and institutional arrangements, limited budget and finance, a shortage of human resources, and limited tools, equipment, and methodologies to improve the quality of climate research and assessment.

Climate Finance. Mongolia pre-estimated its climate finance need in its NDC, as USD 11.5 Billion by 2030. Yet, NDCs are not included in the medium-term or annual budget frameworks of the Government –

which puts the NDC implementation in a risk. A low economic performance, corruption, and a volatile political and policy environment have caused budget deficits and soaring inflation in the country. Climate actions in Mongolia highly rely on international climate finance. Mongolia has received USD 1.29 billion in climate-related finance between 2017 and 2019. 67% of the total funds received is allocated for mitigation, 17% for adaptation, and the remaining 17% for adaptation and mitigation combined projects. Besides, those projects and programs, there are other internationally funded climate projects being undertaken.

Support needed. The above mentioned gaps and constraints in addressing climate change and related challenges are making significant barriers for the country to effectively tackle climate change. In order to speed up efforts toward addressing climate change, the additional effort is crucial to prioritize various activities such as strengthening climate science research, developing appropriate policies, maintaining a stable workforce, and improving government funding. Finally, it is important to enhance collaboration among stakeholders through effective implementation of relevant activities.

10. Other relevant information

Climate observation network. Meteorological observation in Mongolia was first started in 1869, when some foreign explorers and expedition established observation stations in some areas of Mongolia, data of which were published in climate book of that period of time. But the first station of the national network of the National Hydrometeorological Service of Mongolia was established in 1936. Since then, the meteorological observation network has been expanding. Currently, throughout Mongolia, 137 meteorological stations (8-times-a-day measurements) and 181 meteorological posts (3-times-a-day measurements) are carrying out permanent observation under the standard programme of the World Meteorological Organization (WMO). Since 2003, the high-sensitivity automatic weather stations (AWSs) were installing as a part of the national weather network, and automatic measurements are being made at 124 stations and 52 posts as of 2022.

Based on the long-term observations of climate, water and environment, the IRIMHE provides 11 reviews and recommendations, and 10 forecasts in timely manner, annually. In addition, four special reviews and recommendations have been provided by the request of the Government such as winter-spring season's pasture carrying capacity (2001), drought and dzud assessment (2001), dzud risk maps (2015), and time of spring planting period (2000).

Climate service system (CSS). CSS of Mongolia, an user-friendly platform with a comprehensive databese, was outlined and developing in consistent with the structure of the Global Framework of Climate Service (GFCS). The CSS platform includes the 8 categories of products with information and services for different end-users such as 1) climate regime and resource, 2) monthly and seasonal outlook, 3) background information related to the NDC, 4) background information related to the NAP, 5) livestock, 6) arable farming, 7) water resource and 8) infrastructure. Main purpose of the platform is to provide information, products, and services which in turn helps to reduce risk of individuals and organizations, and increase the resilience and adaptative capacities.

Environmentally Sound Technologies (ESTs) Development and Transfer. Mongolia has engaged in bilateral and multilateral cooperations, while enhancing its legal and policy frameworks in support of technology transfers to enable the Article 4.5 of the UNFCCC that promotes the development and transfer of environmentally sound technologies (ESTs), including solar energy, and energy efficient technologies with the support of the green loans from the commercial banks.

Regarding to the climate-smart technologies, Technology Needs Assessment (TNA, 2013) has been conducted in 2013, however, it requires an update to identify the latest climate-smart technologies. Currently, the 262 technologies were identified as a ESTs of Mongolia and majority of them are in the field of renewable energy, air pollution, water, and waste treatment technologies in residential and industrial sectors.

Education and Awareness Raising. Climate change is not fully integrated into the education sector i.e., formal, non-formal and higher education programmes to the extent to drive the transformational change needed to achieve a low-carbon and climate resilient development. *In formal education programmes,* climate change education for sustainable development is quite a new concept in Mongolia. There are natural science related subjects are taught in upper level grades including 6 subjects that focused on environment, ecosystem, pollutions, and sustainable development and 4 subjects that addressed the climate change issues. While recognizing the importance of content-specific concepts such as ecology, it is important to respond to the emerging challenges related to of climate change and revise the fundamentals and examine the degree to which existing educational provision is adapted, rather than just simply input new the curriculum.

In Mongolia, *a non-formal education* programmes is introduced since early 1990s and to enable this form of education, the life-long learning centers were established at provinces, cities, and Ulaanbaatar districts. The main cirriculum of the training includes (i) communication and ethics, (ii) family and health, (iii) civil rights and politics, (iv) culture and beauty, (v) art of living, and (vi) science.

Eco School program. As of 2021, nationwide 335 secondary schools, 189 kindergardens and 6 colleges were registered in the program and being implemented the ISO 14001 environmental management system, which aims to promote an environmental-friendly lifestyle.

Green Passport. In 2018, under the leadership of the Minister of Environment and Tourism, “Green Passport” national campaign launched and implemented with the motto of changing our perspective. The champaign aimed to empower the youth and future generations towards adopting the environmentally conscious habits, actions, and attitudes to ‘live green’. The passport has 12 pages with different contents such as water, waste, green environment, traditional methods of natural conservation.

Youth Parliament. Another initiative was the Youth Parliament of Mongolia, which launched in 2021 under the support of the Parliament's subcommittee on the Sustainable Development Goals and the United Nations Resident Coordinator Office in Mongolia. The Parliament election was open for students in 9-11th grades, and 76 children from 21 provinces and nine districts of Ulaanbaatar were selected.

Higher education. As of 2021, there were 37 universities, 48 institutes, and 3 colleges in Mongolia (meds.gov.mn). In recent years there has been a significant decrease in the number of students in the areas of environmental studies. For comparison, in the year of 2008-2009 the number of students enrolled in these specialties at universities was 10,900 while in the year of 2018-2019, this number reduced to 4,200 students.

Information sharing, and networking. The central government administrative authority responsible for climate change information and knowledge sharing and networking is the MET and its agencies and their websites are: the information on the national GHG inventory and the national climate change reports via http://www.ccrcc.mn/; the information on Mongolia-Japan Joint Crediting Mechanism and its projects are shared via https://www.jcm-mongolia.com/; and the climate services system via http://climate-service.mn/climateservice/.

Gender-responsive climate change. Mongolia, as one of the few countries that have reached a medium level of gender equity and globally ranking 69th out of 156 countries, with the Gender Gap Index with a score of 0.716 (WEF, 2021).

In 2020, the 124,300 female herders were registered nationwide (NSO, 2020). Women, children, and the elderly were identified particularly vulnerable during the dzud. Due to dzud and extreme road conditions, most rural hospitals are not able to reach to herders to conduct the precautionary check-ups – particularly for pregnant women, newly born infants, and elderly people or respond to emergency calls etc.

Regarding to the legal frameworks, Mongolia is highly committed as the concepts on prohibiting discrimination and ensuring gender equality are embedded in the Constitution of Mongolia as well as the Law on the Promotion of Gender Equality (LPGE), and the National Programme on Gender Equality (NPGE). While the LPGE and NPGE serve as a gender responsive legal and policy frameworks, it is found that the sector laws and policies that affect women's resilience to climate change and disasters-preparedness in Mongolia are not yet gender mainstreamed as referred in the Women's Resilience in Mongolia (ADB, 2022).

CHAPTER 1. NATIONAL CIRCUMANTENCES

1.1 Geographical location

Mongolia is one of the biggest continental inland landlocked country, located in Northeast Asia, between the latitudes of 41°35’N and 52°09’N and the longitudes of 87°44’E and 119°56’E. It borders with the Russian Federation and the People’s Republic of China (Figure 1.1).

Mongolia’s territory landmass featured by relatively high altitudes. The average altitude is 1,580 meters above sea level, while 81.2% of the territory is higher than 1,000 meters, and half of the territory is higher than 1,500 meters. The highest point is Khuiten Mountain (Mongolian Altai Range, 4,374 m) and the lowest point is Khukh Lake (Mongolian Eastern Steppe, 560 m).

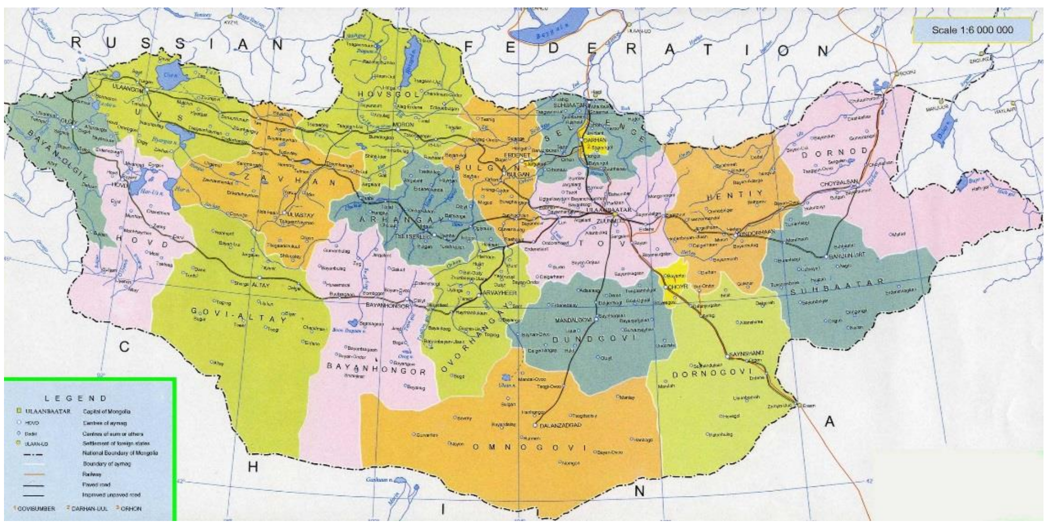


Figure 1.1 Geographical location of Mongolia

Among the countries from the temperate zones of the Northern Hemisphere, Mongolia can be considered as an unique by its the size, diversity, and health of natural ecosystems.

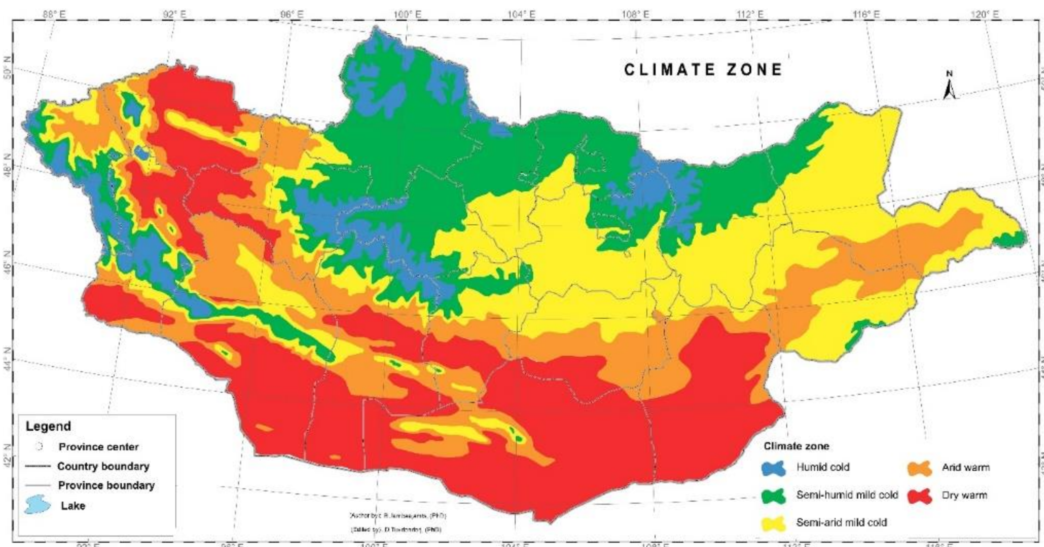
In Mongolia, all natural zones such as high mountains, valleys between the mountain ranges, wide steppe, desert and semi-desert zones are combined, forming some kind of mixed structure. Ecologically, Mongolia occupies a critical transition zone in the centre of Asian continent, having the great Siberian taiga forest, the Central Asian steppe, the high Altai mountains and the Gobi desert converge.

The northwest and central parts of Mongolia are high mountainous regions, while the eastern part is a vast and relatively untoached steppe region. The southern part of the country represents the semi-desert and desert area that is known as the Mongolian Gobi. Forests cover 9.1% of the country’s territory, consisting mainly of larch and pine. Saxaul *(Haloxylon Ammodendron)* forests occupy certain areas in the Gobi.

1.2 Natural resource

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

According to climatic zone, country territory is classified into humid cold, humid cool, arid cool, arid warm and dry warm (Figure 1.2). This climatic zone main feature is defined by humidity, heat supply and winter condition (B.Jambaajamts, 1989).



Source: Munkbat B. et al., 2018

Figure 1.2 Climatic zone of Mongolia

The annual mean air temperature is minus 6…-10^{o}C in the Altai, Khangai, Khentii and Khuvsgul mountains ranges, the depressions between mountains ranges, also along the valley of big rivers, but less than minus 10^{o}C in near mountain peak, warmer than 2.0°C in desert steppe and warmer than 6.0^{o}C in south gobi region. Warmest place was indicated in Shinejist soum of Bayankhongor province where annual mean air temperature is 9.1^{o}C. It was registered at Ekhiingol meteorological station (978 m above sea level), Shinejist soum of Bayankhongor province where annual mean air temperature is 9.1^{o}C (Figure 1.3).

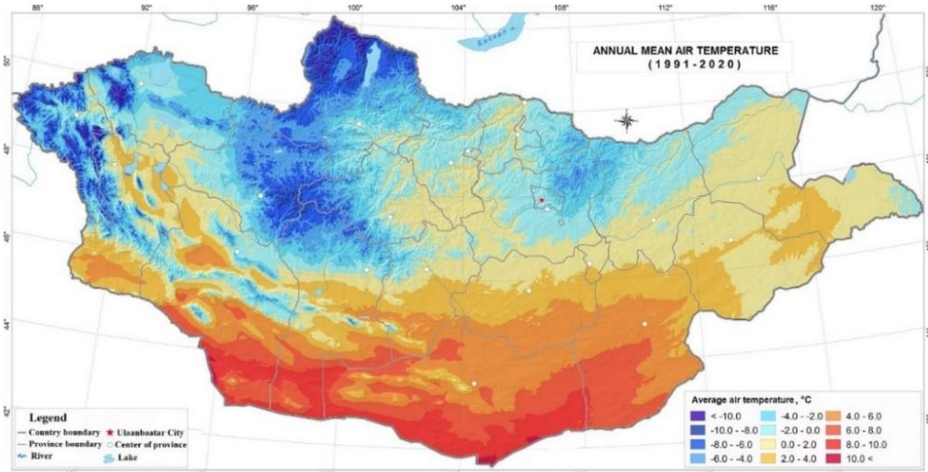


Figure 1.3 Geographical distribution of annual mean temperature

Seasonal temperature in Mongolia are minus 32.0...-8.0°C in winter (Dec, Jan-Feb), in range between +9.0...+29.0°C in summer (Jun-Aug), in range between minus 20.0...+17.0°C in spring (Mar-May) and autumn (Sep-Nov). The coldest month is January and its temperature is minus 32.0…-26.0°C in valley between Altai, Khangai, Khuvsgul and Khentii mountains, minus 26.0…20.0°C in high mountains and in their between valleys, minus 23.0…20.0°C in steppe and minus 17.0…11.0°C in Gobi and desert region (Figure 1.4).

Since 1936 when begins systematic instrumental observation for weather, absolute minimum air temperature was recorded as minus 55.3°C in Zuungobi soum (1001 m above sea level) of Uvs province on 31st December of 1976. In case of capital city of Ulaanbaatar, absolute minimum air temperature rrecorded as minus 49.0°C in December of 1954.

Warmest month is July and its temperature is not warmer than 17.0°C in Altai, Khangai, Khuvsgul and Khentii mountains, in range of 17.0-21.0°C in Great lake depression, Orkhon and Selenge river basin and valleys of Altai, Khangai, Khuvsgul and Khentii mountains, and in range of 21.0-29.0°C in southern part of Dornod steppe and desert and Gobi region (Figure 1.4). Absolute maximum air temperature was recorded as 44.0°C in Darkhan city (710 m above sea level) on 24th July of 1999.

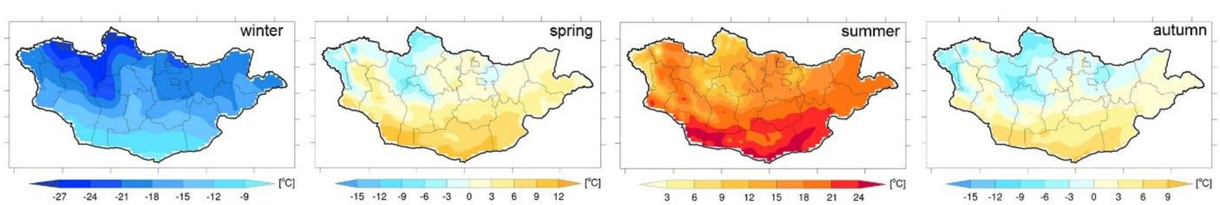


Figure 1.4 Geographical temperature of seasonal temperature in winter, spring, summer and autumn

Mongolia is located in the arid and semi-arid region, therefore amount of precipitation generally is low. The annual precipitation is exceeded 400 mm at high mountain region, 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 area, 150-250 mm in steppe and 50-150 mm in Gobi and desert regions. In south-inner side of Altai Mountain, annual precipitation ranges even less than 55 mm. Spatial distribution of precipitation in Mongolia is unique due to difference in landscape features, topography and geographical location. Typically, precipitation decreases from north to south and from east to west, however, surface roughness has much impact on spatial distribution of precipitation (Figure 1.5).

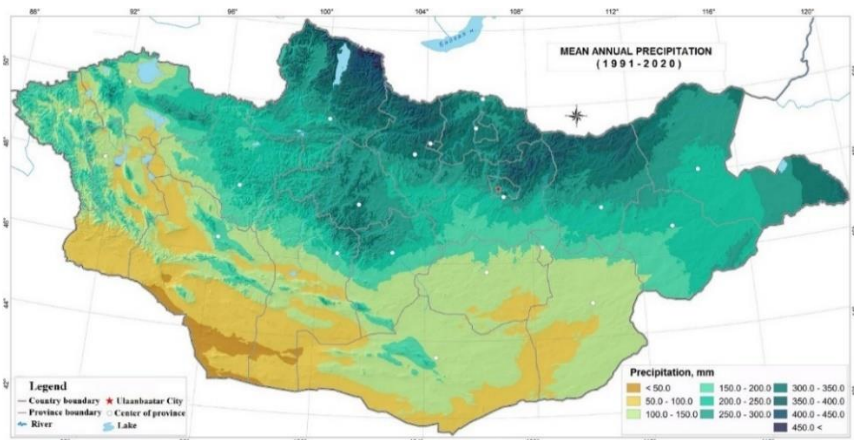


Figure 1.5 Geographical distribution of annual mean precipitation

About 90% of total precipitation falls from April to October and among them 50-60% falls only within July and August. Precipitation amount during the cold season is about 25-30 mm in the mountain area while 5-10 mm in the Gobi region (Figure 1.6). Duration of forming snow cover is about 150 days in the mountain regions such as Khangai, Khentii and Khuvsgul where winter precipitation is 25-30 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 Dornod Mongol steppe, and less than 50 days in Gobi and desert zone. Snow cover depth is in average nearly 5 cm in mountain region and its maximum could be higher than 30 cm while 2-5 cm in steppe region, where maximum value is 15-20 cm.

Generally, precipitation amount is low, however its intensity is high. In accordance with the data of the systematic, instrumental observation since 1940th, highest daily maximum rainfall was observed in the Dalanzadgad where daily maximum rainfall reached 138 mm (5th of August, 1956). Hourly rain recorded up to 40-65 mm ever less than 1 hour in some areas.

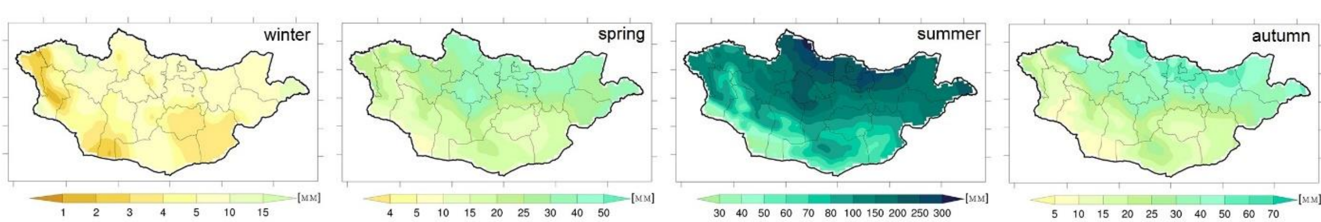


Figure 1.6 Geographical distribution of winter, spring, summer and autumn precipitation, mm

Land Resources: Mongolia's total area is 1,564,116 km^2. The distance between the most western and most eastern points is 2,392 km, and between northern to southern points is 1,259 km and the total length of the national border is 8,252.7 km. Mongolia is the seventh largest country in Asia and the 19th largest in the world.

According to the revised in 2002 Law on Land, the land in Mongolia is classified into six categories: agricultural land; land of cities, villages and other urban settlements; land under roads and infrastructure; land for special needs or purposes; land with forest resources, and land with water resources.

Based on this classification, as of 2022, 72.6% of the territory of Mongolia is agricultural land, 16.7% is land for special needs, 9.1% is land with forest resources, 0.6% is urban areas, 0.4% is land with water resources and 0.5% is land under roads and infrastructure. Land category changed recently are presented in Table 1.1.

Table 1.1 Unified major land classification of the territory of Mongolia, thousand ha

	2000	*2005*	*2010*	*2015*	*2020*	*2021*	*2022*
Agricultural land	130,541.3	115,232.7	115,525.8	114,982.8	114,041.8	113,980.0	113,567.1
Land of cities, villages and other settlements	416.4	466.0	620.6	716.9	917.6	956.2	1,005.3
Land under roads and networks	336.7	355.4	407.1	462.5	474.8	477.2	836.0
Land with forest reserve	18,292.0	14,748.1	14,297.9	14,334.4	14,255.9	14,256.6	14,260.3
Land with water reservior	1,667.4	967.6	682.8	686.1	660.9	660.9	660.3
Land for special needs	5,157.8	24,641.8	24,877.4	25,228.9	26,060.6	26,080.7	26,082.6
Total area	**156,411.6**	**156,411.6**	**156,411.6**	**156,411.6**	**156,411.6**	**156,411.6**	**156,411.6**

Source: Agency for Land Administration and Management, Geodesy and Cartography (ALAMGaC)

Urban development: Intensive urbanization started in Mongolia in the 1950s, when only about 20 per cent of the population resided in urban areas. The urban population has increased from 1.2 million in 1990 to 2.5 million in 2023, accounting for 57.4% and 70.8% of the total population respectively. Mongolians are increasingly abandoning the traditional nomadic way of life and moving into urban and settlement areas. From the historical predominance of nomadic and rural habitats, Mongolia is now overwhelmingly urban, with more than two thirds of its population living in cities and towns. Correspondingly, the area of land of cities, villages and other settlements, including lands under urban constructions and buildings, industrial and mining sites and urban common tenure land, has expanded from 416,4 thousand ha in 2000 to 1,005.3 thousand ha in 2022.

Rangeland and livestock: In 2020, pastureland accounts for around 96.15% (109,645.6 ha) of the agricultural land. Whereas the term more commonly used in Mongolia is pastureland, this land should more accurately be described as rangeland because it grows primarily native vegetation and serves as a habitat for wildlife, including both grazers and predators and critically endangered birds, while being used for nomadic livestock herding and haymaking. The area of rangeland had decreased from 123,554 thousand ha in 1987 to 109,645.6 thousand ha in 2020, a decrease of 11.25%. Pastureland plays an important role for the Mongolian animal husbandry, because they are grazing home to over 65 million livestock.

Meanwhile, the livestock herd - predominantly sheep, cattle and goats - grew to 67.3 million in response to higher cashmere prices, increased demand for meat and other animal products. Pasture degradation has become a serious issue in the country due to increased numbers of livestock and frequent natural disasters. The livestock population had increased by 2.96 times, from 22.7 million head in 1987 to 67.3 million head in 2021. Consequently, the density of livestock had increased from 18 head per hundred ha in 1987 to 61 head per hundred ha in 2021.

The composition of animal type when the number of livestock is totalled as 64.7 million head, the horses were 4.8 million, cattle 5.3 million, camels 473.9 thousand, sheep 29.4 million, and goats 24.6 million in 2023. Compared to 2022, the number of livestock decreased by 6.4 million head or 9.1%, of which cattle were down 162.0 thousand or 2.9%, and sheep 3,337.8 thousand or 10.2% goats 2,950.8 thousand or 10.7% and where as the horses were up 8.7 thousand or 0.2% and camels 3.4 thousand or 0.7% (Figure 1.7).

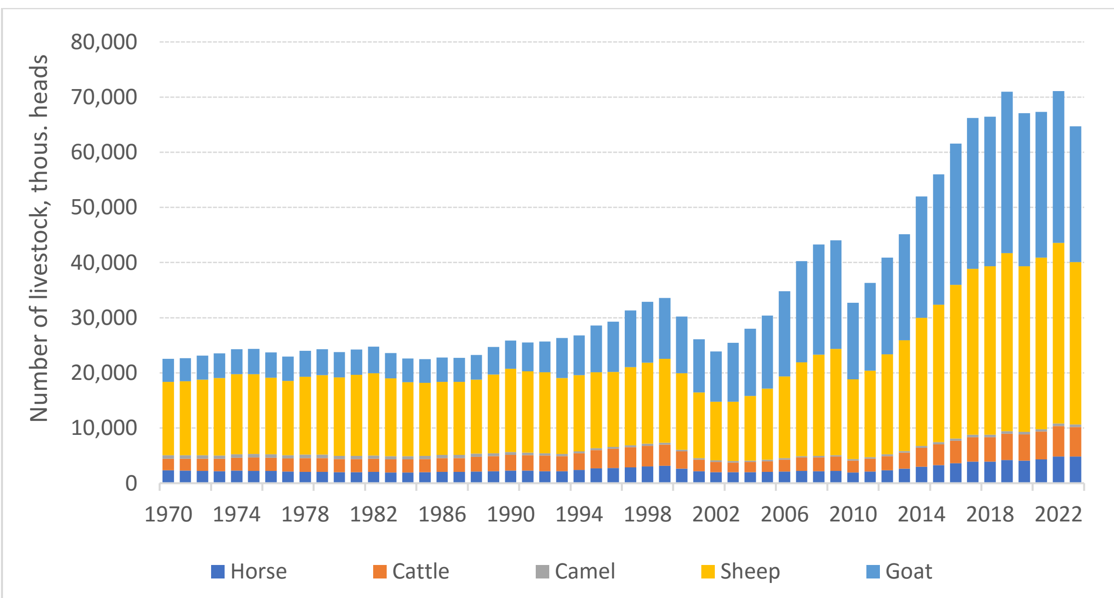


Figure 1.7 Number of livestock dynamic, million head

In Mongolia, herds have free access to rangeland, which is creating a certain barrier for regulated grazing management, since modern days livestock breading is more profit oriented not like traditional one which was almost subsistence form of economy.

Along with the increase in the livestock population, the composition of livestock had changed substantially. In recent years, herders are to have more goats, due to increasing market demands for and the high price of cashmere. The proportion of goats in the total number of livestock had increased from 19.83% in 1990 to 38.06% in 2023, while that of other livestock, including sheep, cattle, horses and camels, continually declined (Figure 1.8). Goats are considered as more harmful to rangeland compared with other livestock, due to their grazing habits of not only eating grass leaves but also destroying grass roots.

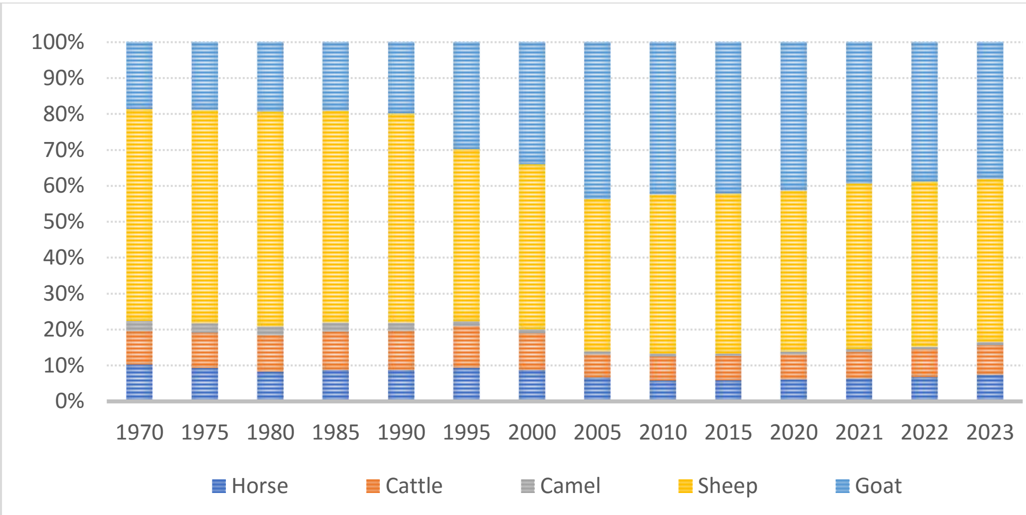


Figure 1.8 Ratio of different livestock herds, in percent

Arable land and crop production: The arable land from the agricultural land accounts for less than 1 per cent. The arable land in Mongolia has declined from 1.334 million ha in 1987 to 1,127 million ha in 2020. Only part of the arable land is used for crop production.

Mongolia launched Atar-I campaign in 1959, Atar-II campaign in 1976, Atar-III campaign in 2008, Atar-IV campaign for sustainable farming development in 2019. The meaning of the word "atar" is a virgin or untoached land or unused land for crop production.

Prior to a Atar-I campaign herders and citizens mostly grew barley and rye for their own needs, and in the 1950s, wheat cultivation and harvest accounted for only about 30 percent of the cereals. In 1950, 51.4 thousand hectares of land were planted with cereal at the national level, which is the size of tillage of the current two big entities specializing in cereals.

The Atar-II campaign, carried out between 1976-1978, not only met the country's domestic demand for crop products, but also exported them.

In the late 1980s and early 1990s, more than half of arable land was used for crop production. Since then the proportion of sown area in the total arable land has decreased, and was quite low between 1994 and 2008, with the lowest proportion, 18%, in 2000. During this period, most of the arable lands were abandoned or left fallow. For this reason, in 2008, the Government of Mongolia launched the National Crop Rehabilitation Plan-III to restore crop production.

Between 2008-2010, the Atar-III campaign was launched to increase production, meet domestic demand, and implement new technical and technological innovations. In 2010, 345.5 thousand tons of wheat, 168.0 thousand tons potatoes, 82.3 thousand tons vegetables were harvested. As a result, harvested wheat increased 235.9 thousand tons (2.2 times), harvested potatoes 53.5 thousand tons (46.8%), harvested vegetables 5.8 thousand tons (7.6%) from 2007.

In 2020, 430.3 thousand tons of cereals, 244.3 thousand tons of potatoes, 182.1 thousand tons of fodder crop, 121.2 thousand tons of vegetables, and 1,186.2 thousand tons of hay harvested nationwide, which was substantial progress toward a goal to meet at least the national demand.

During the Atar-IV campaign which was started in January 2020, several measures are planned to be undertaken towards mitigation of soil degradation, erosion and soil fertility decline, re-havilitation of soil, development of climatic resilient farming, improvement of its risk-bearing capacity to ensure agro-ecosystem sustainability.

Table 1.2 Sown area and harvest of cerials

	1960	*1970*	*1980*	*1990*	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Sown area of cereals, thous.ha	246.7	419.6	557.5	654.1	194.7	259.2	390.7	408.0	432.6	385.1	363.1
Harvest of cereals, thous. tonne	259.5	326.5	286.8	718.3	142.1	355.1	216.3	430.3	614.5	428.6	470.3
Yield of crop production, per hectare	10.5	7.8	5.1	11.0	7.3	13.7	5.5	10.5	14.2	11.1	12.9

Source: Statistical Yearbooks of Mongolia, www.1212.mn

Mongolia has a relatively short period of vegetation period, particularly, in relation with a cropland use. The dry climate and the long winters limit the growing period to 80–100 days in the north and 120–140 days in the south, and make conditions for crop growing unfavourable. Cereals, including wheat, barley, oats, rye and buckwheat, are the most important crop, followed by potatoes and vegetables. 363,061.0 ha is planted with cereals, 19,425.0 ha with potatoes and 15,790.0 ha with vegetables. Another 106, 931.0 ha is used for fodder crops in 2023 (Figure 1.9).

More detailed coverage of crop production issue in this report is related to needs to highlight more the land use and land use change associated challenges, particularly, in term of GHG sink and dust /aerosol problems.

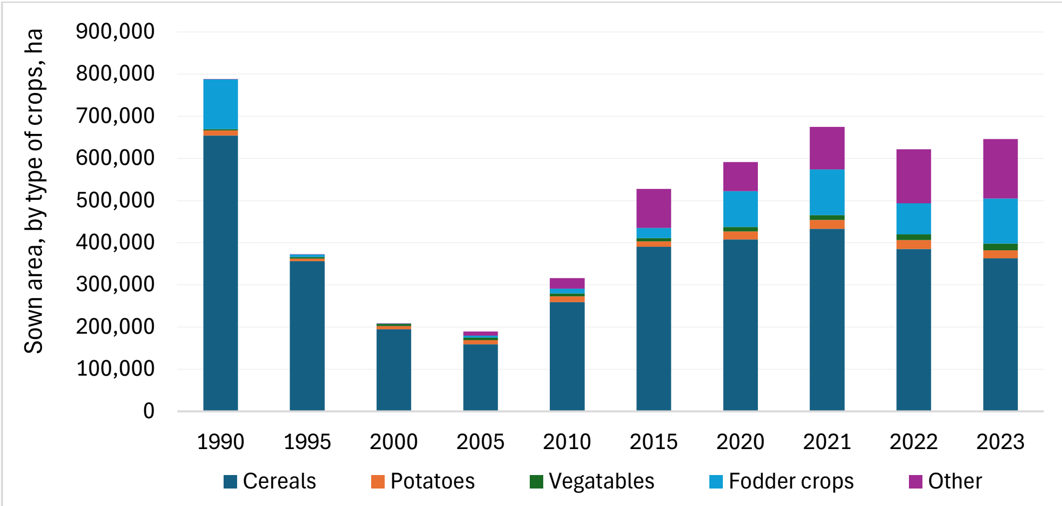


Figure 1.9 Sown area, by type of crops, ha

The country in the 2023 harvested 470.3 thousand tonnes of cereals, 258.2 thousand tonnes of fodder crops, 208.4 thousand tonnes of vegetables, 179.4 thousand tonnes of potatoes, 55.4 thousand tonnes of technical crops and 2.3 thousand tonnes of friuts and berries. Compared to 2022, some increase of production was occurred like fodder crops 87.0 thousand tonnes or 50.8%, vegetables 59.6 thousand tonnes or 40.1%, and cereals 41.7 thousand tonnes or 9.7%, whereas potatoes decreased 34.6 thousand tonnes or 16.2% (Table 1.3).

Table 1.3 Gross harvest of crop production, by type, thousand tonne

Type	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Cereals	355.1	216.3	483.5	238.1	453.8	433.3	430.3	614.5	428.6	470.3
Potatoes	168.0	163.8	165.3	121.8	168.9	192.2	244.3	182.6	214.0	179.4
Vegetables	82.3	72.3	94.4	82.1	100.7	99.5	121.2	121.7	148.8	208.4
Fodder crops	34.8	49.2	53.4	47.9	123.8	121.1	182.1	293.7	171.2	258.2
Technical crops	11.1	23.1	21.5	13.9	23.9	34.0	22.6	52.3	49.2	55.4
Fruits and berries	0.6	1.4	1.6	1.5	1.7	1.8	1.6	2.4	2.6	2.3

Forest land and resource. As of 2022, about 14,260.3 ha are considered as forest land, representing 9.1% of the country's total area (ALAMGaC, 2023). In Mongolia, the term "forest land" is used to refer to both forested and non-forest areas and the surrounding spaces, including the area needed for forest growth. Forest land includes forested areas, planted forests, bush and shrub stands, logging areas, forests damaged by forest and steppe fire, insects and diseases, glades, and an area of 100 metres outside the forest edge, as well as seedlings and tree nursery areas. Non-forest areas include grasslands, shrub lands, wetlands and agricultural areas. Therefore, the revised in 2012 Law on Forests defines forest land as a form of land use rather than forest cover and includes areas not covered by forests in addition to the forested areas.

According to forest report of 2020, Mongolian forest resource is estimated by 18,596.1 thousand ha, from which 18,075.7 thousand ha (97.2%) corresponds to the forested area and rest of them considered just as a forest zone. About 67.9% of forest area (12,619.4 thou.ha) is covered by forest. From them, 11,851.7 thousand ha is occupied by natural trees, 759.7 thousand ha by shrubs and bushes, 8.0 thousand ha by planted forest and 32.1% (5,631.1 thousand 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 (FRDC, 2021).

Mongolian forest can be divided into two broad types of northern boreal forests and southern saxaul forests. About 83.4% of forest area (10,530 thousand ha) is covered by boreal forests, 16.6% (2,089 thousand ha) is covered by saxaul forests (Figure 1.10).

Mongolian forest resource consisted of more than 140 species of trees and shrubs. Among them, 62.0% is occupied by larch, 10.06% by birch, 5.17% by cedar, about 4.26% by pine, 0.23% by spruce, 1.29% by willow, 0.3% by aspen, 0.23% by spruce, 0.12% by poplar, 0.02% by elm, 16.59% by saxual, 0.01% by fir as respectively (FRDC, 2021).

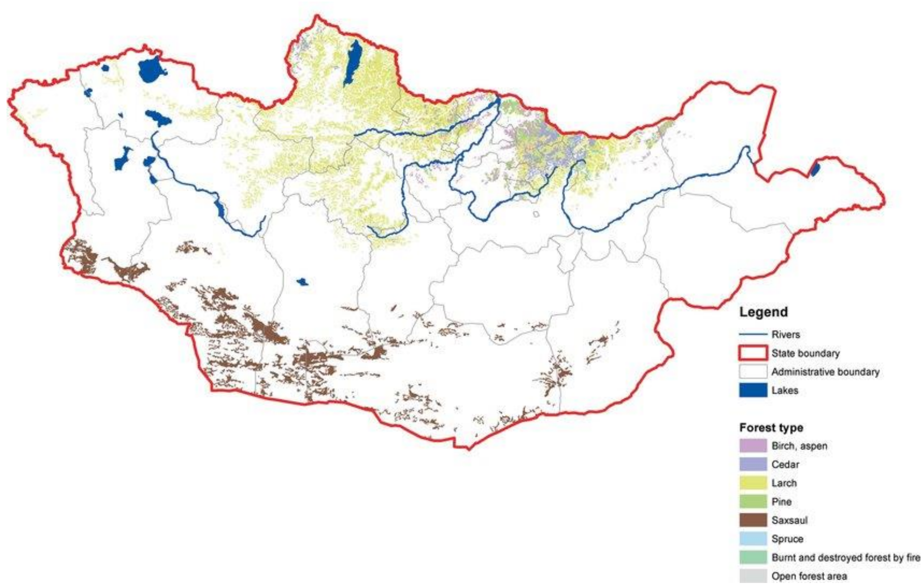


Figure 1.10 Forest map of Mongolia

In 2014, the National Forest Inventory 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 ha with growing stock volume of 1,036 million m^3 (per hectare growing volume is 114 m^3). Aboveground dry biomass is 60.3 tons/ha and its carbon pool is 30.7 tons C/ha, while belowground biomasses is 18.3 tons/ha and its carbon pool is 9.3 tons C/ha. The stock volume of dead standing trees is 18.7, with biomass of 6.2 tons/ha and carbon pool is 3.1 tons C/ha. The belowground biomass of dead standing trees is 2.1 tons/ha, its carbon pool is 1.1 tons C/ha. The stock volume of stumps is 2.0 m^3/ha, and its biomass is 0.5 tons/ha. The related carbon pool is 0.2 tons C/ha, root biomass is 1.1 tons/ha and its carbon is 0.5 tons C/ha. The stock volume of fallen trees is 25.8 m^3/ha with biomass of 5.9 tons/ha and its carbon pools 3.0 tons C/ha (MET, 2016).

Water land and resources: Mongolia is a country with scarce water reserves. The key reasons for this is the severe continental dry climate in the remote location from the oceans and seas and highlands of the Euro- Asian super continent. The rainfall in Mongolia is low with sporadic distribution and high level of evaporation. Most of the bigger rivers have outgoing flows.Precipitation is the only source of surface water and groundwater. Therefore water resources depend mostly on rivers flowing out of the country.

Mongolia has three watersheds. The rivers belong to the inland catchments basins of the Arctic Sea, the Pacific Ocean and the Central Asia Inland Basin (Table 1.4). In the north and west mountains, the water network featured by relatively high density. The south, central and south-east parts have a few rivers and other water resources, as a rule, available in depressions with no outflow.

Table 1.4 Distribution of water resources among drainage basins

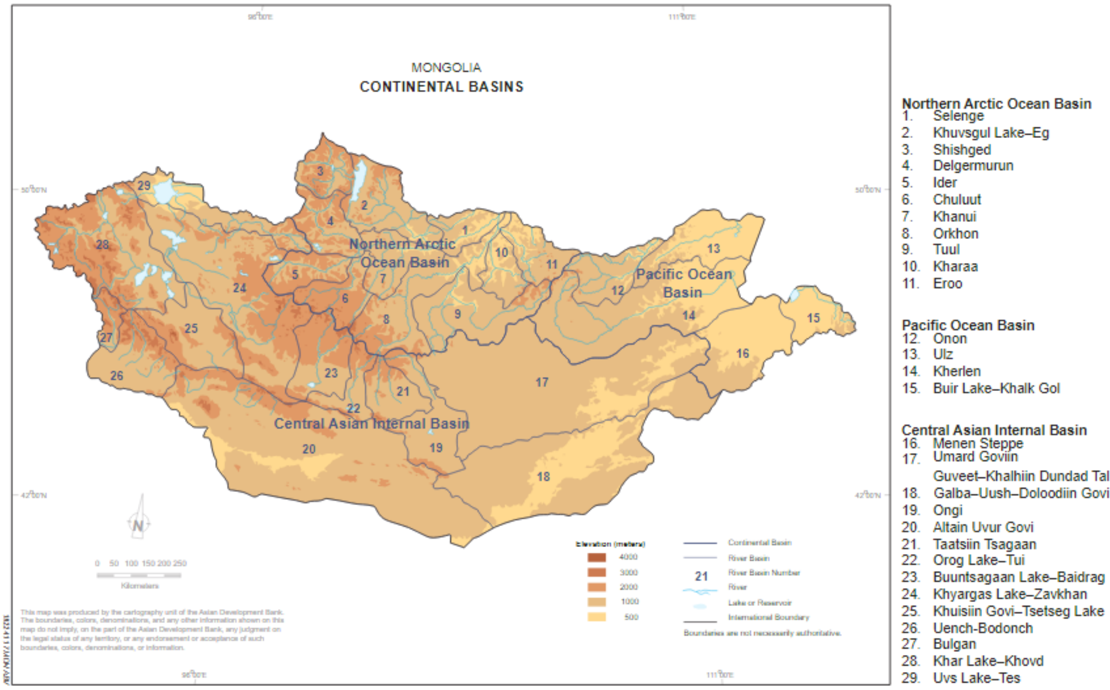
	Water resources (km^3)	National territory under the drainage basin (%)
Arctic Ocean Basin	16.9	20.5
Pacific Ocean Basin	13.9	11.5
Central Asian Internal Drainage Basin	3.8	68.0
Total	**34.6**	**100.0**

Source: UNECE, 2018

Surface water: Annual water resources are estimated at around 564.8 km^3. Around 500.0 km^3 (88.5%) accumulates in the lakes, 34.6 km^3 (3.4%) forms in river systems, 19.4 km^3 (6.1%) is in glaciers, and 10.8 km^3 (1.91%) is groundwater.

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. The surface water census covered 6,356 rivers, 584 mineral water sources, 13,222 springs, and 4,057 lakes and bonds in 2020 (NSO, 2021a). In 2019 around 1,266 surface water sources dried out and 457 recovered, while in 2020 out of 6,365 rivers and streams, 381 were dried out and 268 recovered. In that year out of 13,222 springs, 116 were dried out and 84 recovered, of 584 mineral water sources 5 were dried out and 15 recovered, and of 4,057 lakes and ponds, 180 were dried out and 107 recovered.

The rivers in the western and south-west parts of the country, flowing down from mountains, fall into the intermountain basins and cannot reach the ocean and, as a rule, end in one of the lakes.



Source: Asian Development Bank.

Figure 1.11 Map of the main drainage basins and rivers of Mongolia

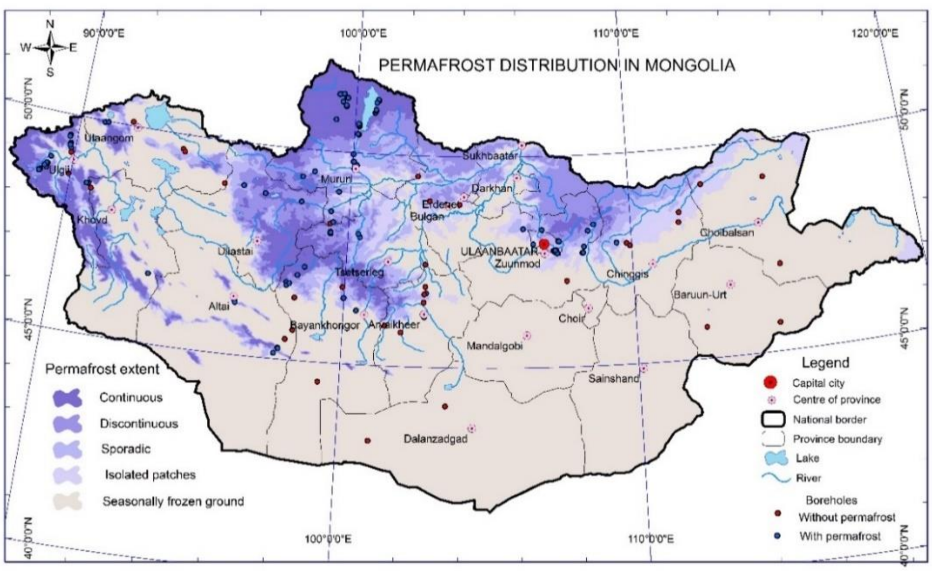
Almost all rivers at the Mongolian territory freeze for 140–180 days each year, with ice depths of 80–120 cm. In the low-lying plain areas, rivers thaw in April, but in the mountain regions, the thaw can delyed until mid-May. As a result, Mongolia is heavily reliant on groundwater, and this resource is a key factor for economic development of the country.

In general, the water availability is limited by low and variable precipitation and high evaporation rates so that little water is available on a renewable basis. About 70 per cent of water resources and flows are formed in the Mongolian Altai, Hangai, Khuvsgul and Hentii mountainous areas, which make up 30 per cent of the territory of Mongolia. The largest rivers of the country are the Kherlen (1,213 km), Orkhon (1,124 km), Selenge (1,095 km), Tuul (898 km) and Zavkhan (808 km) rivers. The Selenge River's basin area is the largest in Mongolia.

Commonly reffered source of information said that there are about 262 glaciers in Mongolia with a total surface area of 659 km^2, which are distributed in 41 mountainous systems.

The water resources of these glaciers are estimated at 19.4 km^3, while in 1999, the volume of water stored in the glaciers was estimated as 62.9 km^3. The outcome of particular study said that the total area of glaciers in Mongolia is 667.77 km^2 if estimated by topography map scale of M1:100,000 and it does not cover total available glaciers. According to the LANDSAT satellite data from 2000-2002, the total area of the ice massif distributed in 42 mountains is 451.0 km^2. Past record said that the total glacial area of Mongolia in the 1940s was about 535.0 km^2. In this case, the error of the glacier field estimated using map of scale M1:100,000 is probably about 20%. From all this, it can be concluded that the area of glaciers and glaciers in Mongolia was about 535 km^2 in 1940, about 470 km^2 in 1990, 451 km^2 in 2000, and 389 km^2 in 2011. The area of glaciers decreased by 12.1 percent from 1940 to 1990, by 4.0% in 1990-2000, by 13.7 percent in 2000-2011, and by 29.9% in the last 70 years. The melting of glaciers was relatively low until 1990, and has intensified since then, the highest in the last 10 years (G. Davaa et al., 2016). Glacier melting is highest in the Tsambagarav Mountains, which are dominated by flat-topped glaciers, relatively high in the Tavanbogd, Kharkhiraa, and Turgen mountains, which have valley glaciers, hanging, lateral, and pointed glaciers, and relatively low in the Munkhkhairkhan Mountains.

Permafrost is found across the country's north, over much the same area as the forests. As temperatures climb, Mongolia's permafrost is shrinking, accordanly. Before 1970th, 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, produced in 1971, the permafrost is found in approximately 63% of the land surface in a continuous and discontinuous form (Gravis et al., 1974). In the 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) the permafrost was classified into continuous, discontinuous, rare patchy, occasional and seasonal categories. In Mongolia, as shown on the new map of permafrost (Figure 1.12), the permafrost occupies about 29.3% of the country's area from isolated to a continuous distribution.



Note: Points represents borehole observation for permafrost *Source: Jambaljav Ya et al., 2016*

Figure 1.12 Permafrost distribution in Mongolia, 2016

As regards renewable and exploitable groundwater resources, Mongolia has total potential exploitable groundwater resources of 10 km^3/year or 42.34% of the total annual renewable groundwater resources (23.644 km^3) (UNECE, 2018).

About 95% of the water used in the country is supplied from groundwater resources, which amount to only 1.91% of the total volume of Mongolia's water resources (UNECE, 2018).

Agriculture is the biggest user of water (40%), followed by industry (25%), livestock (19%) sectors and around 16% of water is used by householders. Most of the water withdrawn by the industry and householders will be returned to the nature as wastewater and potentially it is available for reuse after adequate treatment. In contrast, most of the water used in agriculture, particularly in irrigation, is lost by evapotranspiration of plants (ADB, 2020a).

In 2019 and 2020 around 578.2 million m^3/year and 591.0 million m^3/year of water was extracted and used nationwide. In 2020 the agriculture sector had the largest share in the distributed water (59.7%). This was followed by the mining and quarrying (16.1%), drinking water and household use (14.1%), energy (6.9%), and industrial and household services (22.3%) (MET, 2021).

The other source of information said that in 2020 around 665.6 million m^3 of water used nationwide from which 487.6 million m^3 utilized for production, 153.6 million m^3 for drinking water and household use, and 24.4 million m^3 for services, respectively (NSO, 2021a).

Total water use of Mongolia in 2021 was 594.8 million m^3 of which livestock -194.4 million m^3 (33%), irrigated agriculture 144.8 million m^3 (24%), mining 113.4 million m^3 (19%), drinking 84.5 million m^3 (14%), power industry 41.5 million m^3 (7%), and factory 16.2 million m^3 (3%). Over 70% of the total water consumption, or 416.0 million m^3/year, was supplied by groundwater (Myagmar Sh, 2022).

Desertification and land degradation: Soil erosion, desertification and other forms of land degradation are considered as high priority issues, in view of the strong dependence of Mongolia's economy and food supply on agriculture, and the reliance of other sectors, including mining, on land resources. The degraded area is growing year to year. The development of strip mines and the deposition of overburden, spills and tailings all degrade land resources. The waste from all purpose of construction, like industry and household and other forms of waste are currently deposited on the soil surface including designated dumping sites on the outskirts of cities and towns.

According to the report by the Agency for Land Administration and Management, Geodesy and Cartography, a total of 4.8 million ha area were damaged nationwide in 2022. Some 4.7 million ha of Pasture and other wood land and 81.5 thousand ha of cultivated area were damaged. Also, 10.5 thousand ha of settlement land, 56.8 thousand ha of forested area, and 0.2 thousand ha of water reservoirs were affected by some degree of degradation. Some of 14.3 thousand ha from these areas were affected heavily or damaged by digging and other form of use (Table 1.5).

Table 1.5 Land degradation, thousand ha

	2005	2010	2015	2020	2021	2022
Cultivated area	326.0	184.5	120.3	86.6	112.5	81.5
Pasture and other wood land	10,586.3	6,775.3	9,099.9	5,255.6	5,907.10	4,681.50
Land of cities, villages and other settlements	26.7	8.5	10.0	44.2	44.5	10.5
Land with forest resources	347.8	375.7	339.2	136.6	229.1	56.8
Land with water resources	2.7	0.9	0.2	0.2	1.4	0.2
Damaged by digging and other form of use	193.1	19.4	5.9	36.1	12.7	14.3
Total land degradation	11,482.6	7,364.5	9,575.4	5,559.2	6,307.40	4,844.80

Source: Agency for Land Administration and Management, Geodesy and Cartography

The overgrazing in Mongolia stems from soaring global cashmere prices amid a lack of land-use regulations or pasture management standards. Since 1990, the number of domestic animals has tripled to 70 million, vastly exceeding the carrying capacity of the land.

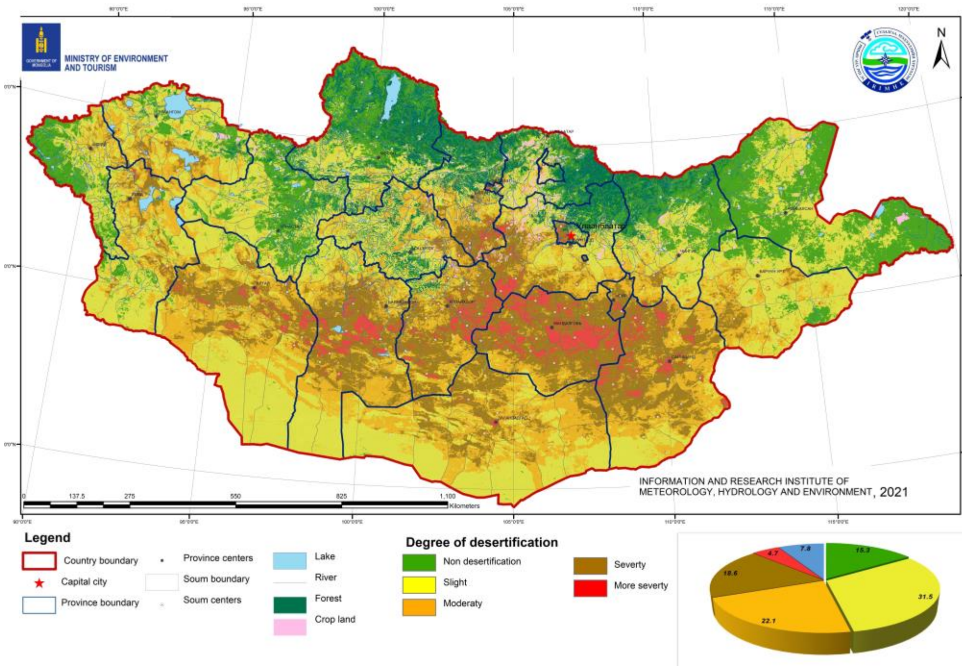


Figure 1.13 Desertification and land degradation in Mongolia, 2020

The depiction of desertification on the map of Mongolia shows that 76.9% percent (120.3 million ha) of the country's total territory has been affected by desertification to a certain degree (Figure 1.13). More specifically, 31.5% of the territory of Mongolia has been assessed to be affected by 'weak' level of desertification, while 22.1% as 'medium', 18.6% as 'strong', and 4.7% as 'very strong' levels (NAMEM, 2021).

Table 1.6 Classification of desertification

Classification	*2006*	*2010*	*2015*	*2020*
Slightly degraded	23	35.3	24.1	31.5
Moderately degraded	26	25.9	29.8	22.1
Heavily degraded	18	6.7	16.8	18.6
Severely degraded	5	9.9	6.1	4.7
Share of total area%	72	77.8	76.8	76.9

Source: www.eic.mn

Protected Area: Mongolia's Protected Area (PA) network and ecologically important areas are included most sensitive, in term nature conservation and environmental protection, areas. Since the beginning of the 1990s, Mongolia has developed a complex system of PAs, designated at different administrative levels. The number of PAs has increased since the Parliament adopted the National Programme on Protected Areas (1998) that set the goal of establishing a PA network covering 30% of the national territory. The protected area was 21.7 million ha (or 13.8%) in 2000, and 27.2 million ha (17.4%) in 2014 of the total territory (GoM, 2015).

As of 2020, there are a total of 120 specially protected areas (31 million ha), including 21 strictly protected areas (13.8 million ha), 37 national parks (13.5 million ha), 48 nature reserves (3.6 million ha and the Government decision to confirm an additional 1.68 million hectares is awaited), and 14 monuments (0.098 million ha and the government decision to confirm an additional 0.002 million hectares is awaited) contributing to the preservation of the nature, and ensuring the balance of the ecosystem. In addition, as of 2023, there are 1,401 locally protected areas covering 24.5 million ha and 15.7% of the total territory of Mongolia (https://eic.mn/spalocal/index_en.php).

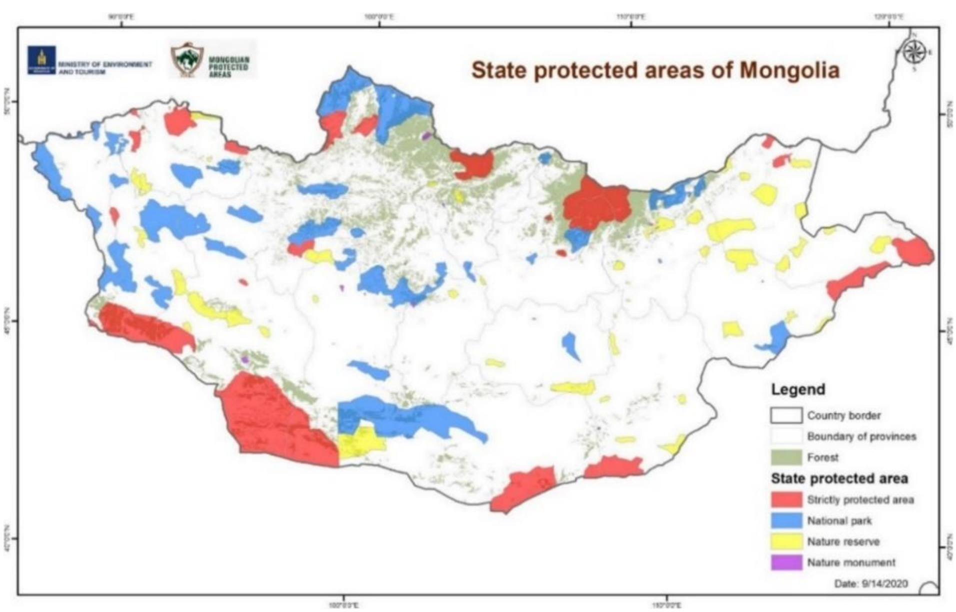


Figure 1.14 State protected areas of Mongolia

Ecosystem and biological resource: Mongolia is of global significance because of its location at the convergence of the Siberian taiga and the Central Asian steppe and deserts that form a rich diversity due to the transitional ecosystems that occur nowhere else and unique assemblage of species. Therefore, it hosts a range of globally important biodiversity, including parts of two WWF Global 35 priority eco-regions (the Amur-Heilong in Eastern Mongolia and the Altai-Sayan in Western Mongolia), as well as 2 UNESCO natural World Heritage Sites, 11 Ramsar sites, 70 Important Bird Areas (IBA) and habitat of globally endangered mammals like wild horse/Takhi (*Equus ferus przewalskii),* Wild Bactrian camel (*Camelus ferus*), Asiatic wild ass (*Equus hemionus*), Gobi bear/Mazaalai (*Ursus arctos gobiensis*), Saiga antelope (*Saiga tatarica mongolica*) and others (ESMF, 2021).

Biodiversity was an integral feature of Mongolia's intact ecosystems until the middle of the 20th century. Pasture-based livestock husbandry was a subsistence economic activity functioning in a semi-natural ecosystem integrated with the seasonal climate regime and distinct landscape patterns. In fact, it was a reference point or basic line for biodiversity, which could be sustained across this geographic domain in accordance with the associated climate variability (Batjargal and Shiirevdamba, 2016).

Nowadays, there are 18,300 species of vertebrates, invertebrates, and plants registered in Mongolia as biodiversity. At present, 3191 taxa (including 134 subspecies and 34 varieties) of vascular plants, representing over 684 genera from 108 families, 39 orders, 12 classes, includes 5 divisions, and 3 superclades (Ferns, Gymnospermae and Angiospermae) are registered in Mongolia. Therefore, currently a total of 125 species (3.91%) are "endemic", and 532 species (16.65%) are "sub-endemic" to the vascular flora of Mongolia, respectively (Urgamal, 2019) and 195 species were introduced in Mongolian Red Book as critically endangered and near threatened. Moreover, 1574 species of algae, 1030 species of lichen and 470 species of mushroom have been registered. Mongolia's fauna consists of 138 species of mammal, 75 species of fish, 22 species of reptile, 6 species of amphibian, 476 species of bird, over 13 thousand species of insect and 516 species of mollusc. Total of 110 species of fauna and 192 species of flora were deemed to be endangered and introduced in Mongolian Red Book as either critically endangered or endangered (GoM, 2015). 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 in according the list by the Government resolution under No. 07 from 2012. Due to threats to the habitats, about 11% of mammals near threatened, 3% are vulnerable or extinct risk in the wild, and 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 (TNC, 2018).

Renewable energy sources: Mongolia has a plenty of renewable energy sources, particularly, wind and solar energy. According to the "Renewables Readiness Assessment" undertaken by the International Renewable Energy Agency (IRENA, 2016), Mongolia's mostly untapped renewable resources could be used to kick-start a major cross border power corridor between Russia, Mongolia, China, South Korea and Japan. Mongolia's Gobi Desert has a vast renewable energy potential of 2.6 TW. The report said that Mongolia has potential to become one of the major wind power producers. 10% of the total land area can be classified as excellent for utility scale applications. Having the power density 40 – 600 W/m^2, the resource could potentially supply over 1100 GW of installed capacity of electrosity production. Wind power classification of Good-to-Excellent wind power resources are equivalent to 1,113,300 MW of wind generated electricity.

About 270-300 sunny days per year with an average sunlight duration of 2,250-3,300 hours are available in most regions of Mongolia. Annual average amount of solar energy is 1,400 kWh/ m^2 with solar intensity of 4.3-4.7 kWh/m^2 per day.

There are 3,800 small and big streams and rivers in Mongolia, which could support up to 6,417.7 MW of power and deliver 56.2 billion kWh of electric energy annually. Theoretical potential 6.2 GW has been identified.

Mongolia's power generation capacity from renewables is currently made up of just 7% and the government set a target of 20% renewables by 2023 and 30% by 2030. Recently have been endorced by the Parliament and the Governement a series of policy documents in which reflected broad measures aimed at future sustainability, particularly on energy sector, namely the Green Development Policy, Longterm Development Vision-2050 and as well some specific issue regulatory frameworks like the Law on Energy Conservation and Efficiency. The new laws are enabling Mongolia to have a certain guarantee in respect of energy security and reliability.

Disaster: Mongolia is among the countries most vulnerable to global warming in the world. Climate change is contributing to occurance of more extreme weather events and climate hazards. Mongolia is prone to many types of disasters, including droughts, dzuds, floods, snow and sand blizzards, intencive wind and water induced soil erosions, infectious diseases among humans and animals, earthquakes etc. Mongolia has experienced a 67.9% increase in weather and climate-related disasters and hazards in the last two decades, and the death toll has increased by 37.5%, reaching 248 in 2020 from 180 in 2005. In 2020 alone, fires accounted for 79.3% of all disasters while 13.6% were human-induced disasters (NEMA, 2021). More frequent and harsher dzuds are also expected, with nationwide dzuds estimated to occur every four to five years, instead of every ten, according to the IRIMHE.

In 2019, 78 dangerous weather events and 21 catastrophic events in broad areas were occurred, which killed 22 people, injured two people, killed 23,847 livestock, destroyed five roads and bridges, destroyed 233 gers, 226 fences, and damaged the roofs of 31 buildings. 27 power transmission lines fell, and 1,052 hectares of farmland were affected, causing around 15 billion MNT of direct damage to the country and society (NAMEM, 2021).

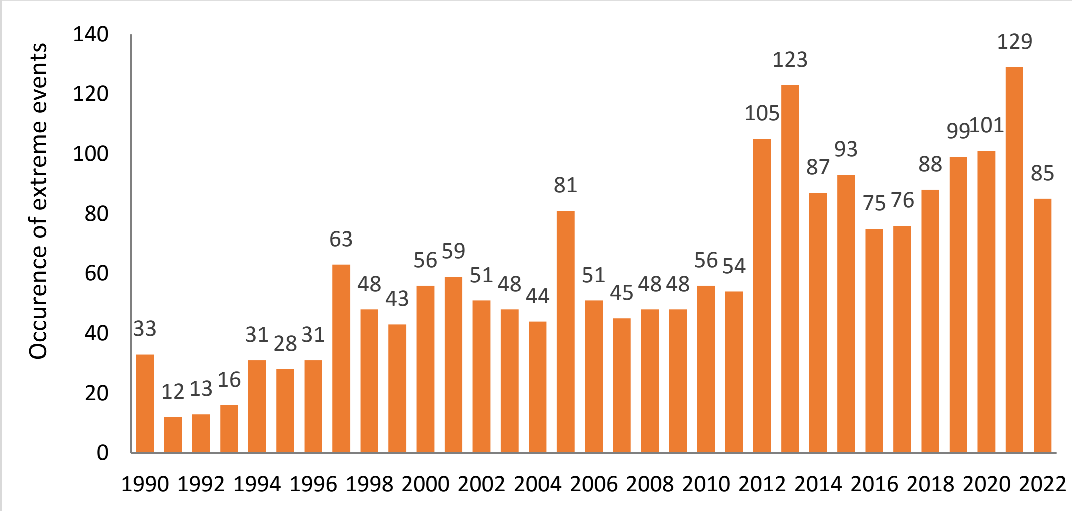


Figure 1.15 Frequency of hydrometeorological extreme and disastrous events in Mongolia

In 2020, around 90 weather disasters and 11 catastrophes nationwide were recorded, killing 15 people, injuring 14, killing 11,955 livestock, destroying 7 roads and bridges, destroying 976 gers and fences, and tearing down the roofs of 17 buildings. 7 poles fell, and 11,339 hectares of agricultural land were affected, causing 7.6 billion MNT of direct damage to the country and society.

Natural disasters, especially increased frequency of drought and dzud, are leading to the increased rate of abnormal livestock losses. In the year 1999-2002, roughly 11.2 million animals were lost due to the dzud and drought. Between 2009-2011, another 9.7 million animals killed and economic losses reaced to 527 billion MNT, affecting livelihoods of 76,900 rural residents (MOFALI, FAO).

Table 1.7 Disasters, accidents and damages caused

Disasters and damages	*Unit*	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Number of disasters and accidents	**number**	**2,547**	**2,976**	**5,422**	**3,977**	**4,053**	**4,299**	**4,484**
Forest and field fires	number	264	104	354	142	65	179	101
Burnt forests and fields	million hectares	1.1	1.0	6.5	0.3	0.2		2.5
Property fires	number	2,220	2,541	4,561	3,036	2,671	3,075	3,054
Strong dust and snow storm	number	7	32	21	51	91	56	75
Heavy rain and flooding	number	2	14	23	64	74	35	107
Deaths caused by disasters and accidents	number	76	223	198	143	319	247	320
Damages caused by disasters and accidents	billion tugrugs	87.1	534.8	79.9	31.3	25.8	33.2	52.1

Source: Statistical Yearbooks of Mongolia, www.1212.mn

In Mongolia more than 240 earthquakes of magnitude 3.5 or above have been recorded in the first half of 2021. For example, in January 2021, there were 8 times earthquakes of a magnitude of 4.6-6.5 in Khankh soum, Khuvsgul province.

In 2021, total of 4,053 disaster and accidents were occurred and totally 295 earthquakes were registered.

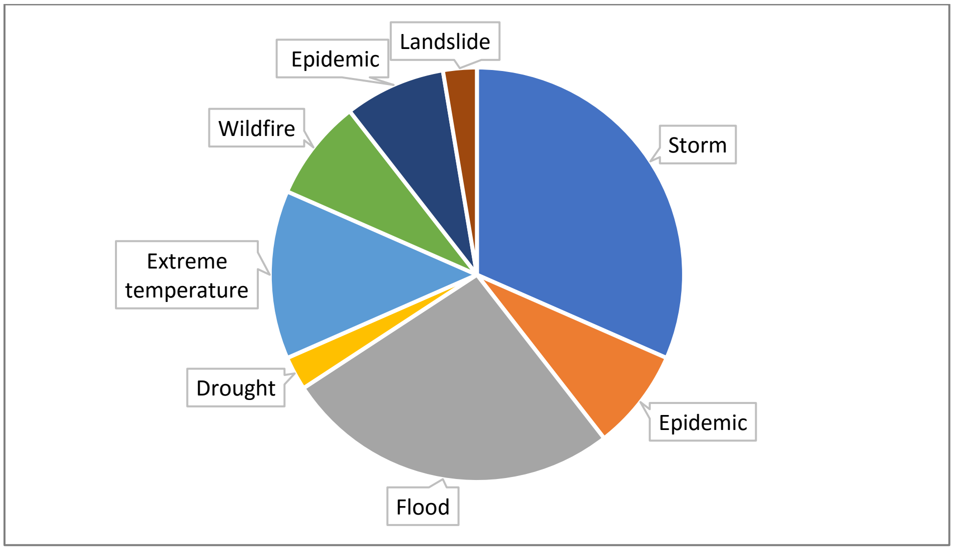


Figure 1.16 Average annual natural hazard occurrence, 1980-2020

Flood. In July 1966, Mongolia experienced one of its worst floods in history. From 10 to 11 July 1966, the Ulaanbaatar area recorded 103.5 mm of daily rainfall, which accounted for about 43% of the total annual precipitation. The floodwater velocity reached 4-5 m/sec, the flood discharge reached 1,700 m^3/c, and the water level rose to 151 cm within 24 hours, eventually reaching 311 cm at the highest level. Approximately 2,000 people lost their lives. IFRC had allocated CHF 654,800 of Emergency Appeal funding to support MRCS with the response and relief.

The heavy rainfalls in Ulaanbaatar on 4th July 2023 had broken a record of rain volume for the same period in the past 60 years. On 8th July, the Tuul River water levels reached 311 cm, the highest level since 1966. As of 10th July 2023, the water level of the Tuul River had remained at 263 cm. With more precipitation forecasted for 11 and 12 July 2023, the anticipated surge in floods resulting from the persistent heavy rainfall did not materialize. The expected peak water level on 12th July 2023 surpassing that of 1966, did not occur. Compared with the situation in 1966 when the devastating floods occurred, the population of Ulaanbaatar had increased drastically from 200,000 in 1966 to 1,673,000 in 2023, with associated rapid urbanization and population movement in the past decades (IFRC, 2023).

Flood damage: 4 person dead, about 128.1 thousand people affected. 364 buildings, more than 300 homes and apartments and 231 vehicles, seriously damaged and 74,943 citizens lost power (NEMA, 2023).

Dzud. This is perhaps the most unique hazard to Mongolia. A dzud refers to a severe winter, particularly one that follows a dry summer. The harsh conditions can make it impossible for livestock to find or access food beneath the snow cover, leading to massive die-offs of animals, which is catastrophic for the nomadic herders who rely heavily on them for livelihood.

Over the past 70 years, dzud has occurred 13 times in Mongolia, resulting in a total of 45 million head of livestock have been killed. In 2010, 22 percent of the total livestock killed and 8.6 thousand herding families lost their livestock.

The National Agency for Meteorology and Environmental Monitoring (NAMEM) of Mongolia reports that as of February 2024, a total of 80% of the country is in a “Dzud” weather disaster condition and the so called Iron / Glass dzud (snow covered by ice) hitting regions covering 58 soums, across 13 provinces. Such kind of the phenomenon arising from summer drought followed by harsh winter weather conditions usually are lead to large-scale livestock deaths.

According to the NEMA report on the 11th of April 2024, the loss of livestock reached 6.3 million. Resulting from dzud situation in this year, there were 1,521 herding households that have lost 70% of their livestock, 732 households that have lost 88% of their livestock, 326 households that have lost 90% of their livestock, and 380 households that have lost all of livestock.

On April 11th, 2024, the NEMA report showed that 6.3 million livestock were lost due to the dzud situation. This resulted in the loss of 70% of livestock for 1,521 herding households, 88% for 732 households, 90% for 326 households, and all livestock for 380 households.

Migration and dzud are closely linked, with records and statistics kept by the NSO since 1983. Between 1983 and 1987, around 2,500-3,400 citizens migrated to Ulaanbaatar. However, in 1988, this number increased by 4.8-6.6 times, exceeding 16,000. The reason for this was the severe winter of 1986 and 1987, which caused more than 800,000 livestock to die. Although it may seem like a small number, it was equal to 4% of the total livestock at that time. Since then, the movement of people from the countryside to the city has been relatively stable, varying between 10,000 and 12,000.

After consecutive years of dzud from 1999-2002, there was a surge in migration towards Ulaanbaatar. In 2003, the city gained 40,172 new citizens, and in 2004, it gained 41,592 citizens. In the winters of 1990-2000, 2000-2001, and 2001-2002, around 12-19% of the country's total livestock was lost. The same situation occurred after the dzud of 2009-2010, which resulted in the loss of 10 million livestock, ranking first in terms of the number of livestock lost, and second in terms of its percentage of the total livestock.

1.3 Socio-economic profile

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 since 1990s. Mongolia has a unique history and it is important to understand the socio-economic background of the country to identify challenges and opportunities it faces. Since early 1990’s Mongolia has made a political and economic transition from a one-party political and top down governance system to more de-centralized with bottom up elements and democratic system, and from a planned economy to a private sector-led, market economy. Although having to reach yet at planned targets and results in each area, the government implements a number of 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. As a nation with a nomadic tradition, Mongolia has been reliant on livestock and agriculture for long period of time of its history. In recent years, large mineral deposits were discovered in the southern part of the country, where in the past was less focused in term of economy development due to its extreme arid climate. Nowdays these areas become more attractive as the economic activity shifted towards mining and thus daubling a stress on the ecosystem in this area because of coupled affect of climate change and human activities.

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 (like provinces) 329 soums (like districts) and 1,560 bags (like counties). As for the capital city of Ulaanbaatar, consists of 9 districts and 132 khoroos (similar to counties).

State structure: Since the re-establishment of the Mongolian National State in 1911, the government of Mongola commenced adopting and enforcing laws and regulations aimed at stabilizing its internal situation and strengthening the social structure of the country. Between 1921 and 1924, the reign of the Constitutional Monarchy ended and a new era of the establishment of the Republic commenced for the first time in Mongolia. Article 1 of the Constitution, adopted by the First State Great Hural on November 24, 1924, states that declaring the name of the nation to be the Mongolian People's Republic, the supreme power of the state shall be vested in the people and any affairs of the state shall be addressed by the State Great Hural and the Government, elected by that Parliament, and shall be universally followed. This means that the State Great Hural (Parliament) shall be the highest organ of state power.

In September 1944, the Presidium of the State Baga Hural granted the right to those who had previously been disenfranchised and amended some articles of the Constitution. As a result, all citizens of the People's Republic of Mongolia had equal rights to vote and to be elected.

The 9th State Great Hural, assembled in 1949, amended the Constitution to dissolve the State Baga Hural and designate the State Great Hural as the governing legislature. In 1951, an election of the State Great Hural was held using a new electoral system (equal, direct, universal, secret) and 297 people were elected as deputies of the Hural.

The Constitution, adopted by the first session of the 4th Great Hural of the People's Republic of Mongolia on July 6, 1960, declared that the political basis of the People's Republic of Mongolia shall be the Assembly of People's Deputies of all levels.

The democratic reforms of 1990, which put Mongolia on the path of development and progress, were a major step in making the transformation of the country irreversible, liberating the country from stagnation and accelerating the process of transition to a democratic society.

The new Constitution of Mongolia was adopted on January 13, 1992, and legalized the democratic form of government with a one-tier parliament and a presidential institution in Mongolia.

The President of Mongolia is a constitutional institution that plays a unique role in Mongolia's political system and governance relations. The Constitutional Amendment Law states that the President is the head of state and the guarantor of the independence of Mongolia. The President of Mongolia is elected by the people through a free and democratic election held every 6 years.

During the first democratic election in 1990, a vote was taken for the political parties, and the number of seats in the State Baga Hural was allocated based on the results. In the electoral practice, a proportional system was used for the first time.

In 1992, Mongolia adopted a new democratic constitution and election law. In accordance with this new legal system Mongolia has a parliamentary democracy, with an election held every 4 years to elect 76 members of the parliament. Furthermore, a local election is held every 4 years and the hurals of the citizens at the province, the capital, soum and district levels are established.

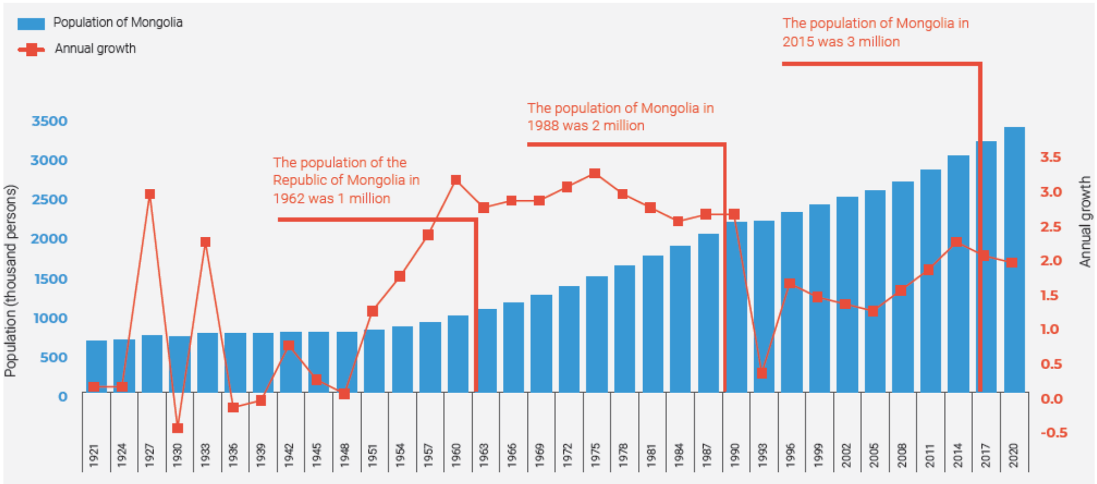
Population: As of 2023, the population of 3,504,741 people is scattered across the country, making Mongolia as one of the least densely populated regions in the world, with average density of 2 people per square kilometer. The population increased by 1.36% in 2023 compared to 3,457,548 million in 2022. Mongolia is ranked 135th in terms of population and 66th in terms of population growth rate. There are 66.8 thousand births, 19.0 thousand deaths in Mongolia in 2023 (Table 1.8).

Table 1.8 Population of Mongolia, thousand

	1990	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Population of Mongolia	2,153.5	2,403.1	2,761.0	3,057.8	3,357.5	3,409.9	3,457.5	3,504.7
Urban	1,226.5	1,361.3	1,910.7	2,096.2	2,316.5	2,367.6	2,424.8	2,479.9
Rural	926.9	1,041.8	850.2	961.6	1,041.0	1,042.3	1,032.8	1,024.8
Number of births	73.2	48.7	63.3	82.1	77.7	73.3	67.9	66.8
Number of deaths	17.6	15.5	18.3	17.6	17.0	20.9	19.3	19.0
Number of households			742.3	859.1	908.7	920.2	941.5	983.5
Life expectancy at birth		66.1	63.2	75.8	76.2	76.5	76.7	76.9

Source: Statistical Yearbooks of Mongolia, www.1212.mn

There is a strong trend toward urbanization and the country has undergone rapid economic development and industrialization in the past four decades. As of 2023, 2.48 million people are living in urban areas, which is 70.8% of Mongolian population. A high migration stream to the Ulaanbaatar city is becoming a cause of rapid growth of population in capital city, with associated challenges related to air pollution, waste management, social services, traffic congestion etc.



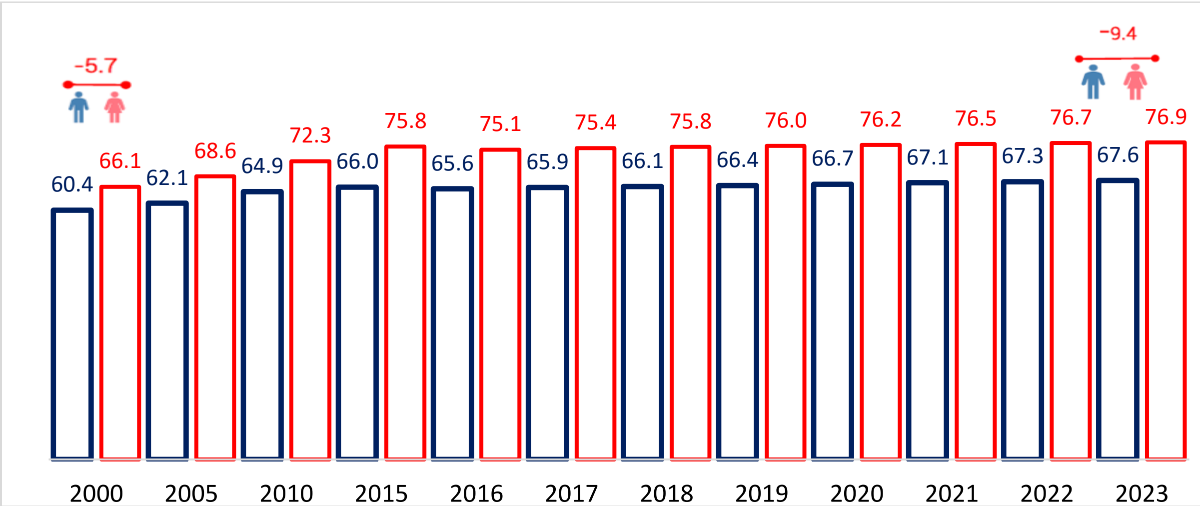
Source: NSO, 2021a

Figure 1.17 Population of Mongolia

The accelerating growth in population, therefore, has been matched by an increase in the per-capita rate of natural resource consumption. The sustainable rates of use or loss of renewable natural resources, including surface water, ground water, forest, soil and rangeland resources, have already been exceeded in some areas. The situation is likely to become more widespread if current trends continue, and measures to conserve and manage natural resources need to be strengthened and improved.

Health: The first hospital in Mongolia was open in 1925. At that time, there were 2 physicians, 5 feldshers, 3 nurses and 13 pharmacists and a total of 23 employees worked for 2 hospitals and 3 medical centers. In 1930, there were 11 health centers, 4 laboratories, 2 pharmacies and women's and children's counseling centers at the national level and 20 health centers in the provinces with 108 employees. As a result of measures taken to develop the health sector and train qualified staff, a two-year nursing course was launched in 1929, and expanded into a medical specialized secondary school in 1933. Thanks to these measures, there were 20 hospitals, 20 physician stations, 157 feldsher stations, and 169 soum nurse stations, and the number of health employees was 1515, or 20 per 10,000 populations in 1940. Until the transition to a market economy, the number of health facilities and their staff constantly grew and reached a historic high of 222 health workers per 10,000 by 1990. But as started transition this figure was down to 134 (1.7 times less than before) between 1990 and 2000 due to diminished government support. It was even less as 29 in 2010 (NDC baseline year) and gradually recovering and reached level of 179 in 2021 (NSO, 2022b).

The population increased from 2.2 million in 1990 to 3.5 million in 2023, while the average life expectancy of people in Mongolia has increased by 7-10 years in the last 24 years, which is one of the few positive phenomena in society, observed during the challenging period of transition. An average life expectancy of the country in 2023 is 71.5 year. An average life expectancy according to gender diversity, for women is 76.9 year and for men is 67.6 year (Figure 1.18).



Source: NSO, 1212.mn

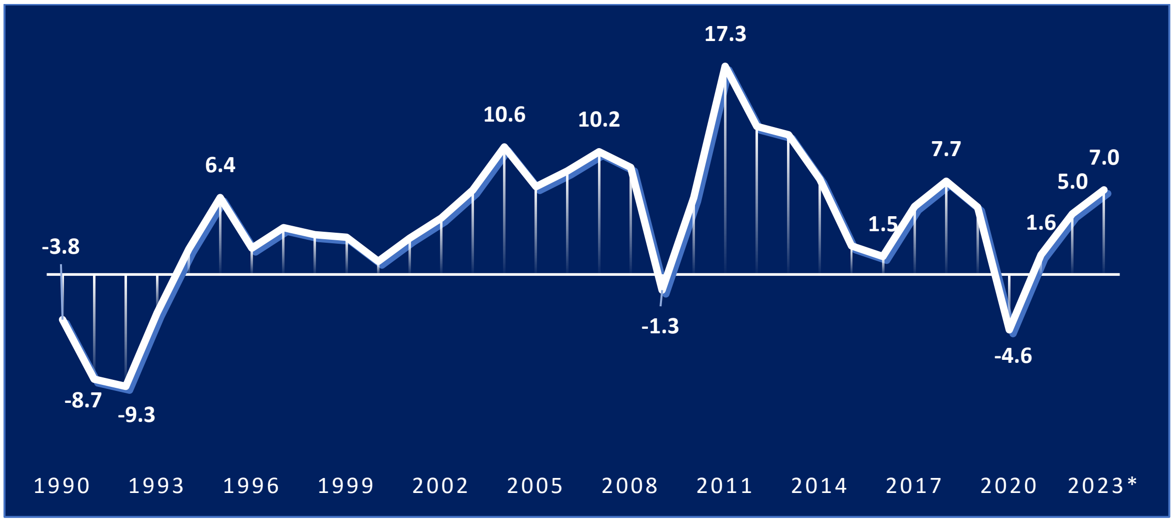
Figure 1.18 Life expectancy at birth, by sex, 2000-2023

Some study shows that Mongolians are dying from chronic conditions more frequently than they are from communicable diseases. A major concern for Mongolia's health care professionals is the sustained – and growing proportion of Mongolians who are dying in road accidents, from self-harm, and from chronic alcohol use, which is more relevant to change in social development rather than climate condition.

Macroeconomy: Mongolia's high economic growth, fuelled in the past by a mining boom, has been on the decline since 2013. In 2016, an economic recession ensued which led to a situation in which the government was at risk of defaulting on its public debt, amounting to billions of dollars. In 2017, the International Monetary Fund helped Mongolia avoid a possible default. In 2018-2019, the government was able to reverse the economic decline thanks to prudent fiscal management and increased revenues from mineral exports, maintaining a 5% annual growth in GDP. The poverty rate in Mongolia declined from 38.7% in 2010 to 21.6% in 2014 but rose to 29.6% in 2016. The rate declined somewhat to 28.4% in 2018. However, 15% of the population lives just above the poverty line and is therefore extremely vulnerable to falling into poverty (BTI, 2022).

Mongolia's economy is primarily based on mining, quarrying, and agriculture. The country is rich in natural resources, but despite government efforts, have been made very modest progress in respect of industrialization and diversification of economy. Over 80 percent of Mongolian exports are mineral products, such as copper ores and concentrates (31.0%), bituminous coal (29.9%), unwrought or semi-manufactured gold (10.9%), iron ores and concentrates (10.3%), crude oil (3%), and others (NSO, 2022b). The second largest export from Mongolia is cashmere, representing around 3% of the total exports.

Mongolia's economy grew by 5.6% in 2019, and due to the pandemic the GDP growth was minus 4.6% in 2020 and little progress as the plus 1.6% in 2021 (Figure 1.19).

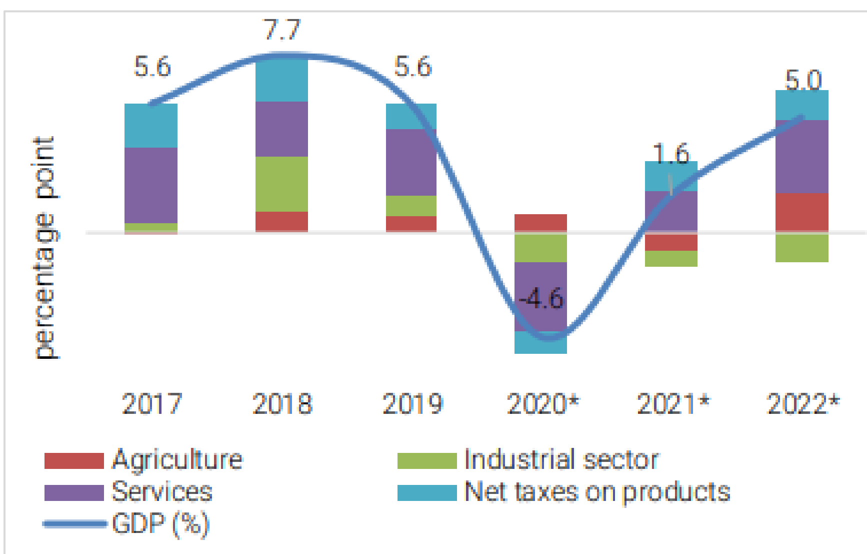


Source: NSO, 1212.mn

Figure 1.19 Changes in economic growth, percent

The average annual growth of GDP per capita for 2016-2021 was 1.1%, while the average annual growth of GDP per person employed was 3.1%.

In 2022, the economic growth of Mongolia reached 5.0% (at 2015 constant prices), which of 3.2 percentage points was from Services, 1.7 percentage points was from Agriculture sector, 0.8 percentage points was from Industrial sector, 1.4 percentage points was from Net taxes on products, and -2.1 percentage points was from Mining and quarrying sector (Figure 1.20).



**- Estimation based on annual survey of entities* *Source: NSO, 2023b*

Figure 1.20 Annual changes of GDP, by percent

In 2023, GDP at 2015 constant prices was MNT 30.5 trillion, which is increased by MNT 2.0 trillion (7.0%) compared to the previous year (NSO, 2024). The GDP growth of nearly 7.0% in 2023, from 5% in 2022, driven mainly by a surge in mining activity. To this 7.0% increase in GDP at 2015 constant prices in 2023, the agriculture sector contributed 1.3 percentage points, the mining and quarrying sector contributed 2.6 percentage points, industry and construction sectors contributed 0.6 percentage points, the service sector contributed 4.3 percentage points and net taxes on products contributed 0.9 percentage points, which indicated a certain progress in sense of recovery. Post COVID-19 pandemic and the war in Ukraine, Mongolian economy fared relatively well in 2022 and 2023.

GDP per capita at current prices reached 5.9 thousand US Dollars in 2023, an increase 15.7% from the previous year(Table 1.9).

Table 1.9 Some social and economic indicators of Mongolia

Indicators	*1990*	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Population, million	2.2	2.4	2.7	3.0	3.4	3.4	3.4	3.5
GDP per capita, thousand USD	1.6	0.5	2.7	3.9	4.1	4.7	5.1	5.9
GDP, at current price, billion US dollars	3.3	1.1	7.2	11.6	13.3	15.3	17.1	19.9
Agriculture, forestry and fishing, value added (% of GDP)	*12.5*	*27.4*	*11.7*	*14.1*	*13.0*	*13.2*	*13.0*	*10.2*
Mining and quarrying, value added (% of GDP)	*12.5*	*10.8*	*21.5*	*18.1*	*23.3*	*24.7*	*23.0*	*28.2*
Manufacturing, value added (% of GDP)	*20.4*	*6.7*	*6.8*	*7.0*	*7.8*	*7.1*	*7.1*	*6.9*
Electricity, gas, steam, air conditioning supply, value added (% of GDP)	*2.2*	*2.1*	*1.9*	*1.9*	*1.8*	*1.6*	*1.4*	*1.4*
Water supply; sewerage, remediation activities, value added (% of GDP)	*0.4*	*0.4*	*0.3*	*0.5*	*0.6*	*0.5*	*0.4*	*0.4*
Construction, value added (% of GDP)	*5.7*	*2.2*	*2.6*	*4.0*	*3.7*	*3.1*	*3.3*	*3.0*
Services, value added (% of GDP)	*43.3*	*39.2*	*44.8*	*46.2*	*40.5*	*39.6*	*41.0*	*40.1*
Net taxes on products, value added (% of GDP)	*3.0*	*11.2*	*10.2*	*8.2*	*9.5*	*10.1*	*10.7*	*9.7*

Source: Statistical Yearbooks of Mongolia, www.1212.mn

In 2023 the mining and quarrying sector's share in GDP was 28.2%; agriculture, forestry and fishing 10.2%; manufacturing 6.9 %, constraction 3.0%, electricity and water supply 1.8%, and service sector's share was 49.8% (Table 1.9).

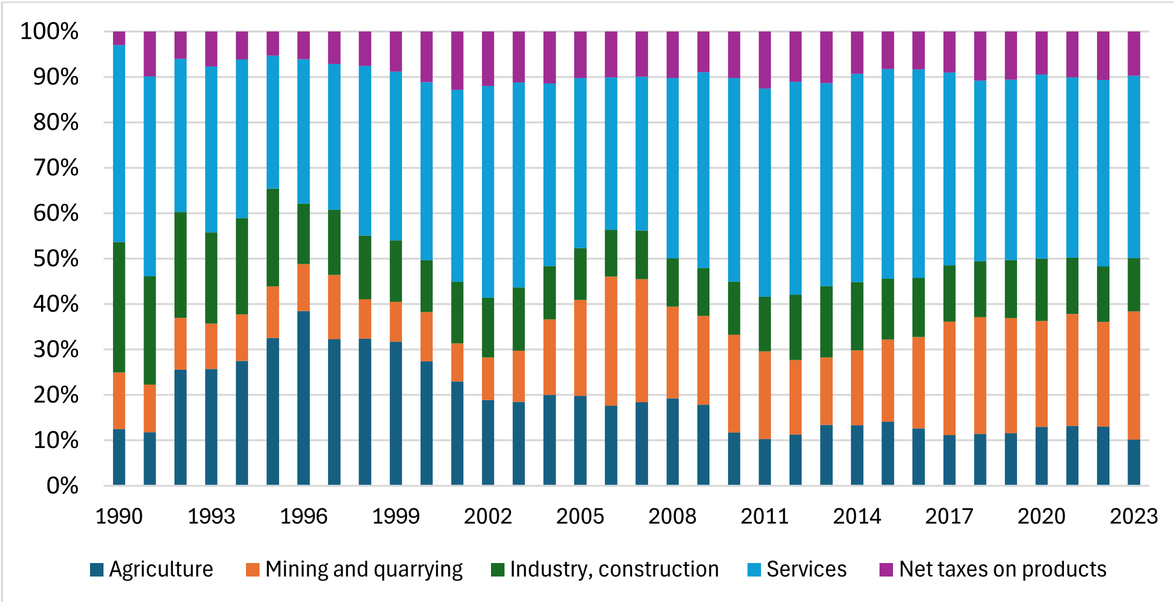


Figure 1.21 Industrial composition of GDP by industrial classification of economic activities, percent

Industry: Mongolia's industry sector is divided into the mining, quarrying, and manufacturing sub-sectors. The industry sector's share in GDP was 35.1%, which is mining and quarring accounted for 28.2% and manufacturing for 6.9% in 2023.

In terms of the total production structure of the industrial sector, the mining industry dominates. Mining and quarrying accounted for 16.1% of the total industrial production in 1990, and increased to 57.7% in 2022. However, the share of manufacturing industry in industrial sector decreased from 71.8% in 1990 more than halved and is now down to 31.4% in 2022, it is mostly due to not adequate way of transition to market economy, specifically, issues related to privatization of state owned enterprises (Table 1.10).

Total industrial output at current prices reached MNT 43.7 trillion in 2022, an increase of MNT 8.6 trillion (24.4%) compared to the previous year, mainly due to increase of the mining and quarrying production output by MNT 5.3 trillion (26.6%), and the manufacturing production output by MNT 2.8 trillion (25.6%).

Table 1.10 The total production structure of the industrial sector,%

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2021*	*2022*
Mining and quarrying	16.1	51.4	51.7	63.3	63.6	55.5	55.7	56.7	57.7
Manufacturing industry	71.8	34.4	32.4	21.0	25.0	34.1	32.4	31.4	31.7
Other	12.1	14.2	15.9	15.7	11.4	10.4	11.9	11.9	10.6
Total	100	100	100	100	100	100	100	100	100

Source: Statistical Yearbooks of Mongolia, www.1212.mn

Mining and quarrying sub-sector: As mentioned above the mining and quarring accounted for 25.4% of the country's GDP which is 56.7% of the industrial sector. This sub-sector has the following five divisions according to the International Standard Industrial Classification: (i) mining of coal and lignite, (ii) extraction of crude petroleum, (iii) mining of metal ores, (iv) other mining and quarrying, and (v) mining support service activities. Mining and quarrying have rapidly developed in recent years to become one of the leading sectors in the economy of Mongolia. This is largely due to the start of mining activities at the largest mineral deposits of a strategic significance, such as Oyu tolgoi and Tavan tolgoi.

Mongolia has continued its reliance on mining-led growth. Mineral exports account for 80% of total exports. 90% of exports are to China. Mongolia’s coal exports hit an all-time high in 2018, reaching a total of 36.5 million tons. The share of the minerals sector in fiscal revenue increased from 13% in 2016 to 22% in 2017 and 26% in 2019. Mining generated 25% of GDP in 2020, compared to 10% in 2000 (BTI, 2022).

Mongolia’s mining and quarrying sub-sector’s share in total exports is about 92.0% (Forein trade, 2021).

Mongolia is among the top 10 countries in the world with coal reserves. There are currently over 300 deposits from 15 basins, and Mongolia's coal reserves are estimated at 173.3 billion tons and may increase further. Currently, in mining sector operate 7 state and locally owned entities in 8 mining sites, 28 domestic and joint ventures and organisations in 33 mining sites and 7 foreign investment companies in 8 mining sites (EITI, 2020).

Before the pandemic, Mongolia used to export over 30 million tons of coal annually, which was declined significantly. But despite the decline in the volume of mineral exports, the income from export in 2021 was equal to those of previous years as a result of high commodity prices in the world market and response to the pandemic. For instance, the country exported around 36 million tons or the same amount of coal in 2018 and 2019 but has earned USD 2,803 million in 2018 and USD 3,079 million in 2019. In 2021 coal export was declined by 55 per cent in comparison of 2018-2019 period but amount of earned money was only 4 per cent less than that period (MMHI, 2022). The same situation was in relation with the copper concentrate export.

Table 1.11 Main products of mining and quarrying

Mining and quarrying	*1990*	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*
Coal, mln.t	7.2	5.2	25.2	24.2	43.8	33.7	37.3
Crude oil, thous.barrel	-	65.5	2,181.4	8,769.3	4,105.9	4,667.1	2,565.40
Copper, with concentrate, thous.t	-	-	522.0	1,334.7	1,276.7	1,326.3	1,189.80
Molybdenum, with concentrate, t	-	-	4,448.0	5,207.0	6,147.7	6,326.1	5,914.20
Gold, kg	-	11,808.1	5,998.6	14,532.8	20,225.5	19,054.4	19,382.70
Fluor spar thous.t	455.9	733.5	727.0	183.5	127.3	118.3	122.9
Fluor spar, with concentrate thous.t	121.9	210.0	140.7	47.3	85.0	60.3	24.5
Iron ore, with concentrate thous.t	-	-	3,076.6	4,273.6	9,224.4	9,171.9	7,659.90
Zincum, with concentrate thous.t	-	-	112.6	89.6	76.3	75.2	400.13

Source: Statistical Yearbooks of Mongolia, www.1212.mn

The production of some major industrial products are listed in Table 1.11 which shows that coal production has increased from 7.2 million tons in 1990 to 37.3 million tons in 2022, which was increased 5 times. The coal production since 2020 to 2023 was increased 2 times.

In 2023, 81.2 million tons of coal were extracted, of which 69.6 million tons were exported; 14.9 tons of gold were extracted, of which 11.7 tons were exported. The amount of exported products in the mining sector is: 69.7 million tons or 88.9% of coal, 5.6 million tons or 7.2% of iron ore, 1.3 million tons or 1.7% of copper concentrate, 524.6 thousand tons or 0.7% of earthen oil, zinc concentrate accounted for 144.8 thousand tons or 0.2% in 2023.

Manufacturing sub-sector: At present the industrial processes and activities during the cement production and metal industry considered as a main contributors of GHG emissions of IPPU sector.

Cement production: Until 2013 two main cement plants were operating in Mongolia, namely Darkhan cement plant which was built in 1968 and “Cement and Lime” cement plant was built in 1982 in Khutul. These two plants used a wet-processing technology for cement production until 2014. From 2014 they shifted the technology from wet to dry-processing. Khutul cement plant capacity increased to one million tons of cement per year with the new processing technology.

In 1990, 440.8 thousand tons of cement were produced, and in 2022 production tripled to 1,373.5 thousand tons. Even though, Mongolia does not fully meet its cement demand and therefore cement production expected to increase further.

Metal industry: Modern steel production with electric arc furnaces (EAFs) has relatively long history in Darkhan city by Darkhan Metallurgical Plant starting from 1994. In October 2009, Khukh Gan joint-stock company (JSC) in Erdenet city established a direct reduced iron (DRI) production facility with annual production capacity of 30.0 thousand tons.

Table 1.12 The production of some major industrial products

Manufacturing	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2021*	*2022*
Copper, 99% t	-	-	0.6	2.5	2.7	15.0	9.5	9.7	9.70
Metal steel, thous.t	-	15.6	13.0	65.5	64.2	43.7	15.3	35.9	25.0
Metal foundries, thous.t	-	6.6	7.4	36.2	61.8	49.5	16.7	35.6	26.10
Cement, thous.t	440.8	108.8	91.7	111.9	322.5	410.1	1,182.2	1,293.3	1,373.5
Lime, thous.t	103.0	51.4	37.0	81.2	50.2	52.3	70.2	50.7	66.5
Combed down, t	240.1	420.8	450.9	581.9	824.7	754.5	516.7	511.7	938.80
Scoured wool, thous.t	9.7	1.2	1.4	0.9	2.3	1.8	1.5	2.8	2.2
Carpet thous.m^2	1,971.2	595.7	704.8	586.9	609.6	680.1	361.4	379.3	423.7
Milk, dairy products, mln. l	59.6	1.8	1.5	7.1	42.0	69.6	176.2	152.5	113.60
Meat, thous.t	57.8	11.3	6.4	4.8	11.7	12.6	25.8	26.3	21.9

Source: Statistical Yearbooks of Mongolia, www.1212.mn

Agriculture sector: The sector is one of the priority sectors for the country's economy and cultural heritage. The food and agriculture production compounds 10.2% of the national GDP, 24.9% of total Mongolian work force. In 2022 the size of land classified as a agriculture was occupying 72.6% of the national land. Animal husbandry is still the main livelihood element of local communities and source of wealth for most of people who are living in rural areas. The production of animal husbandry plays an important role in the country's economy, as well.

The share of agriculture in total GDP peaked at 36% in the mid-1990s, but output shrank in the early 2000s amid rising industry and services growth, the share was 27.4% in 2000 (ADB, 2020b). At present the agriculture's share more than halved and is now down to 13.0% in 2021, compared to 2020.

Livestock production comprises 82.5% of the total agriculture production. In particular, 21.9 thousand tons of meat, 113.6 million litre of milk, 938.8 thousand tons of combed down, 2.2 thousand tons of scoured wool were produced in 2022.

Mongolia have exported a total of 14.3 thousand tons of meat in 2022 and in 2023, meat exports reached a record high of 80.4 thousand tons. The export volume of combed cashmere reached 5,449.1 tons and earned 95.8 million US dollars and export of washed cashmere was 1,001.1 tons and earned 264.0 million US dollars in 2023.

Cashmire is considered not only as a key export items but also as a product which is triggering uncontrolled increase of goat numbers, leading to pasture overgrazing and land degradatioin.

As is widely acknowledged, one of Mongolia's advantages is its natural and agricultural resources from which enterpreneurs are able to produce high-quality products. Many of the country's export products can be regarded as of being exclusive natural and organic. These include organic meat, milk and other organic food and beverages, such as raw honey, berry juices and nature based items. In addition cashmere and wool, as wel as herbal and natural skincare products also can be considered as a less altered ones from original or natural features (ADB, 2020b).

Mongolia is able to supply 16 main food raw materials and products, such as meat, wheat, flour, and potatoes, domestically. Dairy products are 27.1%, bakery products 38.2%, vegetables 38.5%, eggs 48.6%, butter 67.4%, chicken meat 98%, and vegetable oil 98.5%. All kind of of legumes, rice, sugar, fish and fish products, and 95 percent of the main raw materials for food packaging are importing. Total of 2.7 trillion MNT worth of food was imported and an average of 2.5 trillion MNT is spending per year for food import.

The above-mentioned 16 types of food raw materials are grown on 557 thousand ha of unirrigated land and 30 thousand ha of irrigated land.

Table 1.13 Output of main agricultural products, thousand tonne

Commodities	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2021*	*2022*
Meat, by slaughter	248.9	211.7	310.6	193.1	241.1	448.0	744.5	512.7	654.0
Hide and skin, mln.pcs	8.5	7.5	11.4	6.9	9.5	15.2	27.1	18.0	19.9
Sheep wool	21.1	19.6	21.7	14.2	17.2	25.8	35.6	33.2	34.7
Cashmere	1.5	2.1	3.3	3.7	6.5	8.9	11.8	10.1	9.7
Milk	315.7	369.6	375.6	335.1	365.8	874.4	1,082.4	789.5	990.4

Source: Statistical Yearbooks of Mongolia, www.1212.mn

The livestock industry in Mongolia accounts for about 90 percent of agricultural production and employs around 25 per cent of population, which is more than any other sector. But the industry is facing major challenges. Hotter, drier summers and massive overgrazing have resulted in sharply rising land degradation. The damaged land then undermines the foragy supply for the livestock and leaves animals ill-prepared to survive increasingly frequent extreme cold spells.

While it is difficult to reverse the effects of climate change, particularly in the short run, policies to prevent overgrazing are feasible and could have a positive and lasting impact on the sector. This is important because a stronger and more sustainable livestock sector would help Mongolia diversify away from mining and achieve more inclusive economic growth.

The overgrazing in Mongolia stems from soaring global cashmere prices amid a lack of land-use regulations or pasture management standards, as mentioned above. Since 1990, the number of animals has tripled to 70 million, vastly exceeding the carrying capacity of the land. IMF analysis finds that the percentage of livestock deaths following cold spells is greatest in the provinces that had the largest increase in their livestock population. In total, these losses of wealth can reach 12 percent of GDP during extreme winters, like it was happened during the dzud event occurred for the period of 1999-2001 and 2009-2010.

This rise in challenges facing herders and their families has triggered massive migration to the capital city, Ulaanbaatar. Today, more than 20 per cent of residents lives in the so-called “ger district”, in the outskirts of the capital. Actually most of them are former herders, who lost their livestock as a income source due to natural disaters and moved to Ulaanbaatar for job. This has placed large strains on the city’s infrastructure and contributed to a sharp increase in air pollution, traffic congection and other challenges.

Another implication of land degradation and desertification is the increased dust or aerosols in the atmosphere and attributed dust storms, which have resulted in rising health and economic costs. The dust storms plague not only Mongolia, but also neighboring countries across East Asia, covering the territories of China, both North and South Korea and Japan, reaching sometime west coast of America. It is necessary to note that in some official statements and publications a dust originated from the

Mongolian territory called as “yellow dust” which is misleading terminology and colored dust is associated with the specific geographical region like Yellow river basin in China.

Mongolia needs to address overgrazing and balance the size of its herds with nature’s capacity for pasture regrowth. Some policy documents in this regard have been developed and appoved by the Governement but implementation of them on the ground is encountering a certain obstacles, mostly due to lack of alternatives for income generation for local communities. Without solid economy based insentive it would be difficult to address this issue only in name of desertification.

Some progress has been made recently reintroducing a pasture tax, with a certain differentiation in relation with number of livestock of individual householder. Effort is making to introduce incentives to boost quality of animal products. Number of projects supported by international organizations and parther countries are organizing training for herders in this rerspect. For instance, training on techniques that improve the quality of the cashmere might improve profit margins and reduce the reliance on large herds. In addition to cashmire the meat industry is in the focus of the Governement and it aimed to provide a natural limitation on herd size and further incentivize herders to focus on quality over quantity.

Recent years sharp increase of livestock number in Mongolia was partly related to marketing issues. In fact before the transition to market economy an export of meat and other livestock products like wool, animal hides and skins have been organized well in accordance with the planned economy principles without serious obstacles except animal health requirement. Mongolia could use the positive element of cooperation with neighbour countries in the past and initiate more flexible trade policy with neighbour and current trade partner countries to promote an extension of export of livestock products that would increase Mongolian incomes and reduce land degradation thanks to balanced number of livestock.

Energy resource and energy production: The energy industry of Mongolia consists of five energy systems: Central energy system (CES), Western energy system (WES), Altai-Uliastai energy system (AUES), Eastern energy system (EES), and Southern energy system (SES), as well as other diesel plants and renewable energy sources. Currently, the central energy grid supplies 70% of Mongolian territory; CES consists of eight combined heat and power plant (CHPPs), small and medium capacity wind and solar plants, and is connected to the Russian and Chinese electricity systems. The other three grids are small scale rural systems. The overview of the power supply system of Mongolia is illustrated in Figure 1.22.

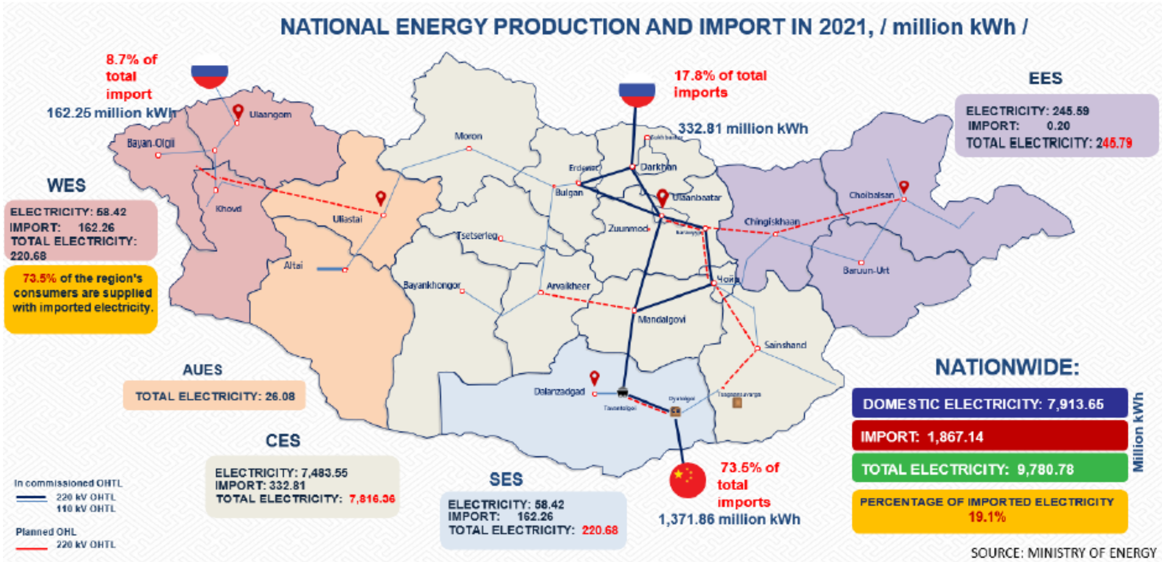


Figure 1.22 Overview of national energy production and import of Mongolia

Coal, mainly lignite, made up to 80% of primary energy supply. It is mined in the country and delivered by rail to the electricity generating and heating plants that consume 65% of the coal mined. Some 49% of total energy supplied to the heat and power plants was lost in conversion processes and 11% was lost in transmission, distribution and the operation of power stations. Thus, 40% of the heat is lost in distribution via above ground, leaking and poorly maintained pipes. The net result is that only about 25% of the energy as coal was finally consumed as heat and electricity.

The electricity and heat production of Mongolia for the period 1990-2022 is shown in Table 1.14. During this period the electricity and heat energy demand of Mongolia increased by 2.4 times.

Thermal energy production is 11,929.3 thousand Gcal in 2022, which is 3.3% (265.0 thousand Gcal) more than in the previous year (ERC, 2023).

Table 1.14 Total electricity and heat production

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2021*	*2022*
Power production, billion kWh	3.3	2.6	2.9	3.4	4.3	5.6	7.1	7.9	8.2
Heat production, million Gcal	5.3	6.8	6.9	7.8	8.4	10.7	14.1	11.1	11.9

Source: Statistical Yearbooks of Mongolia, National Statistical Office of Mongolia and Energy Regulatory Commission

As of 2022, Mongolia produced 8,178.6 GWh (79,1%) of electricity and imported 2,161.5 GWh (20.9%), with 90.8% of total demand supplied by CHPPs, 8.4% by wind and solar power energy sources, 0.8% by hydropower and 0.01% by diesel power generators, respectively. Table 1.15 contains breakdown information of the electricity production sources.

Table 1.15 Electricity production sources, million kWh

Electricity production sources	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Combined heat and power plants (CHPPs)	4,256.0	5,415.8	5,555.9	5,826.9	6,152.4	6,346.6	6,493.6	7,109.6	7,428.5
Diesel power plants (DPPs)	21.4	6.0	3.8	3.7	3.7	3.0	2.7	1.1	1.2
Solar power plants (SPPs)	-	0.5	0.3	19.7	51.1	109.0	108.9	156.9	178.7
Hydro power plants (HPPs)	20.0	59.4	84.7	84.5	78.7	85.4	83.3	83.1	61.7
Wind power plants (WPPs)	-	152.5	157.5	154.4	339.0	459.3	457.2	563.0	508.5
Total electricity generation	**4,297.4**	**5,634.2**	**5,802.2**	**6,089.2**	**6,624.9**	**7,003.3**	**7,145.7**	**7,913.7**	**8.178.6**
Import		**1,416.8**	**1,446.3**	**1,574.3**	**1,665.7**	**1,683.6**	**1,705.6**	**1,861.9**	**2,161.5**

Source: Statistics on energy performance 2018, 2021. Energy Regulatory Commission

In 2022, 2,161.5 million kWh of electricity were imported and the import increased by 299.6 million kWh (16.1%), compared to the previous year. These recent year to year increased trend of electricity production indicated the actual increase of demand. Currently Mongolia is experiencing the challenges that demand is exceeding installed electricity production capacity. There is still no any more feasible solution was proposed except CHP type facilities which required adequate investment and time, while being not consistent with the NDC targets. Use of renewbly energy is declared by development policy documents but in fact because of tarif issue the government, particularly, Ministry of Energy is not much entisuastic to support those businee entities who are willing to invest in renewably enegy sector. Some tecnological problem also is provocating to create a certain barrier, particularly in respect of back up system for wind and solar energy facilities and waste recycling issue if involved in this excersise baterei based installation. In addition it is necessary to note that consumers in Mongolia are “spoiled” to some degree consuming more cheap electrocity produced using coal with government subsidize and some economy instrument for public goods like renewable energy “feed in tarif” is critisised. The same situation with new energy soarce development like “green hydrogen” in regard of support from the government, which can appeal without tangable support needed fot that both public and private business and research institutions. Since energy sector is a main contributer to the GHG emission in Mongolia a feasibility of Mongolia NDC target in term of GHG reduction would fully depending on this sector progress.

Transport. There are four sub-sectors of transportation operating in Mongolia. These are road, railway, air, and water transport. It is essential that transport and logistics in Mongolia should cope with increased demand for their services. Road transport was the first modern transport sector to develop in Mongolia. Mongolian first highway was built in 1937 and it connected Ulaanbaatar with Sukhbaatar and Altanbulag, close to border with the Russia.

Freight turnover: By looking at all types of freight turnover by each type of vehicles (Table 1.16), the total freight turnover in 2023 was 29.5 billion tons km, of which 63.9% was done by rail, 36.0% by road and only 0.1% by air. A total amount transported freight reached 107.4 million tons in 2023, which increased 76.6% from the previous year, driven by a 50% increase in the mining industry and a 21% increase in total exports.

As mentioned above, out of 107.4 million tons of transported freight in 2023, 94.1 million tons or 87.6% were products of the mining industry, 4.4 million tons or 4.1% were products of the construction industry, 1.4 million tons or 1.3 % - products of the food and agricultural sector, and 7.5 million tons or 6.9% are freight from other industries.

Mining industry products account for 78.4 million tons or 98.7% of export shipments. A transportation of minerals by road in freight transportation is accounting for 86.2% or 67.5 million tons and 13.8% or 10.8 million tons by rail.

Table 1.16 Freight turnover, by transport types, million tons km

Indicator	*1990*	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Freight turnover:	6,971.6	4,418.3	12,124.8	13,844.3	23,861.0	20,674.6	17,534.1	29,512.7
Rail transport	5,087.8	4,282.5	10,286.7	11,462.6	19,167.6	18,345.1	14,910.2	18,869.3
Road transport	1,870.9	126.1	1,834.0	2,374.0	4,685.3	2,313.9	2,591.9	10,619.1
Air transport	8.0	9.4	4.2	7.7	8.1	15.6	32.0	24.3

Source: Statistical Yearbooks of Mongolia and MRTD, 2024

In 2023, around 7,088.0 million tonne freight and 146.5 million passengers were carried by all types of transport, the freight turnover reached 25,963.3 million tonne-kilometers and the passenger turnover reached 6,492.7 million person -kilometers. The freight carried increased 7.5 times in 1960 and 11.6 percent in 1990.

By looking at all types of passenger turnover by each type of vehicles (Table 1.17), the total passenger turnover in 2023 was 6,492.7 million person km, of which 59.8% was done by air, 27.9% by road and 12.3% by rail. In 2023 passenger turnover by air increased 2 times compared to the previous year.

Table 1.17 Passenger turnover, by transport types, million person km

	1990	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Passenger turnover	**2,056.1**	**1,946.0**	**3,607.5**	**4,931.6**	**3,416.9**	**1,563.4**	**4,444.8**	**6,492.7**
Rail transport	570.1	1,067.2	1,220.0	996.7	579.3	90.7	701.5	797.5
Road transport	914.6	364.2	1,480.2	1,940.5	2,178.0	1,023.0	1,914.9	1,813.2
Air transport	571.4	514.6	907.2	1,993.5	659.6	449.4	1,828.4	3,880.8
Water transport	-	-	0.0	0.9	0.0	0.4	0.9	1.2

Source: Statistical Yearbooks of Mongolia. National Statistics Office of Mongolia

Road surface: Roads in Mongolia are administratively classified into two main classes: (i) state roads, which are intended to connect Ulaanbaatar with province centers, key settlements and towns, and important border crossings; and (ii) local roads, which are intended to connect province centers with other province and district centers. The total length of the road network in Mongolia is 111,916.7 km, of which there are 14,921.3 km of state roads, 96,040 km of local roads, and 955.8 km of special roads (MRTD, 2024).

The length of the improved road was 1,029.0 km in 1950, of which 182.0 km were sealed road, and 4,316.9 km in 1990, of which 1,243.0 km were sealed road, and 6,734.4 km in 2010, of which 3,015.6 km were sealed road, and 12,158.4 km in 2023 were sealed road 10,307.0 km (Table 1.18).

Table 1.18 Improved auto road surface, km

	1990	*2000*	*2010*	*2015*	*2020*	*2021*	*2022*	*2023*
Improved auto road-total	4,316.9	3,453.5	6,734.4	9,812.1	11,963.8	12,025.5	11,562.0	12,158.4
Sealed road	1,243.0	1,567.4	3,015.6	7,125.3	10,151.0	10,243.8	9,943.7	10,307.0
With Gravel cover		938.4	2,071.6	1,715.6	1,207.9	1,176.8	920.5	1,111.1
Improved earth road		947.7	1,647.2	971.2	604.9	604.9	697.7	740.3

Source: Statistical Yearbooks of Mongolia. National Statistics Office of Mongolia

Road transport means in Mongolia consists of sedans, taxis, trucks, buses, and special purpose vehicles. In 2023, the total number of registered road vehicles was 1,192.5 thousand, an increase of 101.3 thousand or 10.3% from 2022. From this number, 788.0 thousand sedans, 224.9 thousand trucks, 23.4 thousand buses are registered in Mongolia, 64.4% are right-hand drive vehicles (i.e. the steering wheel is on the right side) and 35.6% are left-hand driven. Road vehicles aged 10+ years comprise 77.1%; those aged 7–9 years, 12.0%; those aged 4–6 years, 3.9%; and those aged 0–3 years, 7.0%. Road transport vehicles run on the following types of fuel: 37.8%, on gasoline; 27.4%, on diesel fuel; 1.2%, on gas; 33.5% on hybrid, and 0.1%, on electricity (MRTD, 2024).

Railway: Due to the geographical conditions, lack of direct access to the sea and vastness of the territory, the rail transport plays an extremely important role in Mongolia. The first railway was completed in 1939, connecting the coal mine at Nalaikh with the power station in Ulaanbaatar. The Trans-Mongolian Railway is the main rail link between Mongolia and its neighbours. It begins at the Trans-Siberian Railway in Russia at the town of Ulan-Ude, crosses border and runs to Beijing through Ulaanbaatar and joins the Chinese railway system at border town Erenhot.

The Ulaanbaatar Railway (UBTZ) was formed in 1949, and a 404 km line was run from Ulaanbaatar to Naushki in Russia, with the connection operating from 1950. The route was extended south to Zamiin-Uud in 1952, and the connection with China was operational since 1955.

Other stops are opened in Sukhbaatar, Darkhan, Choir, and Zamyn-Uud/Erlian (border crossing and gauge-changing station). The line was built between 1949 and 1961. In most part of Mongolia, it is single track, but in China it has double track. The gauge is 1,520 mm in Russia and Mongolia and 1,435 mm in China. There are important branches leading to Erdenet and Baganuur.

A new railway is currently under serious consideration to connect coal mines in the South of the country, including Tavan Tolgoi to the Chinese border where a railhead already exists.

The Mongolian railway network comprises around 1,905 km of 1520-mm gauge track, of which 1,110 km is the Trans-Mongolian rail track line linking Russia to China. Overall railway traffic of Mongolia as well as international transit of goods flow through this single-track line. Also, there are 238 km of line on a separate network in Eastern Mongolia that has its own link to the Russian railway, and the remaining 477 km are branches from the main line.

Air transport: Mongolia has a total of 22 airports including Ulaanbaatar, the only international airport. There are four regional airports and the rest of which have limited facilities. In 2023, 60 aircrafts were registered in Mongolia, of which 18 are passenger aircrafts.

In 2023, the number of domestic flights were 10,310 and it is increased by 1,491 (16.9%) number compared to the previous year. In this same year the number of international flights were 63,463, as well the increased by 11,745 (22.7%) number compared to the previous year.

Table 1.19 Domestic and international flights

	2000	*2005*	*2010*	*2015*	*2019*	*2020*	*2021*	*2022*	*2023*
Number of international flights	28,074	50,545	72,984	97,116	143,805	73,163	71,150	51,718	63,463
International overfligh/cruise	25,675	47,109	67,936	90,686	133,663	71,422	68,715	37,565	43,499
International landing and take off	2,399	3,436	5,048	6,430	10,142	1,721	2,435	5,334	9,654
Number of domestic flights		6,677	6,748	4,556	7,967	5,563	4,663	8,819	10,310

Waterways: Only Lake Khuvsgul has boats that operate on a regular, year-round basis. Much of Mongolia’s 580 km of waterways freezes over between September and May. The boats serving lakes are mostly for tourist travel and have a capacity for fewer than 140 passengers. Lake Khuvsgul is 136 km north-south, and it takes approximately 7 hours to cross the entire lake. The Selenge (270 km) and Orkhon (175 km) rivers are navigable but have a little boat traffic. There is a customs boat that patrols the Selenge to the Russian border.

There are 206 domestic waterway vehicles registered in Mongolia. In 2023, 146 vehicles passed the technical inspection, which is an increase of 42 vehicles or 40.4% from the previous year (MRTD, 2024).

Information communication and technology (ICT): Between 2017 and 2018, the number of mobile telecommunication subscribers in the country increased by 10.5%, the number of mobile broadband subscribers increased by 20.8% and the number of fixed internet subscribers increased by 7.3%. The fibre-optic network deployment increased by 2.5 times from 2001 to 2017, covering over 38,000 km. This allowed parts of the rural population living in remote territories to access high speed internet and mobile connectivity. According to an ESCAP assessment, a 10% increase in broadband access leads to a

1% increase in the GDP and doubling the average broadband speed can increase the country's GDP by 0.3% (ESCAP, 2020).

There were 2.16 million internet users in Mongolia in January 2022. Mongolia's internet penetration rate stood at 64.4 percent of the total population at the start of 2022 (DR, 2022).

Digitalisation in Mongolia offers an important opportunity to increase accessibility to government services and make the public service work better for its citizens. In 2020, the Mongolian government set out its five-year mission to build a 'Digital Nation', harnessing data and technology to facilitate innovation, streamline public services, and diversify Mongolia's mining-reliant economy. Mongolia launched the e-Mongolia platform to streamline public service delivery in 2020. Generally, it takes around 2-5 minutes to get an online service through the e-Mongolia system, while traditional proceedings take an average of three hours but may also take several days. Based on the total number of public services accessed in 2021, citizens are expected to save a total of 3,581 hours per year and 52.6 billion Mongolian tugrik as a result of the 571 services currently available through e-Mongolia.

1.4 National frameworks

Mongolia's prospects for future development face numerous challenges and risks related to climate change and the it's impact on natural ecosystems and socio-economic sectors is expected to be tremendous. However balanced concederation of both negative and positive consequances might result a little bit different picture with different probabilities. In general the climate change outcomes, combined with negative anthropogenic factors on ecosystems and ecosystem services, definitely wouild lead to increased vulnerability of the country's economy and its citizens' livelihood, since current trend of change is faster and deeper than nature and human systems adaptive capacities.

Mongolia does not have a specific law on climate change that regulates cross-sectoral and nationwide climate change actions. The objectives, priority actions, and implementation principles of climate change mitigation, adaptation, and cross-sectoral actions are reflected in the long-term development policy Vision-2050 (2020), the Nationally Determined Contribution (NDC, 2019), the Government Action Programme (2020), and a New Revival Policy of Mongolia (2021).

The Vision-2050 (PoM, 2020): To address the economic and development setbacks and align sectoral policies with the future development goals, the Parliament adopted the Long-Term Development Vision-2050 Policy in 2020. The "Vision-2050" was developed by engaging more than 1500 representatives from research and academia, ministries, government agencies, and non-governmental organizations. It was made more compehencive analysis on different stages of socia-economic development in Mongolia in the past and the lessons learned over the past 30 years of development stages. The Vision-2050 has nine fundamental sections of which the 6th section is dedicated to the green development, which encompasses the principles and objectives of the Green Development (GD) Policy (2014-2021). The GP Policy of 2014 was Mongolia's first effort to make a transition toward a green economy, ensuring the environmentally sustainable and inclusive future development for Mongolia. Upon the approval of a new Law on Policy and Planning and its Management (2020), the GD Policy was nullified. However, the green development concept is embedded in the Vision-2050 Policy.

The green development goal of Vision-2050 is to promote an environmentally friendly green development, maintain the balance of the ecosystem, ensure environmental sustainability, create conditions for present and future generations to reap its benefits, and improve the quality of human life. It has four sub-objectives, and those are:

- Evaluate and protect the value and benefits of nature and maintain a balance of primary ecosystems;
- Rehabilitate natural resources, reduce scarcity, create productive resources, and pass them on to future generations;
- Prevent water scarcity, accumulate surface water, and create conditions to fully meet needs;
- Contribute to international efforts to mitigate climate change by developing a low emission, productive and inclusive green economy.

Besides the objectives outlined in the sixth or Green Development section of the Vision-2050, the concepts of green technology, green cities, sustainable agriculture, efficient use of natural resources and energy are integrated into other sections – for example, under the Ulaanbaatar and Satellite Cities (Goal 9 of Vision 2050). It plans to support renewable energy generation by households for their use as well as supply to the grid to generate additional incomes, also to develop a resilient city which is fully prepared in terms of information sharing, communication and resource management in the event of natural disasters, climate change, other form of disasters, and emergency. Another example is to enhance local disaster protection capacity and strengthen infrastructure to assess risks and plan against disasters, which is encompassed in the Safe and Safety Society (Goal 7 of Vision 2050).

Furthermore, the Vision-2050 will be implemented through the sector-specific five-year programmes and 10-year development plans, and these programmes and plans are under development.

The Government Action Programme, (GoM, 2020): The Government Action Programme, which lays out actions to be implemented for the next four years (2020-2024) was adopted by the Parliament in 2020. Given the challenges brought by the COVID-19 pandemic, the Government put forward the actions to recover from post-COVID socioeconomic challenges, ensure the environmental balance, and strengthen the governance and local development. The GAP covers six main areas – (i) policy on recovery from the post-COVID economic and social setbacks, (ii) policy on human development, (iii) policy on economic development, (iv) policy on governance, (v) policy on green development, and (vi) policy on the development of cities and local administrative units.

Withing its green development scope, twelve actions included are:

- Reduce the Ulaanbaatar’s air pollution by 80%;

- Conduct a comprehensive risk assessment on ecosystem pollution on the Khuvsgul Lake;
- Ensure the freshwater supply in the Ulaanbaatar through the utilization of recycled and greywater in industries;
- Reduce soil pollution by introducing eco-toilets in ger areas as well as campsites;
- Establish the policy environment to incentivize or reward the citizens and companies those planted trees contributing towards the target to increase the forest area to 8.6 percent;
- Expand the state protection of freshwater resources and watershed areas;
- Create the utilization resources of endangered plants and animals through breeding;
- Rehabilitate 8 thousand hectares of land which degraded and left from mining operations;
- Support environmentally friendly, resource-efficient industries, and build the waste-to-energy and hazardous waste recycling plants;
- Increase the water level of the Tuul river basin by prohibiting mining activities and rehabilitating the basin areas;
- Conduct the technical, economic, and environmental feasibility assessments of the "Blue Horse" project in Orkhon-Ongi and Kherlen-Toonot areas to create the nature-based water reservation systems using surface, rain, and snow water; start the construction works.
- Reduce the country's GHG emissions by 12.3 per cent (as a part of 22.7 per cent target by 2030) compared to the BAU in 2010 through the implementation of mitigation and adaptation actions and measures.

The New Revival Policy (PoM, 2021): The New Revival Policy is developed to strengthen the economic independence, minimize adverse socioeconomic impacts of the COVID-19 pandemic, lay the foundation for the successful implementation of a long-term development Vision-2050 policy, and strengthen the economic, infrastructure and government productivity for the next 10 years. The policy emphasizes the public-private partnerships and foreign investors as the foundation for addressing six critical issues which hinder Mongolia's development. It targets to increase the economic growth by an average of 6 percent, GDP per capita by 2 percent, the labor force participation rate to 65 percent; expansion of ports by three times, and energy generation capacity by twice in the next ten years. The six main areas include:

- Port Revival
- Energy Revival
- Industrial Revival
- City and Provincial Revival
- Green Development Revival
- Government Productivity Revival

Within its Green Development Revival, four objectives are set forth, and are:

- Create enabling environment for the successful implementation of a Billion Tree campaign to contribute towards mitigating climate change, with an adaptation co-benefits;

- Conserve water resources, ensure the sufficient and safe drinking water supply, increase water supply for Gobi regions, create the water reservoirs and ponds, utilize the greywater, and rehabilitate dried rivers, springs, and streams;
- Establish the solid waste recycling facilities for regions and cities based on the advanced and environmentally sound technologies;
- Determine the green development models and principles by integrating the traditional environmental approaches in the economic and industrial revival policy implementation.

The Sustainable Finance Roadmap (2022): Since 2013, the sustainable finance initiative has been launched by the Mongolian Bankers' Association with the support of IFC, and the principles have been voluntarily adopted by commercial banks in Mongolia as they introduced environment and social management systems in lending operations. By 2019, the commercial banks started to report the green loan statistics to the Bank of Mongolia following the national Green Taxanomy (2019). As commercial banks convened under the sustainable finance agenda, the public and private partnership-based financing vehicle, the Mongolian Green Finance Corporation, is established with the financial support of the GCF. Significant milestonnes have been reached by the financial sector actors over the past decade in sustainable finance, and yet they acknowledge the need to accelerate the fund mobilization addressing climate-related financial risks and toward a sustainable future. Therefore, the financial sector actors jointly developed and approved the Sustainable Finance Roadmap for 2022-2030 on March 29, 2022.

The Sustainable Finance Roadmap has an objective to create an integrated and multi-stakeholder-based sustainable finance system by 2030 which aligned with the country's sustainable development and climate agendas. It defined the six main goals and 25 actions to achieve its objective, and those are:

- Enable the infrastructure and policy framework for sustainable finance – including the strategy, governance, taxonomy, training and monitoring, and evaluation systems;
- Create the direct budgetary and fiscal measures on sustainable and green finance – including green expenditure, procurement, environmental tax, etc.;
- Increase the capital flows – through lending, bond, insurance, etc.;
- Strengthen the national green financial institutions – such as the Mongolian Green Finance Corporation and other state-owned institutions.
- Strengthen the ESG and Climate-risk management systems – such as climate scenario, risk analysis, GHG accounting, target-setting, etc.;
- Promote transparency and disclosure – including sustainability and ESG reporting.

Snapshot of national initiatives under the UNFCCC: Intended Nationally Determined Contributions (INDCs)/ Nationally Determined Contributions (NDCs), National Adaptation Plans (NAP), National Adaptation Programmes of Action (NAPAs) Nationally Appropriate Mitigation Actions (NAMA), Technology Needs Assessment (TNA), and) and any other relevant initiatives. (e.g., REDD+).

UNFCCC and Paris Agreement: Mongolia 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. As a non-Annex I Party, Mongolia is not obligated to reduce its GHG emissions under the regulations of the Kyoto Protocol, but under the Paris Agreement (PA), Mongolia has a target to reduce its GHG emissions by 22,7 per cent as compared a 2010 business as usual (BAU) scenario, by 2030. Between 1996 and 2017, Mongolia has developed three National Communications for the UNFCCC, and conducted GHG inventories four times, reporting on emissions from 1990 to 2014.

Nationally Determined Contribution (NDC) of Mongolia: Mongolia ratified the Paris Agreement in 2016, confirming to take both adaptation and mitigation action and measures which to reduce greenhouse gas emissions. Mongolia in its INDC approved in 2015 has fixed the emission reduction target as 14% below the business-as-usual scenario in the year 2030. As the Paris Agreement calls upon all Parties to prepare an updated NDC by 2020, Mongolia has enhanced its mitigation commitments in 2020 which has a target to reduce greenhouse gas emissions by 22.7% (excluding LULUCF) below the business-as-usual scenario in 2030, equivalent to an annual reduction of approximately 16.9 Mt CO_2e of economy-wide emissions. Mongolia's NDC outlined a series of policies and measures that the country has committed to implementing through 2030 in energy production, energy consumption (transportation, construction, industry), agriculture, industrial processes, and waste sectors.

In addition to the unconditional efforts, Mongolia's NDC identified conditional measures e.g., carbon capture and storage and waste-to-energy technology, as well as the carbon removal potential in the forest sector. If these additional measures are implemented, the total GHG reduction target could reach 44.9% by 2030, compared to the BAU baseline of 2010.

1.5 Institutional Arrangement for Climate Change Coordination and Reporting

At national level, the Ministry of Environment and Tourism (MET), the central government body responsible for the development and implementation of climate change policies, and liaises the national, subnational, and local as well as international stakeholders.

In the matter of reporting under the UNFCCC, the Law on Air (Article 24.2) mandates the central administration body in charge of environmental issue as a responsible entity for conducting the national GHG inventory in accordance to the decisions and guidelines of the Conference of Parties (COP) to the UNFCCC.

In 2015, the Climate Change Project Implementing Unit (CCPIU) was established as the unit of Environment and Climate Fund (ECF) under MET by an order of the minister of Environment, Green Development and Tourism then to fulfil the commitments and duties of the UNFCCC and enhance the bilateral and multilateral mechanisms for the implementation of the Convention. From 2015-2018, CCPIU has organized the activities for the preparation of NC and BUR within the GEF funded enabling activity projects, as well as the development of INDC and NDC. However due to its limited regulatory power and human resources, CCPIU has faced some challenges in preparing the GHG inventory, reports and mainstreaming climate change into the national, sectoral and subnational development plans. For example, within the preparation of latest reports under the UNFCCC, CCPIU utilised the Bilateral Memorandum of Understandings (MOUs) to formalize data sharing between institutions. Unfortunately, the data are not fully provided as agreed by parties in MOUs. Until now, the preparation of national reports and GHG inventory has been conducted as ad-hoc projects-based activities, thus the systematic integration process into the national government system is not yet resulted.

Moreover, the measuring, reporting and verification (MRV) and monitoring and evaluation (M&E) systems in terms of planning, preparation, and management for reporting are underdeveloped. The initial experience with different elements of MRV for GHG estimation gained through the implementation of CDM, NAMA and JCM. Under the JCM, the Mongolian first validation body (Third Party Entity) accredited for energy sector according to ISO 14064 and ISO 14065. MET and JCM secretariat effectively has collaborated with Mongolian Agency for Standard and Metrology Government Regulatory Agency (MASM) to approve ISO 14064 and ISO 14065 as Mongolian Standards.

Nevertheless, over the last five years, international cooperation and as well as national coordination on climate change efforts are relatively improved due to the approval of Paris Agreement, and implementation of climate projects through international financial mechanisms such as GCF, GEF and other international donors. Moreover, a given situation triggers the need to strengthen institutional arrangements on climate change.

With the effort to strengthen the institutional arrangements and coordination mechanisms, the National Climate Committee (NCC) has re-established by the order of Minister of Environment and Tourism in 2019 as a hierarchy cross-sectoral governing and decision-making body on climate change. The NCC is chaired by the Minister of Environment and Tourism, and vice-chaired by the Deputy Minister of Energy. The members are comprehensive and comprised of Deputy Ministers of finance, food, agriculture and light industry, construction and urban development, road and transportation development, mining and heavy industry, and Directors-general of the National Development Agency and National Emergency Management Agency, a President of Mongolian Academy of Sciences, the Special Envoy on climate change, and other representatives from Ministry of Environment and Tourism, Ministry of Health, Ministry of Education, Culture, Science, and Sports, UB Governors' Office, Information and Research Institute of Meteorology, Hydrology and Environment, and NGOs.

Another change occurred in relation to the institutional arrangements is the formalization of functions of CCPIU by restructuring it as the Climate Change Research and Cooperation Center (CCRCC) in May 2020. The CCRCC is established by the Cabinet as a self-financing state-owned enterprise with mandates to continue the duties of CCPIU, which include the Secretariat of the National Designated Authority (NDA) of Green Climate Fund (GCF) and Joint Crediting Mechanism (JCM), and as well as conducting the national GHG Inventory, and preparation of reports under the UNFCCC and its Paris Agreement. The

CCRCC is a self-funded state-owned enterprise (SOE) operating under the policy guidance of the Ministry of Environment and Tourism of Mongolia with the purpose to enable cooperation and coordination among concerned government agencies, private business entities, NGOs and CSOs by organizing national and international events and supporting the initiative and efforts of organizations to introduce new technologies to combat climate change.

The CCRCC is preparing and delivering reports (Fourth National Communication and Second Biennial Update Report) under the UNFCCC implementation process. It serves as the focal point for the Green Climate Fund (GCF) and acts as the secretariat of the Joint Crediting Mechanism (JCM) within the Mongolia-Japan Low Carbon Development Partnership agreement.

Along with its goal to ensure implementation of the Paris Agreement, the CCRCC may also engage, among others, in developing and implementing internationally funded SDG-aligned cross-sectorial projects and programs, to carry out various research work and provide consultancy services in accordance with its rules.

Figure 1.23 shows the current institutional arrangement for reporting under the UNFCCC.

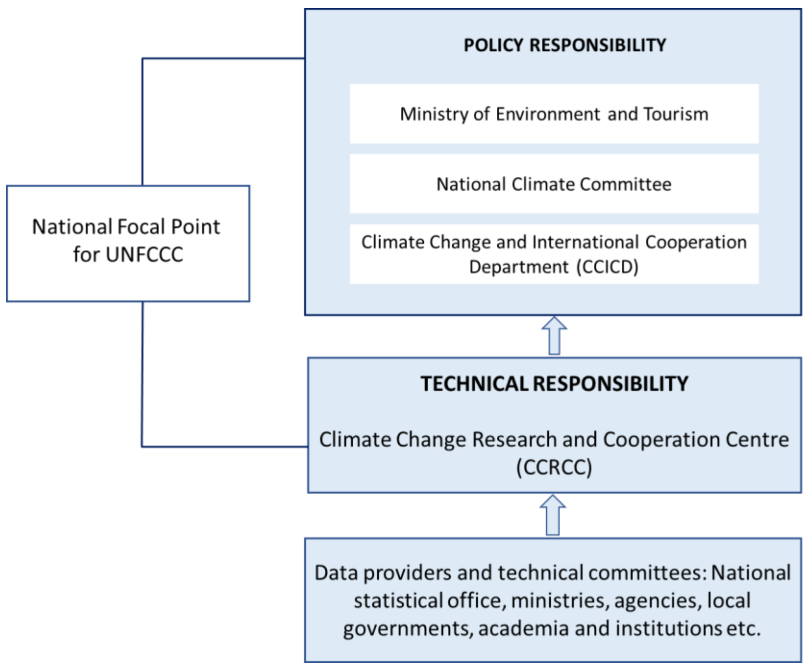


Figure 1.23 Existing stakeholder arrangements for the preparation of reports under the UNFCCC

Recent changes to the institutional arrangements provide both opportunities and challenges for climate change coordination in Mongolia. Mandates on climate change are still fragmented, with lack of well established coordination mechanism. The current situation as a weak coordination and cooperation across various sectors and national, subnational, and local stakeholders could be challenging for the effective use of the newly established mechanisms in accordance with new requirements as the transition from BUR to BTR and newly operationalized Article 6 of Paris Agreement etc. due to the insufficiencies in human and financial resources, as well as institutional mismanagement and over administrative interventions. In this regard, the scheme in the Figure 1.23 can be considered as a tentative, with possible options and alternatives, in term of stakeholders engaged.

1.6 The GHG "Net Zero" target of Mongolia and its feasibility

At the World Leader's Summit organized as part of the UNFCCC COP 27 which was held in November 2022 in Egypt Mr. KHURELSUKH Ukhnaa, President of Mongolia has announced for the first time about the GHG "Net Zero" target of Mongolia which should reached by 2050. Mongolia also has joined to the "Global Methane Pledge"

The Parliament of Mongolia ratified the Paris agreement in 2016 and after that it was developed the Mongolian NDC approved by the Government in 2019. In this document the GHG reduction targets were updated from the targets fixed before Paris document called INDC. These new targets are 22.7 and 27.2 percent reduction of GHG accordantly as the unconditional and conditional ones. At the public level a question was raising if Mongolia can reach the "Net Zero" target by 2050 having those modest targets aimed to reach by 2030 as mentioned here.

An analysis have been made (Batjargal, 2022) in respect of feasibility of the "Net Zero" target of Mongolia, using the finding of studies undertaken by relevant professional organizations and individuals.

The concern in relation with the current "NET ZERO" target of Mongolia (actually not only for this country) is associated with a couple of uncertainties related to climate change science, dynamic of society development in different part of the world, possible alteration in human behavers, due to accelerated population growth and depletion of life supporting natural resources.

The options available are mostly based on the experiences and current circumstance, could be not fully matched or harmonized with a maximum probability of development trend in particular region and on the Earth as a whole.

Those actions identified in the international agreements and NDCs like documents to address the present and emerging challenges are not guaranteed to be implemented in full sense due to lack of solid system science based adjustment mechanisms in proper timeframe and spatial scale.

If downscale of these global challenges to scale of individual developing country, like Mongolia, more vulnerable to climate change, the above mentioned uncertainties are magnified due to limited human capacities, available technologies and financial resources.

Some policy breakthrough like Billion tree campaign (BTC) in Mongolia, initiated by the Head of State, which triggered nation wide movement, engaging every one regardless differences in ideology, religion and other polarization in the society might promote the success in case of its effective implementation.

This movement initially intended to contribute to GHG removal from the atmosphere, but also appeared to provide another important co-benefit as a decrease of evaporation, thus easing negative impact of climate dryness and soil degradation attributed to intensive rainfall and strong winds, in that way addressing partly the desertification issue as well.

In Mongolia the energy and agriculture sector with domination of livestock are the principal emitters of GHG.

At present, the energy sector in Mongolia is struggling to produce electricity and heat matching with demand, since latter is almost exceeding the total installed capacity of production of energy in the country. Energy producers are interested to produce more energy in cheapest way rather than in cleanest way. Despite the announced goal to increase renewable energy use, in fact, wind and solar energy related investment initiatives are not getting needed support from the government due to tariff and grid stability issues. Not better situation with regard to hydropower because of public concern related to land ownership and environmental issues both in the country and beyond it (cross border rivers are in center of dispute).

Livestock sector is facing similar challenges in term of GHG emission due to rapid increase of livestock number which was almost tripled during the last 2-3 decades, leading to pasture overgrazing and peatland degradation, enriching the pool of GHG in the atmosphere including high impact one as the methane. Actually the livestock sector in Mongolia is serving not only a key source of income but also as a more sustained traditional way of life for local communities. In that sense, it is difficult to expect a substantial reduction of GHG from this sector in the near future.

Since the both of principal emitting sectors as the energy and livestock have very limited chance to contribute in progress toward "Net Zero" benchmark at present the focus is moving to another approach, namely to promote a sink, removal of GHG and carbon sequestration issues. In this situation Mongolia has to be more active player in cooperation among countries of Northeast Asia, particularly, in the following areas:

- First because of urgency in energy sector it is necessary to move the GHG related focus back to the energy sector while overturning the challenges to opportunity. In addition to traditional cooperation among countries, like a networking of the energy grids for balancing of production and consumption of electricity it can be suggested to develop a more integrated network to use in efficient way the plenty of renewable energy source of Mongolia establishing some sort of super grid covering the high demand in electricity areas in the Northeast Asia, introducing more innovative transmission systems like mixed use of AC and DC lines etc.
- Second, Some recent studies have shown that a production of green hydrogen can be cheaper in significant part of the territory of Mongolia in comparison with other similar regions in the world. In this regard, the partner countries could be invited to develop joint demonstration projects for production and use of green hydrogen in Mongolia, keeping in mind a goal of scaling up further within Northeast Asia and beyond it.

- Third, Mongolia could share its two decades experiences, including both best practices and lessons learnt from implementation of the “National Green Belt Program” and invite partner countries to develop cooperation programs in line with the goals of the BTC, particularly, restore and expanding of vegetation coverage of the land areas in order to increase resilience of ecosystem to global warming while providing good enough ecosystem service including GHG removal and soil moisture retention.

Summarizing the discussions it is necessary to note that a guaranteed, to some degree, answer about the feasibility of the GHG “Net Zero” target what should be reached by the middle of this century can be provided only after complex science based analysis involving all driving factors, partly highlighted above. Finding of such kind of analysis should be used as a basis for development of strategy and roadmap, which could be upgraded periodically depending on rate of change of key leading factors involved.

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CHAPTER 2. NATIONAL GREENHOUSE GAS INVENTORY

Mongolia's greenhouse gas (GHG) emissions from anthropogenic sources and removals by sinks are presented in this chapter. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (HFCs) as well as indirect gases carbon monoxide (CO), nitrous oxides (NO_x) and sulfur dioxide (SO_2). The summary of annual GHG emissions and removals from 1990 to 2020 and their trend analyses are also included.

The GHG emissions have been estimated from the energy, the industrial processes and product use (IPPU), the agriculture, the land use, land use change and forestry (LULUCF) and the waste sectors according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, UNFCCC (the 2006 IPCC GLs). In addition, Good Practice Guidance (GPG) was used to improve and update default values.

Net emissions have been expressed in carbon dioxide equivalents (CO_2e) using the 100-year global warming potentials (GWPs)[1] of the 1995 IPCC Second Assessment Report (SAR). In general, the Tier 1 IPCC method was applied for the inventory. However, the Tier 2 method was used for the categories such as fuel combustion, fugitive emissions from solid fuels in the energy sector and forest remaining forest category in the LULUCF sector.

Mongolia's GHG inventory was compiled using the activity data from both national and international statistical sources and institutions. The main source of activity data is the National Statistics Office (NSO) of Mongolia, recommended by the 2006 IPCC GLs. 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 (UNFAO), World Bank (WB) and expert judgment were used.

2.1 Greenhouse gas inventory in 2020

In 2020, total GHG emissions in Mongolia were 43,081.62 Gg CO_2e (excluding LULUCF) and 12,909.10 Gg CO_2e, if GHG emissions and removals from the LULUCF sector is included. Without LULUCF, net emissions demonstrated a 82.17% increase from the 1990 level of 23,648.79 Gg CO_2e and 6.20% decrease from the 2019 level of 45,927.72 Gg CO_2e. With LULUCF, net emissions demonstrated a 340.02% increase from the 1990 level of -5,378.40 Gg CO_2e and 17.92% decrease from the 2019 level of 15,726.84 Gg CO_2e (Figure 2.1).

[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-152a=140, HFC-143a=3800. HFC-227ae=2900, HFC-134a=1300, HFC-125=2800, HFC-32=650 GWPs for indirect GHGs are not available. However, they were reported but are not included in the inventory total.*

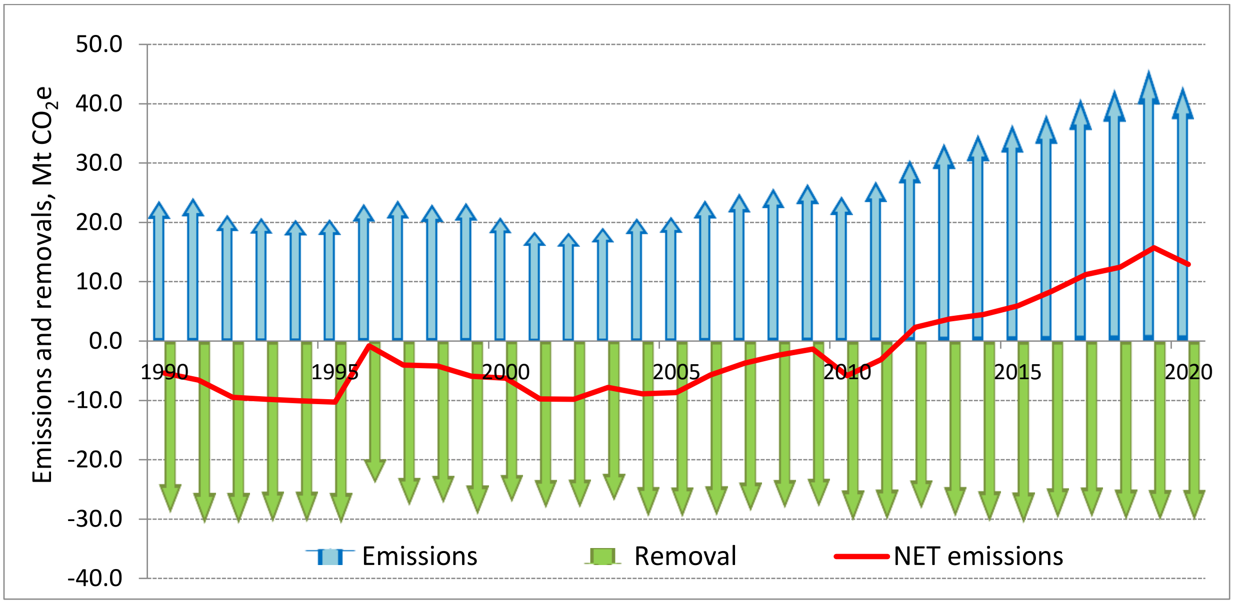

Figure 2.1 Total and net GHG emissions and removals of Mongolia, 1990-2020 (Mt CO_2e)

In general, emissions and removals from each sector are showed an increase in 2020 compared to the base year of 1990, and net values are listed and their percentages for each GHG inventory sector in Table 2.1.

Table 2.1 GHG emissions and removals difference between 1990 and 2020, by sectors in Mongolia

Sector	*Emissions and removals, ($Gg\ CO_2e$)* 1990	*2020*	*Change from 1990 ($Gg\ CO_2e$)*	*Change from 1990 (%)*
Energy	12,086.55	19,292.48	7,205.92	59.62%
IPPU	284.98	1,147.75	862.77	302.75%
Agriculture	11,221.64	22,390.57	11,168.93	99.53%
Waste	55.62	250.82	195.20	350.95%
Total (excluding LULUCF)	*23,648.79*	*43,081.62*	*19,432.82*	*82.17%*
LULUCF	-29,027.19	-30,172.52	-1,145.33	3.95%
Net total (including LULUCF)	*-5,378.40*	*12,909.10*	*18,287.49*	*340.02%*

In 2020, GHG emissions from the agriculture sector accounted for 22,390.57 Gg CO_2e (51.97%), from the energy sector accounted for 19,292.48 Gg CO_2e (44.78%) of the national total emissions (excl. LULUCF), while the emissions from the IPPU and waste sectors accounted for relatively small percentages of 2.66% (1,147.75 Gg CO_2e) and 0.58% (250.82 Gg CO_2e) of the total emissions (Figure 2.2).

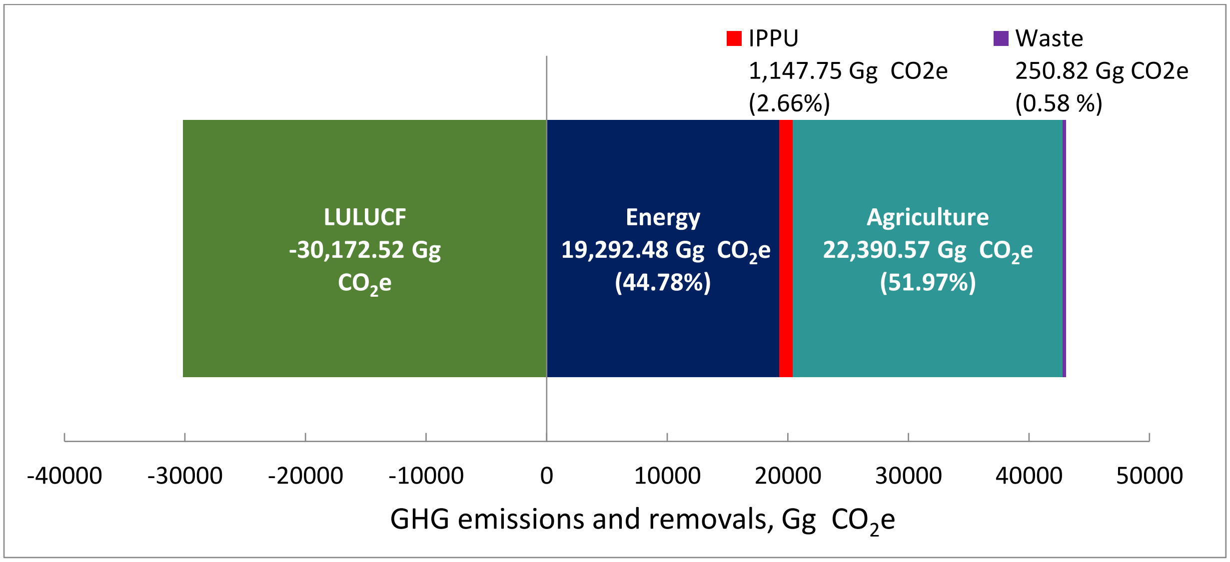

Figure 2.2 Sectoral distribution of GHG emissions of Mongolia in 2020

The aggregated sectoral GHG emissions and removals between 1990 and 2020 are shown in Table 2.2 including the national total emissions estimated with and without LULUCF sector. The trends of emissions and removals from sectors are shown a different pattern along the time series and the main factors affected to trend fluctuation in each sector are discussed later in this chapter.

Compared to 1990 in 2020 emissions increased by 59.62% in energy sector, by 302.75% in the IPPU sector, by 99.53% in the agriculture sector, by 350.95% in waste sector and removals for the LULUCF sector was 3.95%.

Compared to 2019, in 2020 emissions decreased by 9.79% in energy sector and by 3.85% in the agriculture sector, increased by 12.66% in IPPU sector and by 7.06% in waste sector; and removals decreased by 0.09% in the LULUCF sector.

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

Year	*Energy*	*IPPU*	*Agriculture*	*Waste*	*LULUCF*	*Total (excl. LULUCF)*	*Total (incl. LULUCF)*
1990	12,086.55	284.98	11,221.64	55.62	-29,027.19	23,648.79	-5,378.40
1991	12,218.09	159.92	11,779.02	56.18	-30,777.08	24,213.22	-6,563.86
1992	10,589.40	116.78	10,552.74	54.96	-30,796.13	21,313.88	-9,482.24
1993	10,062.97	80.92	10,588.77	53.66	-30,583.27	20,786.32	-9,796.96
1994	8,751.24	90.79	11,574.18	54.00	-30,565.82	20,470.21	-10,095.61
1995	8,752.15	88.50	11,638.09	55.71	-30,820.64	20,534.44	-10,286.19
1996	8,466.61	90.03	14,556.30	56.56	-23,973.92	23,169.49	-804.42
1997	8,306.43	94.96	15,300.84	58.27	-27,806.97	23,760.49	-4,046.48
1998	8,339.22	92.56	14,639.94	58.57	-27,328.36	23,130.29	-4,198.07
1999	8,385.13	85.84	14,836.47	62.71	-29,321.59	23,370.14	-5,951.44
2000	8,792.39	70.55	11,933.07	66.03	-27,139.37	20,862.04	-6,277.33

2001	8,786.65	55.15	9,523.69	68.45	-28,193.79	18,433.94	-9,759.85
2002	9,398.39	101.84	8,727.06	74.16	-28,132.70	18,301.45	-9,831.25
2003	9,119.37	108.38	9,834.85	76.51	-26,968.87	19,139.11	-7,829.77
2004	9,370.65	55.48	11,232.86	79.03	-29,624.81	20,738.03	-8,886.78
2005	9,833.17	116.83	10,977.51	83.32	-29,684.24	21,010.83	-8,673.41
2006	11,039.76	114.37	12,493.57	87.74	-29,450.74	23,735.44	-5,715.30
2007	11,715.13	123.37	13,019.70	92.25	-28,676.81	24,950.45	-3,726.37
2008	11,836.39	176.51	13,707.12	97.65	-28,205.77	25,817.67	-2,388.09
2009	12,333.01	160.31	13,952.16	103.10	-27,917.77	26,548.57	-1,369.20
2010	13,344.88	222.85	10,786.05	108.25	-30,265.24	24,462.03	-5,803.21
2011	14,308.90	289.13	12,264.68	122.13	-30,115.90	26,984.84	-3,130.78
2012	15,637.24	302.13	14,472.57	137.79	-28,257.61	30,549.72	2,292.12
2013	16,942.32	264.32	16,032.15	148.16	-29,648.23	33,386.95	3,738.71
2014	16,902.95	339.28	17,513.60	159.90	-30,466.11	34,915.74	4,449.63
2015	16,313.23	326.58	19,787.87	169.46	-30,691.25	36,597.14	5,905.89
2016	16,920.24	422.96	20,707.36	183.13	-29,852.24	38,233.68	8,381.44
2017	18,333.25	630.67	21,784.24	198.54	-29,743.29	40,946.70	11,203.41
2018	19,813.99	841.88	21,669.69	218.66	-30,087.02	42,544.22	12,457.19
2019	21,386.93	1,018.81	23,287.71	234.28	-30,200.88	45,927.72	15,726.84
2020	19,292.48	1,147.75	22,390.57	250.82	-30,172.52	43,081.62	12,909.10
Diff% 1990/ 2020	59.62%	302.75%	99.53%	350.95%	3.95%	82.17%	-340.02%
Diff% 2019/ 2020	-9.79%	12.66%	-3.85%	7.06%	-0.09%	-6.20%	-17.92%

Note: Totals of columns not consistent due to rounding.

The summary shows, the agriculture and energy sectors are major sources for GHG emissions consistently through the whole time series. However, percentages of each sector relative to national total varied depending on the socio-economic and climatic factors, for example, an increasing energy demand in the energy sector and increased frequency of severe weather in the agriculture sector etc.

In Table 2.3 shown the major socio-economic indicators that influence the the national total GHG emissions including Mongolian population, per capita GHG emissions, gross domestic production (GDP) and GHG emissions per GDP of Mongolia from 1990 to 2020. Mongolia's population has increased by 55.8% from 2.15 million in 1990 to 3.36 million in 2020, and total emissions increased from 23,648.78 Gg CO_2e to 43,081.62 Gg CO_2e, bringing GHG emissions per capita fluctuated between 10.98 and 12.83 tonnes of CO_2e, which is relatively higher than the average for developing countries and the world average. Mongolia has a cold and long lasting winter season and therefore it requires seven months of heating for residential houses and/or gers not connected to central heating system from October to April by burning low efficient fossil fuels. However, GHG emissions per GDP has decreased by 48% throughout the whole time series (Figure 2.3).

Table 2.3 Major indicators of total GHG emissions (excl. LULUCF) of Mongolia, 1990-2020

Indicators	Unit	1990	1995	2000	2005	2010	2015	2020
Total emissions (excl. LULUCF)	Gg CO_2e	23,648.79	20,534.44	20,862.04	21,010.83	24,462.03	36,597.14	43,081.62
Population	thousand persons	2,153.47	2,243.00	2,403.11	2,551.08	2,760.97	3,057.78	3,357.54
Per capita GHG emissions	tonnes CO_2e /person	10.98	9.15	8.68	8.24	8.86	11.97	12.83
GDP*	billion 2015 USD using exchange rate	3.83	3.34	3.82	5.23	7.15	11.62	13.53
Per GDP GHG emissions	Kg CO_2e/US $	6.18	6.16	5.47	4.02	3.42	3.15	3.18

* World bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MN

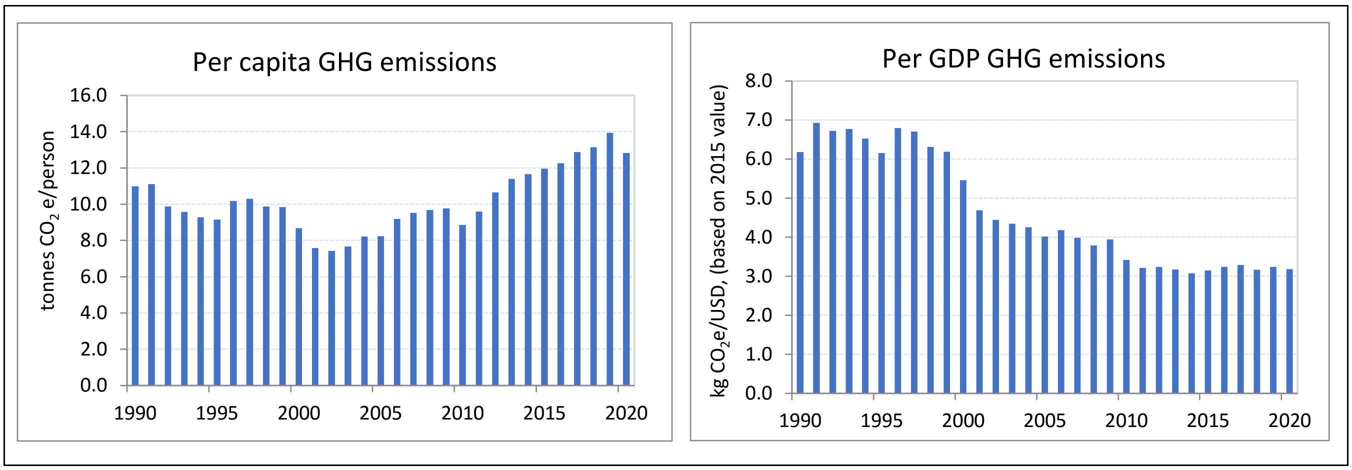

Figure 2.3 Major indicators of total GHG emissions (excl. LULUCF) of Mongolia, 1990-2020

Figure 2.4 presented the contribution of emissions from all sectors with respect to the total emissions of Mongolia for the period of 1990-2020. Two main sources of the total emissions were agriculture and energy sectors for the entire inventory time series.

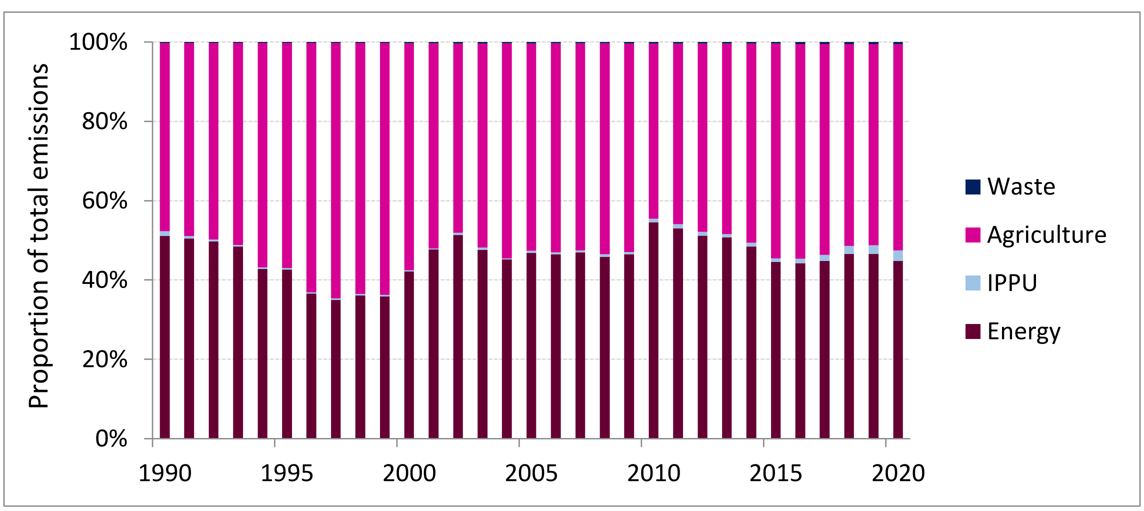

Figure 2.4 Relative contribution of sectors to national total emissions, 1990-2020

2.2 Description and interpretation of emission trends sectors/categories

2.2.1 Energy

In 2020, the energy sector accounted for 44.78% (19,292.48 Gg CO_2e) of total national direct GHG emissions (without LULUCF), being the second major source of GHG emissions after the agriculture sector in the country. The GHG emissions fluctuate in the latest years mainly due to economic trend, the energy supply structure and climate conditions. Total emissions in energy sector in 2020 increased by 56.92% 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 (57.51%). The emissions from energy industries increased by 73.14% compared to 1990 (Figure 2.5). One of the main factors affecting the GHG emissions from energy industries source category is the increasing energy demand, i.e., increase in housing and energy consumption associated with population growth and migration from rural to urban areas. To reduce the GHG emissions from this source category, energy efficiency in power and heat generation, in industries and in buildings should be improved.

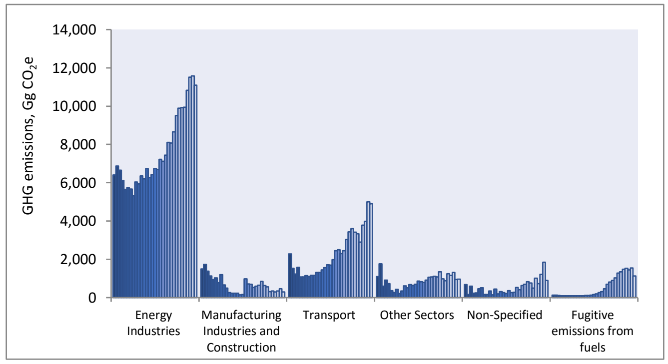

Figure 2.5 Trends in the energy sector by subcategories, 1990-2020

2.2.2 Agriculture

The agriculture sector is the most significant source of the GHG emissions with 51.97% share of the national total emissions (without LULUCF) in 2020. Total emissions in agriculture sector in 2020 increased by 99.53% compared to the base year 1990; in particular, due to increasing the number of domestic livestock which increased 25.8 million in 1990 to 67.1 million in 2020 (Figure 2.6). Emission reduction between 1999-2002 and 2009-2010 caused by livestock loss during the natural disaster. Within the agriculture sector, enteric fermentation contributes the highest to the GHG emissions with 56.90% followed by aggregated sources and non-CO_2 emissions sources on land (41.60%) and manure management with 1.49%.

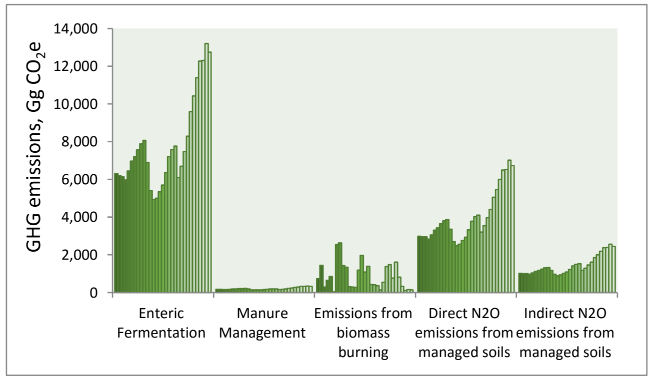

Figure 2.6 Trends in the agriculture sector by subcategories, 1990-2020

2.2.3 Industrial processes and product use (IPPU)

The Industrial Processes and Product Use (IPPU) sector contributes 2.66% of the total GHG emissions in 2020. The total GHG emissions of IPPU sector in 2020 increased by 302.75% 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 2020 by 12.66% compared to 2019. The main contributor to the total emissions from IPPU sector is the mineral industry (cement and lime production) and it represents 50.11% 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 (Figure 2.7).

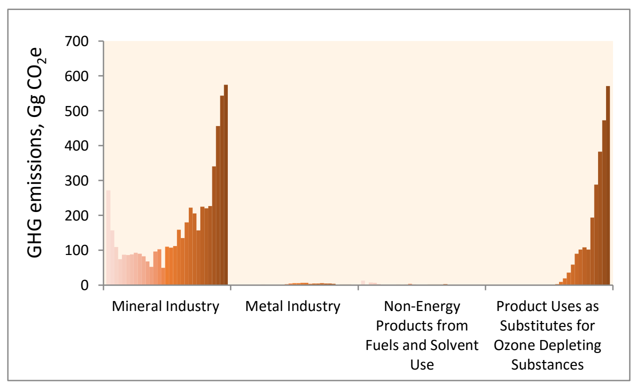

Figure 2.7 Trends in the IPPU sector by subcategories, 1990-2020

2.2.4 Waste

The waste sector is the insignificant source of the GHG emissions contributes only 0.58% to national total in 2020. Total aggregated emissions from the waste sector have increased by 195.20 Gg CO_2e (350.95%) from the 1990 level of 55.62 Gg CO_2e. The total CO_2 equivalent emissions from waste sector in 2020 increased by 7.06% compared to 2019 (Figure 2.8). The emissions from solid waste disposal sites (SWDS) contribute 62.05%, domestic wastewater treatment and discharge 29.65% and industrial wastewater treatment and discharge 8.30% to waste sector's total emissions in 2020. The emissions from waste sector have increased continuously year after year in relation to the population growth especially in urban areas, operational and management changes at some solid waste disposal sites, and the country's poor state of domestic wastewater treatment facilities.

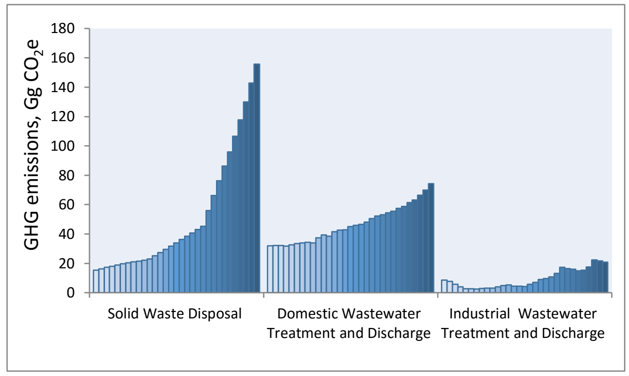

Figure 2.8 Trends in the waste sector by subcategories, 1990-2020

2.2.5 Land use, land use change, and forestry

LULUCF is a net sink in Mongolia accounted approximately 50% of the net removal of the country's direct GHG emissions. In 2020, the removals were -30,172.52 Gg CO_2e which was increased by 3.95% compared to 1990 and mainly occurred in the forest land category including forest land remaining forest land and land converted to forest land (Figure 2.9). However, due to lack of activity data and country specific parameters for GHG removals and emissions, emissions from the second largest source, grassland, in Mongolia not included in this report. From 1986 to 2020, a total of 1,037,932 hectares of land area had converted within the IPCC main classifications out of which 64% is occurred in grassland.

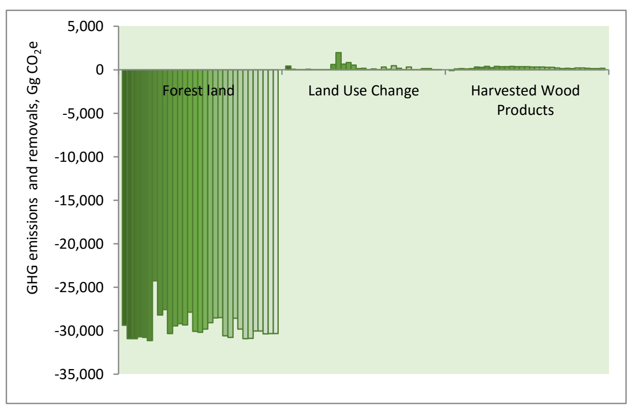

Figure 2.9 Trends in the LULUCF sector by subcategories, 1990-2020

2.3 Description and interpretation of emission trends by gases

Direct gases, namely CO_2, CH_4, N_2O, HFCs and indirect gases which are NO_x, CO gas emissions estimated in the inventory. The most emitted gas in Mongolia was carbon dioxide (CO_2) without removals accounting 42.40% of national total in 2020, primarily from fuel combustion activities in energy sector. The second dominant gas was methane (CH_4) and it contributed 33.82% to national total GHG emissions which mainly originated from enteric fermentation, manure management and solid waste disposal. Followed by nitrous oxide (N_2O) emitted from agricultural soils contributes 22.46% of national total and then the remaining 1.33% attributed to HFCs emission from utilization of refrigeration, air conditioning, fire protector, and foam blowing equipment. Figure 2.10 shows the share of distribution of direct gases CO_2, CH_4, N_2O and HFCs emissions in 2020.

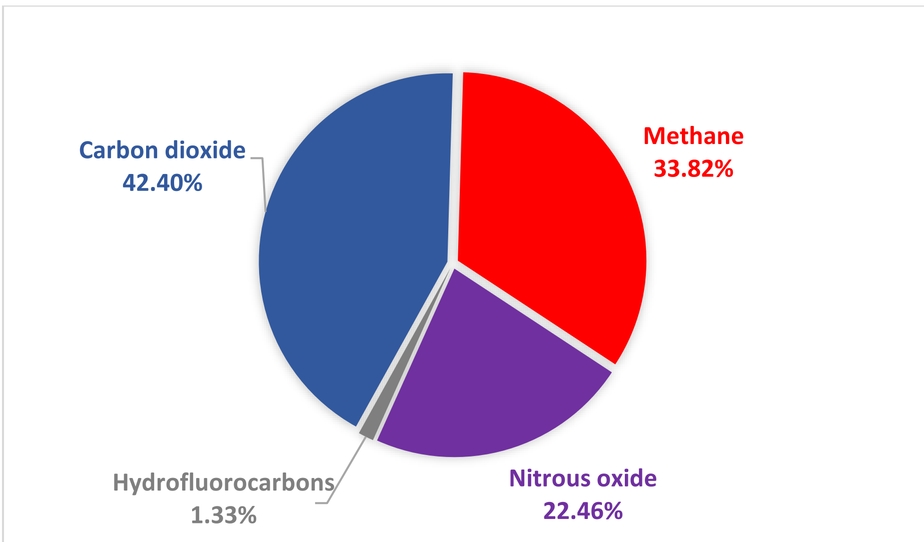

Figure 2.10 The share distribution emissions of direct GHG in 2020

In Table 2.4 demonstrated total GHG emissions of Mongolia gas categories by representing 1990 and 2020. The estimation indicates emissions of methane and nitrous oxide in 2020 approximately doubled compared to the base year.

Table 2.4 Total GHG emissions of Mongolia by gases in 1990 and 2020

Direct GHGs	Emissions, (Gg CO_2e)		Change from 1990 (Gg CO_2e)	Change from 1990 (%)
	1990	2020		
CO_2	11,970.55	18,265.66	6,295.11	52.59
CH_4	7,076.91	14,570.44	7,493.53	105.89
N_2O	4,601.33	9,674.22	5,072.89	110.25
HFCs	NA	571.30	NA	NA
Total	23,648.79	43,081.62	19,432.83	82.17

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.

In Figure 2.11 presented a long-term trend of GHG emissions by gases, CO_2, CH_4 and N_2O and comparisons of emissions between 1990 and 2020. Detailed descriptions are provided in chapters 2.3.1-2.3.4.

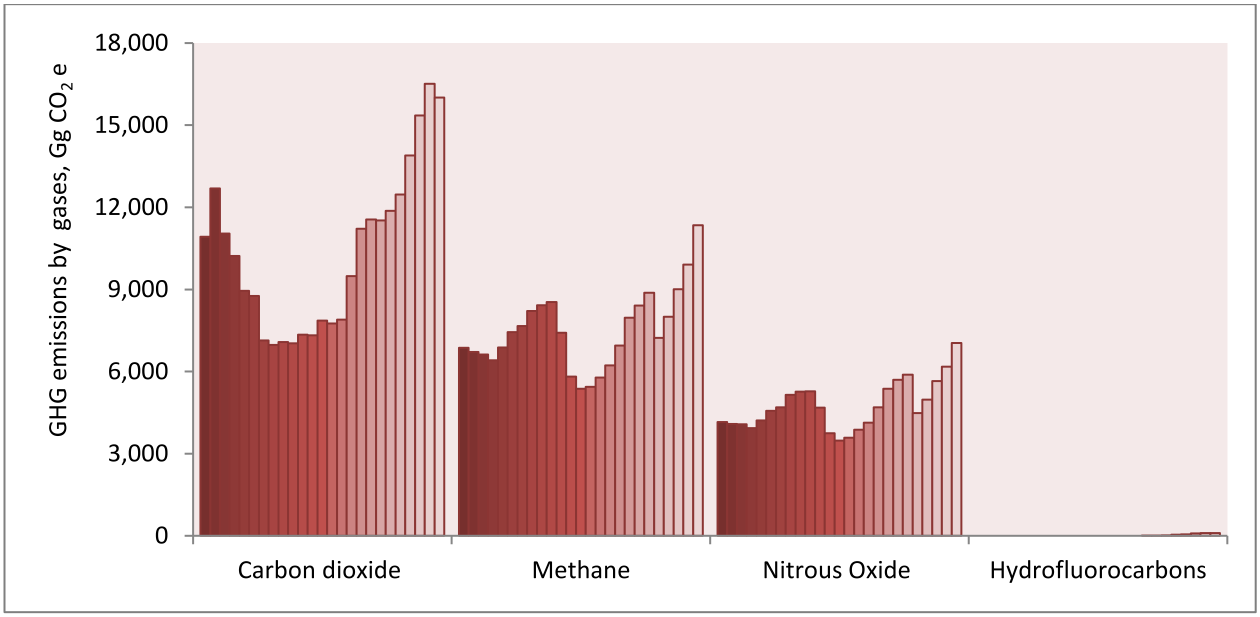

Figure 2.11 Trend of CO_2, CH_4, N_2O and HFCs emissions, 1990-2020

2.3.1 Carbon dioxide (CO_2)

The CO_2 emission from all sectors (excl. LULUCF) increased from 11,970.55 Gg CO_2e in 1990 to 18,265.66 Gg CO_2e in 2020, by 52.69%, mainly due to increased fossil fuel combustion activities in the energy sector, such as energy industries, manufacturing industries and construction, and fugitive emissions from fuels.

2.3.2 Methane (CH_4)

CH_4 emissions increased from 337.00 Gg in 1990 and 693.83 Gg in 2020, overall change by 105.89%. Main sources of CH_4 emissions are enteric fermentation process, coal mining and handling activities, and solid waste disposal on lands (landfills).

2.3.3 Nitrous oxide (N_2O)

N_2O emissions increased by 110.25%, from 14.84 Gg to 31.21 Gg for the period of 1990-2020. Main sources of N_2O emissions include following subsectors such as managed soils, energy industries, manufacturing industries and construction, transport, residential sectors, and domestic wastewater treatment and discharge.

2.3.4 Hydrofluorocarbons (HFCs)

The activity data for estimation of HFC emissions was available only from 2012 to 2020. Therefore the emissions have been estimated only for the last few years. Since the HFC emissions are directly related to the consumption of applications (i.e. refrigeration, air condition, foam products, fire protections etc.) which are substitute of fluorinated substances. Thus, emissions are increasing with the growing imported applications. The HFCs emissions were estimated using the Tier 1 method of the 2006 IPCC GLs which uses the default emission factors. The year of introduction for HFC-134a (mobile air conditioning) was 2007. Therefore, applied to back-calculate the development of banks of a refrigerant from the current reporting year to the year of its introduction. Finally, the emissions have been calculated for the period 2007-2020 and it demonstrates an increased emissions of 3.10 Gg CO_2e to 571.30 Gg CO_2e for the period from 2007 to 2020, respectively.

2.3.5 Description and interpretation of emission trends for indirect GHGs

In Mongolian case the indirect gases (NO_x and CO) estimated from biomass burning activities in AFOLU sector. Table 2.5 summarizes indirect gas emissions from the AFOLU sector in 1990 and 2020. Therefore, emission fluctuation depends on the frequency of forest and grassland fires mainly caused by the extreme weather conditions (e.g. extremely windy and dry springs) in certain years. According to the 2006 IPCC GLs, these gases should be a part of the common reporting table (CRF) of the country. The result of NO_x emissions shows a -85.29% reduction from 22.84 Gg in 1990 to 3.36 Gg in 2020. CO emissions decreased by 80.21% from 422.31 Gg in 1990 to 83.58 Gg in 2020 which originate biomass burning.

Table 2.5 Total emissions by indirect gases of Mongolia in 1990 and 2020

Indirect GHG emissions	*Emissions, (Gg CO_2e)*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
	1990	*2020*		
NO_x	22.84	3.36	-19.48	-85.29%
CO	422.31	83.58	-338.73	-80.21%

2.4 The trend of GHG emissions by sources (1990-2020)

2.4.1 Energy

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

The energy sector was the main contributor to national total GHG emissions (excluding LULUCF) with its share of 44.78% and 19,292.48 Gg CO_2e the second emitter nationwide in 2020. Figure 2.12 shows the share of each subsector in the national total GHG emissions (excluding LULUCF) of the year 2020.

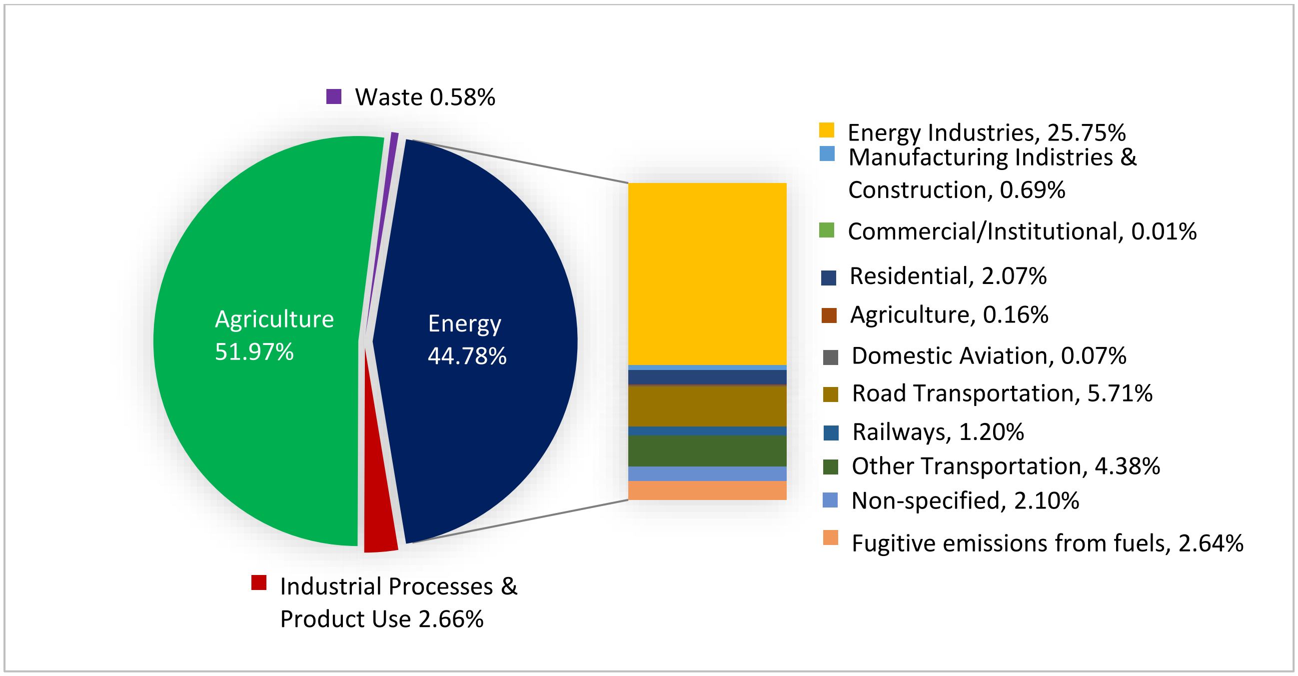

Figure 2.12 Share of each subsector of energy sector in total national GHG emissions (excl. LULUCF), 2020

Within the energy sector, energy industries contribute the most percentage to the GHG emissions and next three major contributors are the road transportation, other transportation (which is offroad transport in the mining industry) and fugitive emissions from fuels each with 57.51%, 12.75%, 9.78%, and 5.89%, respectively (see Table 2.6). The share of energy industries is relatively constant, for example, from 53.02% in 1990 increased up to 72.35% in 2000 and steadily decreased to 57.51% in 2020. The share of manufacturing industries and construction source category is slightly increased from 12.36% in 1990 up to 14.42% in 1997 and unsteadily decreased to 1.54% in 2020. The emissions in the manufacturing and construction category, literally the consumption of coal in this category, are falling because factories are connected to central heating systems and electricity grids and due to technical and technological innovations.

Table 2.6 GHG emissions and share of subsectors from energy sector

IPCC categories	*Units*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Energy industries	Gg CO_2e	6,408.20	5,734.65	6,361.32	6,740.47	8,102.31	9,934.12	11,095.40
	%	*53.02*	*65.52*	*72.35*	*68.55*	*60.71*	*60.90*	*57.51*
Manufacturing industries and construction	Gg CO_2e	1,494.38	1,029.55	262.87	168.24	597.94	315.26	297.25
	%	*12.36*	*11.76*	*2.99*	*1.71*	*4.48*	*1.93*	*1.54*
*Transport **	Gg CO_2e	2,277.86	1,074.46	1,320.03	1,698.12	2,448.87	3,343.24	4,896.88

	%	*18.85*	*12.28*	*15.01*	*17.27*	*18.35*	*20.49*	*25.38*
Domestic aviation	Gg CO_2e	6.02	32.45	29.26	30.06	25.77	43.42	30.54
	%	*0.05*	*0.37*	*0.33*	*0.31*	*0.19*	*0.27*	*0.16*
Road transportation	Gg CO_2e	1,275.58	647.67	816.65	953.05	1,196.25	1,727.66	2,460.63
	%	*10.55*	*7.40*	*9.29*	*9.69*	*8.96*	*10.59*	*12.75*
Railways	Gg	327.40	186.71	176.42	217.06	309.95	368.59	518.81
	%	*2.71*	*2.13*	*2.01*	*2.21*	*2.32*	*2.26*	*2.69*
Off-road transportation	Gg	668.85	207.63	297.69	497.95	916.90	1,203.57	1,886.90
	%	*5.53*	*2.37*	*3.39*	*5.06*	*6.87*	*7.38*	*9.78*
*Other sectors***	Gg	1,098.43	361.66	607.83	856.99	1,082.79	882.73	964.08
	%	*9.09*	*4.13*	*6.91*	*8.72*	*8.11*	*5.41*	*5.00*
Commercial/ Institutional	Gg	2.78	124.49	314.00	243.39	7.04	7.40	4.80
	%	*0.02*	*1.42*	*3.57*	*2.48*	*0.05*	*0.05*	*0.03*
Residential	Gg	840.13	188.35	278.33	565.25	1,030.37	828.58	891.26
	%	*6.95*	*2.15*	*3.17*	*5.75*	*7.72*	*5.08*	*4.62*
Agriculture	Gg	255.52	48.83	15.49	48.34	45.37	46.76	68.01
	%	*2.11*	*0.56*	*0.18*	*0.49*	*0.34*	*0.29*	*0.35*
Non-specified	Gg	676.77	460.02	138.42	210.64	416.49	486.45	903.51
	%	*5.60*	*5.26*	*1.57*	*2.14*	*3.12*	*2.98*	*4.68*
Fugitive emissions from fuels (coal, oil)	Gg	130.91	91.80	101.92	158.71	696.47	1,351.43	1,135.36
	%	*1.08*	*1.05*	*1.16*	*1.61*	*5.22*	*8.28*	*5.89*
Solid fuels	Gg	130.91	91.80	94.84	137.47	461.17	406.34	692.75
	%	*1.08*	*1.05*	*1.08*	*1.40*	*3.46*	*2.49*	*3.59*
Oil	Gg	NO	NO	7.09	21.24	235.30	945.09	442.61
	%	*NO*	*NO*	*0.08*	*0.22*	*1.76*	*5.79*	*2.29*
Energy total	Gg	12,086.55	8,752.15	8,792.39	9,833.17	13,344.88	16,313.23	19,292.48
	%	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*

** Transport sector include domestic aviation, road transportation, railways and off-road transportation subsectors.*

*** Other sectors include commercial/institutional, residential and agriculture/forestry/fishing source categories.*

As of 2020, the share of energy industries (mostly electricity and heat production) in total fuel combustion source category (1.A) is the most highest, namely 57.51% within the energy sector, followed by transport category with 25.38%, and other sectors, where included commercial/institutional, residential, agriculture and forestry categories with 5.00%. Within the category of other sectors, the residential subcategory has the highest share with 92.45% and followed by agriculture/forestry 7.05% and commercial/institutional 0.5% categories in the year of 2020. The road transportation subcategory represents 50.25% and it is the most important key source with one of the highest share on emissions within the transport category. The next important sources of transport category are the other (off-road) transportation and the railways with share of 38.53% and 10.59% each. The domestic and international aviations have the same share of 0.16% each, but the international aviation bunkers should not be reported in the national total emissions and reported as a memo item with 0.16% (30.54 Gg CO_2e) in 2020.

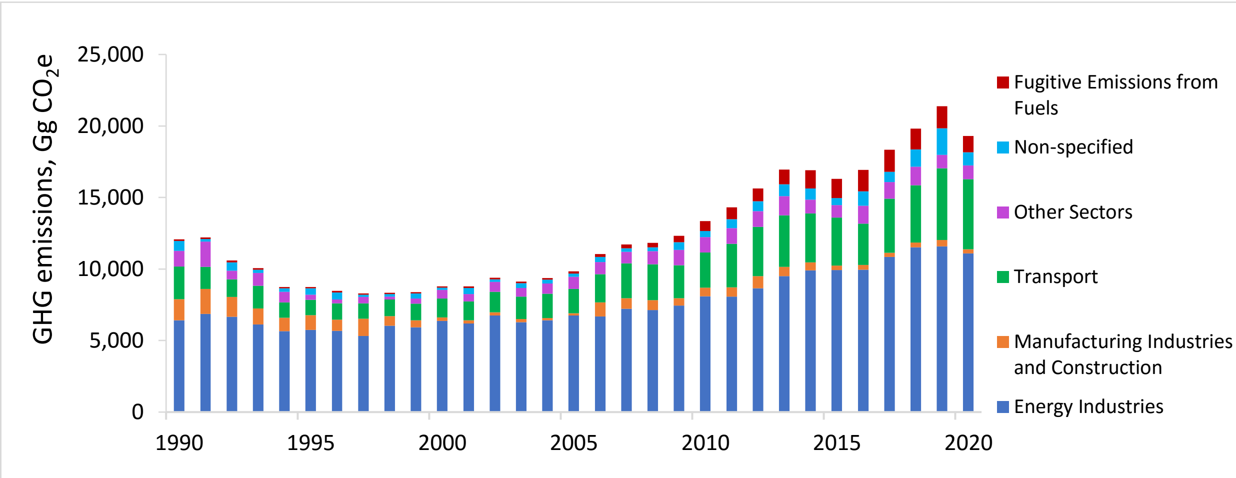

Figure 2.13 Trend in aggregated emissions by source categories within energy sector, 1990-2020 (Gg CO_2e)

In addition to fuel combustion, also emissions 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 the energy sector have increased by 59.62% from 12,086.55 Gg CO_2e in 1990 to 19,292.48 Gg CO_2e in 2020. From Figure 2.13 can be seen that the emissions in the energy sector were decreased in 2020 compared to 2019, which was caused by major decreases in emissions from the manufacturing industries and construction category by 80.11% and other sectors category by 12.23%. The main driving factors behind the overall decrease in emissions in the energy sector are as follows: decrease in emissions from the manufacturing industries and construction category, caused by reduced industrial production during Covid-19 pandemic; the decrease in emissions from fuel production and its transportation due to the overall decline in coal and crude oil production; the decrease in electricity and fuel consumption due to the partial and/or complete closure of small- and medium-sized industries, public places, and offices during the pandemic; the decrease in emissions from civil aviation and rail transport due to the closure of international borders.

Table 2.7 GHG emissions difference between 1990 and 2020 in energy sector

Subsectors	GHGs	Emissions (Gg CO_2e)		Change from 1990 (Gg CO_2e)	Change from 1990 (%)
		1990	2020		
1.A.1 - Energy industries	CO_2, CH_4, N_2O	6,408.20	11,095.40	4,687.20	73.14
1.A.2 - Manufacturing industries and construction	CO_2, CH_4, N_2O	1,494.38	297.25	-1,197.13	-80.11
1.A.3 - Transport	CO_2, CH_4, N_2O	2,277.86	4,896.88	2,619.02	114.98
1.A.4 - Other sectors	CO_2, CH_4, N_2O	1,098.43	964.08	-134.35	-12.23
1.A.5 - Non-specified	CO_2, CH_4, N_2O	676.77	903.51	226.81	33.51
1.B - Fugitive emissions from fuels (coal, oil)	CO_2, CH_4	130.91	1,135.36	1,004.45	767.28
Energy Total	CO_2, CH_4, N_2O	12,086.55	19,292.48	7,205.93	59.62

In the bottom of Table 2.8 are shown the differences between base and last years (1990/2020) of the inventory and the differences between last and prior years (2019/2020) as well. Differences show that emissions decreased in 2020 compared to 2019, which was the cause of the Covid-19 pandemic.

Table 2.8 GHG emissions within energy sector in 1990-2020

Years	1.A.1 Energy industries			1.A.2 Manufacturing industries and construction	1.A.3 Transport			
	1.A.1.a.i Electricity generation	1.A.1.a.ii Combined heat and power peneration (CHP)	1.A.1.c.ii Other energy industries		1.A.3.a Civil aviation	1.A.3.b Road transportation	1.A.3.c Railways	1.A.3.e.ii Off-road
	Gg of CO_2e							
1990	124.64	6,281.03	2.53	1,494.38	6.02	1,275.58	327.40	668.85
1991	90.40	6,778.75	2.53	1,738.05	16.38	836.37	200.64	485.09
1992	55.47	6,603.87	2.76	1,386.98	23.86	743.99	166.83	297.69
1993	96.56	6,023.02	3.00	1,124.45	26.72	718.26	316.73	518.18
1994	44.52	5,609.28	3.00	936.25	31.81	589.41	220.21	238.88
1995	38.69	5,692.97	3.00	1,029.55	32.45	647.67	186.71	207.63
1996	41.09	5,626.25	3.00	781.30	43.74	664.50	216.25	220.49
1997	43.83	5,275.08	3.23	1,196.54	39.28	627.40	190.94	235.19
1998	44.52	5,996.23	3.23	656.02	33.08	728.67	166.32	238.88
1999	54.45	5,874.18	3.23	494.09	25.29	690.57	154.31	292.16
2000	55.47	6,300.77	5.07	262.87	29.26	816.65	176.42	297.69
2001	59.58	6,131.48	5.76	224.53	36.26	794.37	157.19	319.72
2002	65.40	6,669.44	6.45	225.72	32.60	866.33	196.86	350.97
2003	73.62	6,193.81	6.45	228.51	38.01	927.78	198.43	395.08
2004	88.34	6,329.76	6.45	150.26	36.26	989.77	208.87	474.07
2005	92.79	6,641.23	6.45	168.24	30.06	953.05	217.06	497.95
2006	106.15	6,527.46	61.71	977.33	65.85	1,054.82	285.55	569.62
2007	132.86	7,054.33	43.93	717.84	62.35	1,306.74	374.98	712.95
2008	146.56	6,931.33	44.42	702.83	50.26	1,397.10	265.88	786.46
2009	142.44	7,269.86	30.12	523.06	23.38	1,255.82	258.72	764.39
2010	170.86	7,894.75	36.69	597.94	25.77	1,196.25	309.95	916.90
2011	221.54	7,813.50	34.69	649.72	39.92	1,416.29	388.01	1,188.87
2012	245.16	8,381.85	36.86	850.07	57.58	1,656.17	411.36	1,315.62
2013	265.03	9,217.61	31.26	637.44	61.71	1,667.69	441.61	1,422.22
2014	234.89	9,630.66	35.13	570.14	41.67	1,717.83	389.96	1,260.50
2015	224.28	9,684.32	25.53	315.26	43.42	1,727.66	368.59	1,203.57
2016	187.65	9,740.70	13.08	339.11	39.44	1,531.75	321.41	1,006.96
2017	275.74	10,545.18	15.13	294.72	48.76	1,782.17	472.09	1,479.72
2018	290.64	11,198.20	18.91	349.25	64.10	1,885.73	480.81	1,559.68
2019	369.94	11,186.83	18.65	464.66	74.12	2,361.40	582.57	1,985.21
2020	351.62	10,730.08	13.70	297.25	30.54	2,460.63	518.81	1,886.90
Diff% 1990/2020	182.11%	70.83%	441.50%	-80.11%	407.31%	92.90%	58.46%	182.11%
Diff% 2019/2020	-4.95%	-4.08%	-26.54%	-36.03%	-58.80%	4.20%	-10.94%	-4.95%

Table 2.8 (cont.) GHG emissions within energy sector in 1990-2020

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 Residen-tial	1.A.4.c.i Agriculture-Stationary	1.A.4.c.ii Agriculture-Off-road vehicles and other machinery	1.A.5.a Stationary	1.B.1.a Coal mining & handling (surface mining)	1.B.2.a.ii Oil - Flaring	1.B.2.a.iii.2 Oil production and upgrading
	Gg of CO_2e							
1990	2.78	840.13	235.29	20.23	676.77	130.91	NO	NO
1991	700.05	907.75	150.00	14.67	168.68	128.71	NO	NO
1992	312.66	175.17	102.91	9.01	593.94	114.26	NO	NO
1993	585.17	217.77	86.67	15.67	228.02	102.74	NO	NO
1994	489.06	183.96	57.25	7.22	246.04	94.35	NO	NO
1995	124.49	188.35	42.54	6.28	460.02	91.80	NO	NO
1996	94.04	141.26	23.44	6.67	511.11	93.47	NO	NO
1997	101.03	316.36	11.70	7.11	168.68	90.06	NO	NO
1998	33.86	154.54	17.52	7.22	161.78	92.50	0.35	4.50
1999	159.07	135.03	48.47	8.84	346.80	90.80	0.57	7.30
2000	314.00	278.33	6.49	9.01	138.42	94.84	0.51	6.57
2001	178.47	317.11	8.33	9.67	442.27	94.03	0.57	7.30
2002	78.86	574.76	14.42	10.62	189.61	101.41	1.08	13.86
2003	77.52	518.83	15.95	11.95	316.64	97.11	1.43	18.25
2004	53.98	623.28	10.02	14.34	262.85	98.77	1.71	21.90
2005	243.39	565.25	33.28	15.06	210.64	137.47	1.54	19.70
2006	216.17	582.81	15.11	17.23	366.13	152.91	2.96	37.95
2007	125.78	634.02	8.01	21.57	256.00	172.48	6.61	84.68
2008	240.71	641.10	14.99	23.79	276.44	187.81	9.18	117.52
2009	6.71	1,008.33	24.82	23.12	536.47	264.30	14.59	186.86
2010	7.04	1,030.37	17.63	27.74	416.49	461.17	17.04	218.26
2011	2.40	1,052.91	18.15	35.95	630.16	541.34	19.95	255.48
2012	18.64	1,011.92	9.10	39.80	702.27	508.95	28.39	363.50
2013	20.17	1,269.29	12.68	43.02	824.79	474.60	40.07	513.13
2014	12.29	912.14	14.11	38.13	765.34	482.22	57.80	740.14
2015	7.40	828.58	14.11	32.66	486.45	406.34	68.46	876.63
2016	8.65	1,202.56	11.14	30.46	1,009.75	588.35	64.41	824.82
2017	7.11	1,105.45	9.58	44.76	722.34	708.63	59.53	762.33
2018	6.15	1,247.22	5.59	47.18	1,213.93	757.93	49.89	638.80
2019	4.90	876.67	8.35	60.05	1,853.04	799.30	53.69	687.54
2020	4.80	891.26	10.93	57.08	903.51	692.75	32.06	410.55
Diff% 1990/2020	72.66%	6.09%	-95.35%	182.16%	33.50%	429.18%	-	-
Diff% 2019/2020	-2.04%	1.66%	30.90%	-4.95%	-51.24%	-13.33%	-40.29%	-40.29%

The inventory of emissions from fuel combustion includes direct GHG emissions such as CO_2, CH_4, N_2O emissions. The emissions from international bunkers (CO_2, CH_4, N_2O) and CO_2 emission from biomass combustion are included in memo items and not calculated into national total. The following Figure 2.14 shows the share of GHG emissions by source categories and the trend of GHG emissions by categories in Gg of CO_2 equivalents (CO_2e) within the energy sector. The CH_4 and N_2O emissions from all categories of the energy sector were estimated by using the IPCC default conversion and emission factors, but for CO_2 emissions the country specific conversion and emission factors were used for the other bituminous coal and lignite.

In Mongolia the fugitive emissions from fuels occur in the coal mining and handling and in the oil industry. Mongolia does not yet have an oil refining industry. The fugitive emissions from fuels were calculated from the surface coal mining industry, since underground coal mines do not exist in Mongolia.

The overview of the total fugitive emissions from fuels and the share of fuels within this category is shown in the following figures. From Figure 2.13, it can be seen that the total fugitive emissions decreased in 2020, but the share of coal is increased in 2020 compared to 2019. This is due to the decline in the overall production of coal and oil at the beginning of the Covid-19 pandemic.

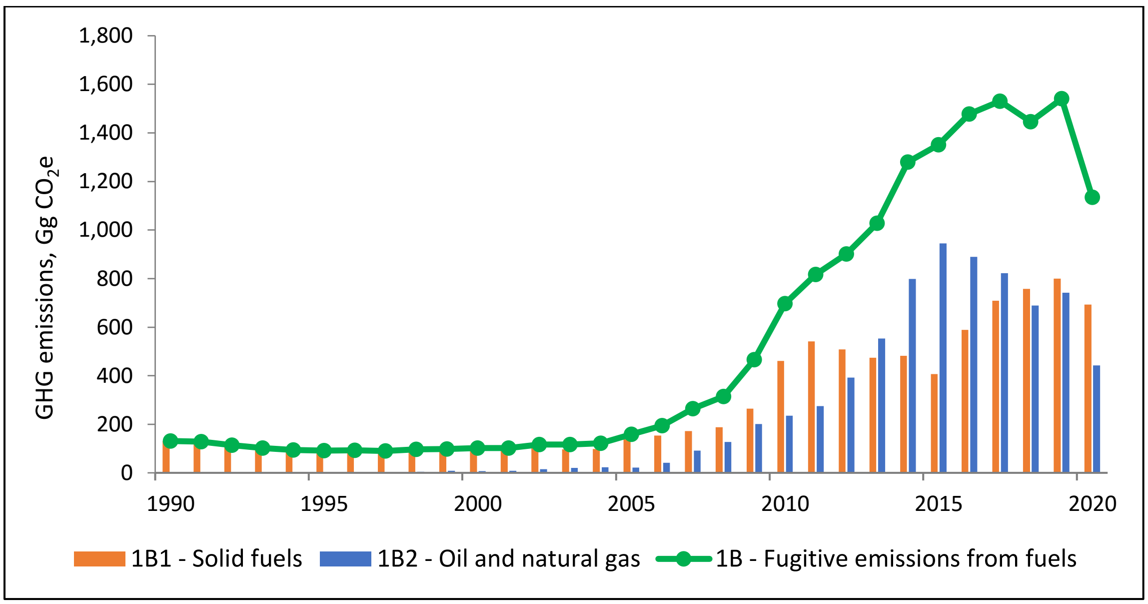

Figure 2.14 Total fugitive emissions from fuels for the period 1990-2020

From the figure above it can be seen that fugitive emissions from coal mining and handling were relatively constant up to 2011 and have continued to decrease slightly. On the contrary, the fugitive emissions from oil production have steadily increased, but dropped in 2020.

2.4.2 Industrial processes and product use (IPPU)

The GHG emissions of IPPU sector estimated from mineral industry, metal industry, non-energy products from fuels and solvent use, and product uses as substitutes for ozone depleting substances. The rest of the activities under IPPU sector were excluded from the inventory because they either do not occur in

Mongolia or there was no sufficient data to use. For example, the chemical and electronics industries are not the cases for consideration at present in in Mongolia. The main contributors to the total emissions from IPPU sector are the mineral industry (cement and lime production) which emitted the CO_2 and the product uses as substitutes for ozone depleting substances the HFCs. Figure 2.15 shows the share of IPPU sector with 2.66% of the national total emissions in 2020.

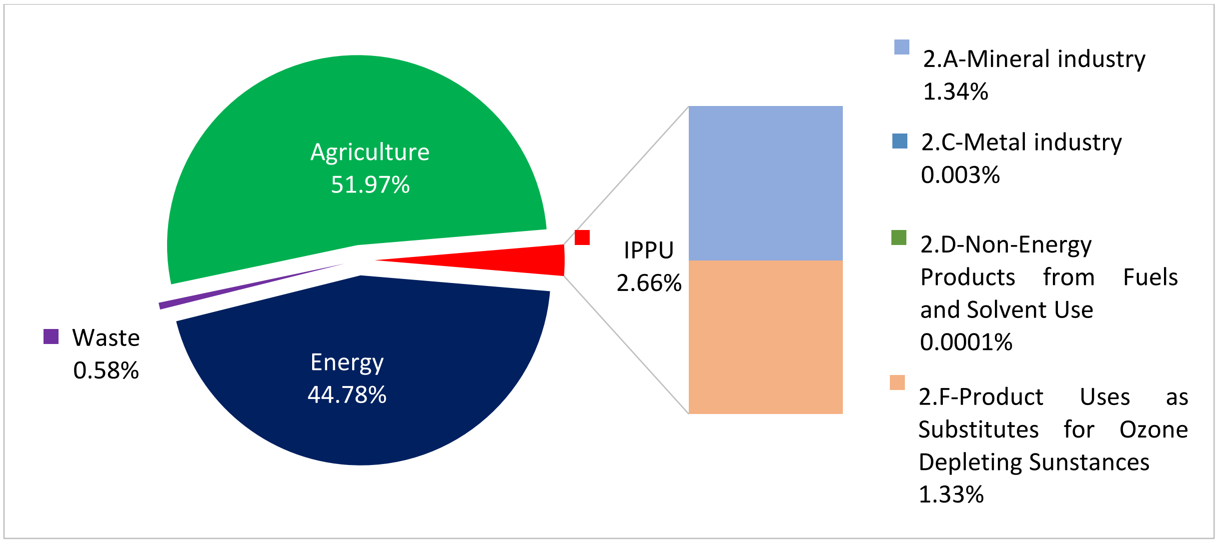

Figure 2.15 Share of each subsector of IPPU sector in total national GHG emissions (excl. LULUCF), 2020

The main contributors to the total emissions of the sector were mineral industry and product uses as substitutes for ozone depleting substances with share of 50.10% and 49.78%, respectively in 2020.

Table 2.9 provides the difference of GHG emissions of IPPU sector between1990 and 2020.

Table 2.9 GHG emissions from IPPU sector by source categories in 1990 and 2020

Subsectors	*Gas*	*Emissions, Gg CO_2e*		*Change from 1990 ($Gg\ CO_2e$)*	*Change from 1990 (%)*
		1990	*2020*		
2.A. - Mineral industry	CO_2	272.08	575.18	303.10	111.40%
2.C - Metal industry	CO_2	NA	1.22	-	-
2.D - Non-energy products from fuels and solvent use	CO_2	12.89	0.04	-12.85	-99.69%
2.F - Product uses as substitutes for ozone depleting substances	CO_2	NA	571.30	-	-
IPPU total	CO_2	284.98	1,147.7 5	862.77	302.75%

Abbreviations: NA-Not Applicable

In Mongolia the metal industry production launched in 1995, thus, GHG emissions were not estimated for the period of 1990-1994. The activity data of product uses as substitutes for ozone-depleting substances were available from 2012. According to the 2006 IPCC GLs, Volume 3, Part 2, if there is Tier 1 method was applied for estimation of HFCs emissions, then it back-calculates the development of banks of a refrigerant from the current reporting year to the introduction year. The introduction year for

HFC-134a (mobile air conditioning) is 2007. Thus, emissions from the metal industry and product uses as substitutes for ozone depleting substances categories in 2020 were incomparable with emissions in 1990, due to the data unavailability. Compared to 1990 the total emissions from the IPPU sector increased by 862.77 Gg CO_2e in 2020.

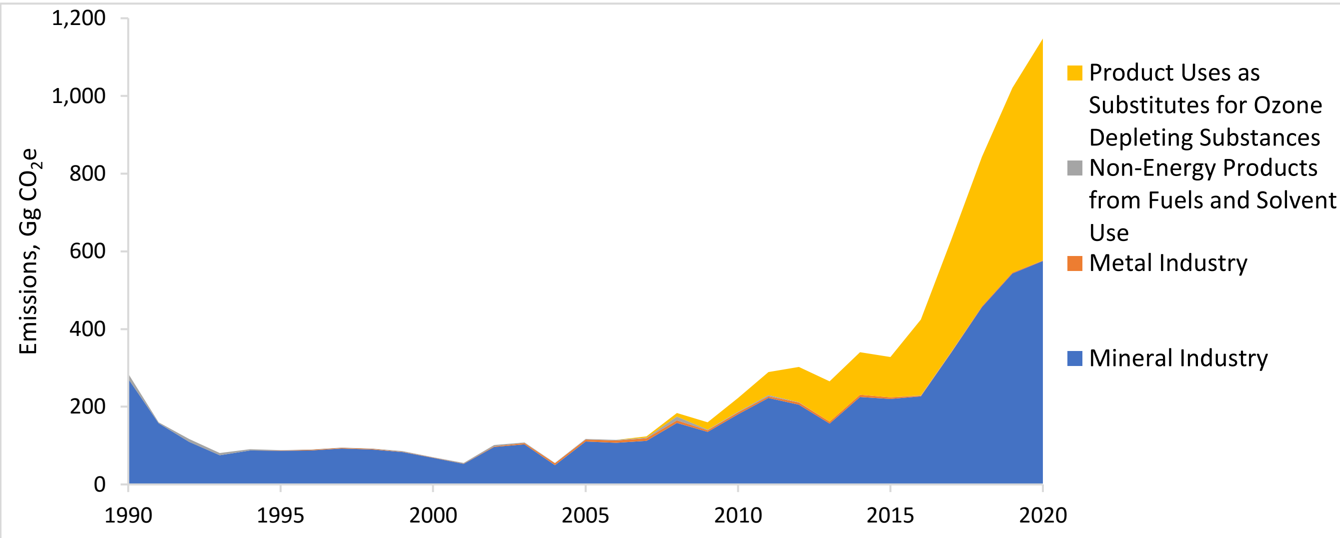

Figure 2.16 GHG emissions from IPPU sector by source categories, Gg CO_2e

Figure 2.16 shows emissions from IPPU sector demonstrated year-by-year variations during the 1990-2020 timeseries, GHG emissions from the IPPU sector continuously increased since 2015. From 2008-2009 there was an economic downturn in Mongolia and after this in 2010 the economy has grown back. The emissions from mineral industry significantly increased since 2014 (Table 2.10). In Mongolia there are two main cement plants operating namely Darkhan cement plant, built in 1968 and "Cement and Lime" cement plant, built in 1983. The processing technology of both plants changed from wet to dry in 2014, with generating capacity of 1 million tonnes of cement per year. The total GHG emissions of IPPU sector had increased sharply since 2016, due to the growth of consumption of products uses as substitutes for ozone depleting substances.

Table 2.10 The aggregated GHG emissions of IPPU sector by source categories, 1990-2020

Year	*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 emissions of IPPU sector*
	Emissions, Gg CO_2e				
1990	272.08	NA	12.89	NA	284.98
1991	157.47	NA	2.45	NA	159.92
1992	109.42	NA	7.36	NA	116.78
1993	74.78	NA	6.15	NA	80.92
1994	87.72	NA	3.07	NA	90.79
1995	86.64	1.25	0.62	NA	88.50
1996	87.88	1.54	0.62	NA	90.03

1997	92.53	1.82	0.62	NA	94.96
1998	90.03	1.30	1.23	NA	92.56
1999	82.95	1.05	1.85	NA	85.84
2000	68.28	1.04	1.23	NA	70.55
2001	52.50	0.80	1.85	NA	55.15
2002	96.89	1.27	3.68	NA	101.84
2003	103.39	3.14	1.85	NA	108.38
2004	49.86	4.39	1.23	NA	55.48
2005	110.36	5.24	1.23	NA	116.83
2006	107.53	5.60	1.23	NA	114.36
2007	111.99	6.43	1.85	3.10	123.37
2008	158.71	6.51	1.85	9.45	176.51
2009	135.18	4.01	1.85	19.27	160.31
2010	180.20	5.14	1.85	35.67	222.85
2011	222.18	4.80	3.07	59.09	289.13
2012	205.54	5.45	0.62	90.52	302.13
2013	156.91	4.48	0.62	102.30	264.31
2014	225.29	5.15	0.62	108.22	339.28
2015	220.49	3.50	0.62	101.97	326.58
2016	226.82	1.34	0.62	194.18	422.96
2017	340.59	1.68	0.31	288.09	630.67
2018	456.76	2.34	0.25	382.53	841.88
2019	543.29	2.29	0.06	473.17	1018.81
2020	575.18	1.22	0.04	571.30	1147.75
Diff% 1990/2020	*111.40%*	*-*	*-99.69%*	*-*	*302.75%*
Diff% 2019/2020	*5.87%*	*-46.72%*	*-33.33%*	*20.73%*	*12.66%*

Abbreviations: NA-Not Applicable

2.4.3 Agriculture

The agriculture sector of GHG inventory covers three main source categories such as enteric fermentation, manure management, and aggregated sources and non-CO_2 emissions on land. The GHG inventory of the sector is based on estimating of methane from enteric fermentation and manure management; and nitrous oxide and methane from the aggregate sources and non-CO_2 emissions on land. The GHG emissions from these three categories were mainly depend on the livestock population of the country. Furthermore, this emission estimation according to Mongolian agricultural subdivisions such as (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 agriculture sector is the main contributor to national total GHG emissions (without LULUCF) with share of 51.97% (22,390.57 Gg CO_2e) in 2020 (Figure 2.17).

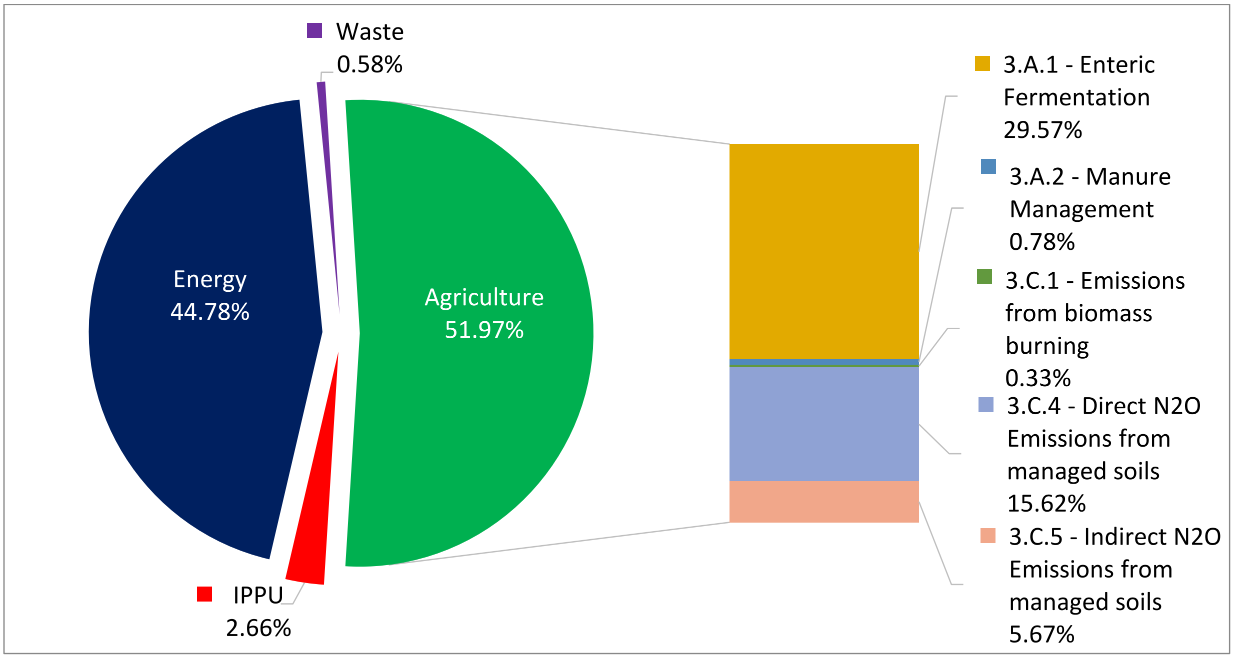

Figure 2.17 Share of each subsector of agriculture sector in total national GHG emissions (excl. LULUCF), 2020

The emissions from agriculture sector increased by 99.53% from 11,168.83 Gg CO_2e in 1990 to 22,390.57 Gg CO_2e in 2020.

Table 2.11 Emissions from agriculture sector in 1990 and 2020

Subsector	*Gas*	*Emissions, Gg CO_2e*		*Change from 1990*	*Change from 1990*
		1990	*2020*	*(Gg CO_2e)*	*(%)*
3.A.1 - Enteric fermentation	CH_4	6,310.67	12,741.16	6,430.49	101.90
3.A.2 - Manure management	CH_4	175.23	334.00	158.77	90.60
3.C - Aggregate sources and non-CO_2 emissions sources on land	CH_4, N_2O	4,735.74	9,315.42	4,579.67	96.70
3. Agriculture total	CH_4, N_2O	11,221.64	22,390.57	11,168.83	99.53

Emissions from livestock are generated through enteric fermentation and manure management of domestic animals such as cattle, sheep, goats, camels, horses and swine. In 2020, the total emissions from livestock were 13,075.15 Gg CO_2e which represented 58.40% in agriculture sector. In general, the total livestock emissions showed an increasing trend from 6,857.25 Gg CO_2e in 1990 to 13,075.15 Gg CO_2e in 2020, in particular, due to population growth of the domestic livestock from 25,856.90 thousand heads in 1990 to 67,068.49 thousand heads in 2020.

Total emissions of the aggregate sources and non-CO_2 emissions sources on land subsector showed an increased by 96.70% from 4,735.85 Gg CO_2e in 1990 to 9,315.42 Gg CO_2e in 2020, due to rising number of livestock, hence the amount of manure deposited on the pasture.

Within the agriculture sector, enteric fermentation contributes the highest in the GHG emissions with 56.90%, followed by aggregate sources and non-CO_2 emissions sources on land with 41.60% and manure management with 1.49% in 2020 (Figure 2.18).

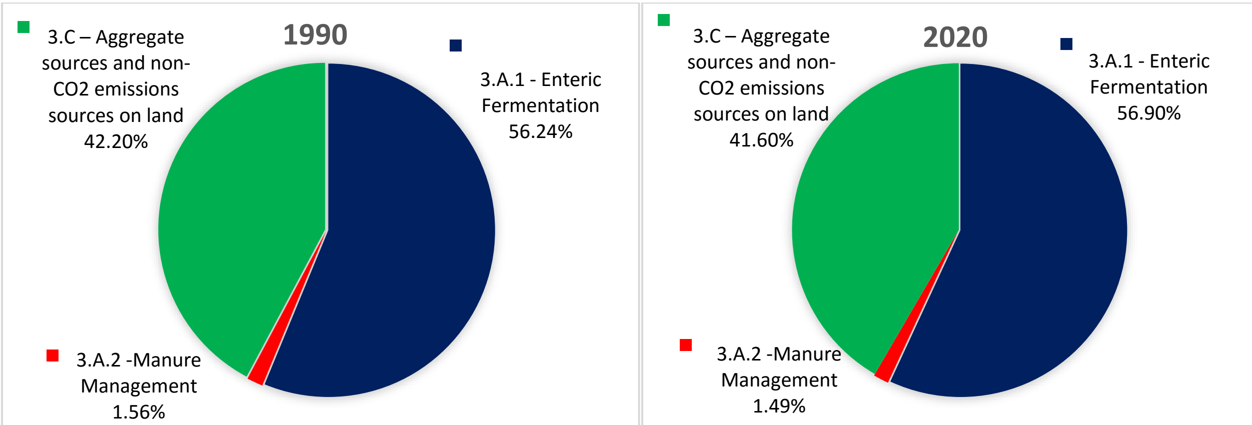

Figure 2.18 Share of GHG emissions from agriculture sector

A long-term trend of GHG emissions from agriculture sector for the period 1990- 2020 is demonstrated by subcategories in Table 2.12.

Table 2.12 Trend in aggregated emissions of agriculture sector, 1990-2020

Year	*3.A.1 - Enteric Fermentation*	*3.A.2 - Manure Management*	*3.C.1 - Emissions from biomass burning*	*3.C.4 – Direct N_2O emissions from managed soils*	*3.C.5 – Indirect N_2O emissions from managed soils*	*3. Agriculture total*
	Emissions, Gg CO_2e					
1990	6,310.67	175.23	731.39	2,984.13	1,020.23	11,221.64
1991	6,197.84	170.32	1,452.54	2,950.02	1,008.30	11,779.02
1992	6,143.54	166.49	287.23	2,947.40	1,008.08	10,552.74
1993	5,966.73	161.61	650.79	2,836.23	973.41	10,588.77
1994	6,438.77	174.75	855.27	3,058.23	1,047.14	11,574.18
1995	6,965.65	189.64	34.72	3,316.34	1,131.73	11,638.09
1996	7,207.51	196.42	2,551.52	3,432.27	1,168.58	14,556.30
1997	7,568.46	205.98	2,639.49	3,642.06	1,244.85	15,300.84
1998	7,882.93	215.10	1,437.65	3,800.42	1,303.84	14,639.94
1999	8,068.33	220.60	1,341.63	3,876.65	1,329.25	14,836.47
2000	6,910.68	188.12	305.49	3,359.35	1,169.42	11,933.07
2001	5,407.56	149.15	291.14	2,701.66	974.20	9,523.69
2002	4,932.29	135.90	280.96	2,482.42	895.50	8,727.06
2003	5,009.97	137.39	1,190.69	2,560.56	936.24	9,834.85
2004	5,335.99	145.01	1,970.29	2,763.56	1,018.02	11,232.86
2005	5,697.09	153.18	1,095.21	2,945.00	1,087.03	10,977.51
2006	6,362.48	168.93	1,401.24	3,329.28	1,231.64	12,493.57
2007	7,203.79	188.79	431.63	3,789.10	1,406.39	13,019.70

2008	7,580.35	195.72	414.84	4,019.96	1,496.25	13,707.12
2009	7,760.63	199.85	355.46	4,111.79	1,524.43	13,952.16
2010	6,112.71	160.44	139.20	3,202.31	1,171.40	10,786.05
2011	6,697.47	176.04	545.20	3,545.11	1,300.86	12,264.68
2012	7,476.71	196.21	1,375.65	3,966.17	1,457.84	14,472.57
2013	8,299.27	218.45	1,474.58	4,418.95	1,620.91	16,032.15
2014	9,588.75	251.22	766.72	5,055.33	1,851.58	17,513.60
2015	10,429.36	273.02	1,621.40	5,465.62	1,998.47	19,787.87
2016	11,400.76	298.63	817.00	5,996.14	2,194.83	20,707.36
2017	12,273.60	321.77	326.12	6,487.49	2,375.25	21,784.24
2018	12,314.29	322.57	106.92	6,534.78	2,391.13	21,669.69
2019	13,201.90	345.26	161.31	7,016.46	2,562.79	23,287.71
2020	12,741.16	334.00	142.25	6,729.39	2,443.77	22,390.57
Diff% 1990/2020	*101.90%*	*90.60%*	*-80.55%*	*125.51%*	*139.53%*	*99.53%*
Diff% 2019/2020	*-3.49%*	*-3.26%*	*-11.81%*	*-4.09%*	*-4.64%*	*-3.85%*

The GHG emissions from agriculture sector generally increased from 1990 to 2020. As seen from the Figure 2.19, the aggregated emissions in the agricultural sector tend to fluctuate depending on the occurrence of drought and dzud, as well as forest and grasslands fires in certain years.

Since the 1990s, the total number of animals generally increased and reached 67,256.93 thousand heads in 2020. However, there is a high impact natural disaster of Mongolia named dzud in which large numbers of livestock die due to severe weather condition like heavy snowfall, cold spells etc. mostly occurring in winter and spring season. For example, 1999-2000, 2000-2001 and 2001-2002, Mongolia was hit by three dzuds in a row, which lead to loss of 3,341.4 thousand heads (10%), 4,152.2 thousand heads (14%), 2,177.6 thousand heads (8%) animals, respectively, excluding swine and poultry population. Whitin the GHG inventory period, the second harsh winter occurred in 2009-2010, during which over 11 million livestock were lost and decreased by circa 26% from previous year’s total.

Compared to 2019, in 2020 GHG emissions demonstrated a decrease in all source categories of the agriculture sector. The decrease of emissions in 2020 depends on the following reasons: (i) summer hay and crop productions were affected by drought, (ii) large number of livestock were preemptively slaughtered to prevent dzud risk, (iii) loss of 2.1 million head of livestock due to dzud in that year.

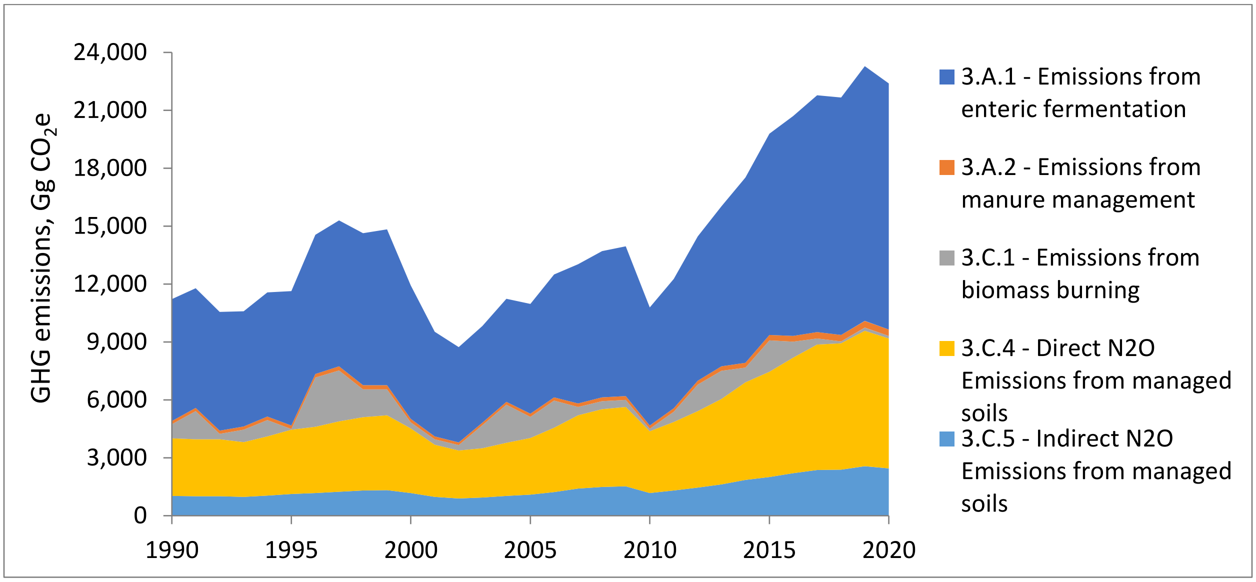

Figure 2.19 Trend in aggregated emissions by subcategories within the agriculture sector for the period 1990-2020, Gg CO_2e

2.4.4 Land use, land use change and forestry (LULUCF)

The 2006 IPCC guidelines for national greenhouse gas inventories for the AFOLU sector and the Good practice guidance (GPG) for LULUCF were used to estimate GHG emissions. **C**ountry specific the land matrix obtained using the Collect earth program from the Agency for land administration and management, geodesy, and cartography (ALAMGAC, 2021) was used for GHG inventory of Mongolia. Land matrix includes six land use categories such as forest land, cropland, grassland, wetland, settlement and other land, and land area conversions among subcategories. However, due to lack of the activity data (grassland and cropland categories) and country specific method for calculations (wetlands, settlements, and other land) emissions and removals from these subcategories were not reported in the national GHG inventory. Thus, this report included GHG emissions and removals from the forest land remaining forest land, and emissions from land conversions among different types of land management into another land types, and the harvested wood products.

Table 2.13 summarizes GHG emissions and removals from the land use, land use change and forestry (LULUCF) sector of Mongolia from 1990 to 2020. In 2020, total removal was -30,172.52 Gg CO_2e which was increased by 3.80% compared with 1990, mainly occurred in forest land category, and decreased by 0.09% compared with 2019.

Table 2.13 GHG emissions and removals from LULUCF sector by source categories, Gg CO_2e

Subsectors	1990	1995	2000	2005	2010	2015	2020	Diff 1990/2020	Diff% 1990/2020
3.B.1 - Forest Land	-29,367.35	-31,124.02	-29,432.74	-30,171.68	-30,598.34	-30,897.70	-30,336.91	-969.56	3.30
3.B.3 -Grassland	422.86	6.92	1,588.08	10.38	8.75	9.32	4.89	-417.97	-98.84
3.B.6 - Other land	NE	NE	367.18	141.55	56.13	NE	NE		
3.D.1 - Harvested wood products	-82.7	296.46	338.11	335.52	268.21	197.13	159.5	242.20	-292.87
3 – LULUCF total	-29,027.19	-30,820.64	-27,139.37	-29,684.24	-30,265.24	-30,691.25	-30,172.52	-1,145.33	3.95

NE - Emissions occur but have not been estimated or reported

A long-term trend of the sectoral GHG emissions and removals is presented in Figure 2.20. GHG emissions and removals from HWP and land use change were less than 1% and 5%, respectively, of the sectoral total during entire time series.

Figure 2.20 GHG emissions and removals from LULUCF sector by source categories, Gg CO_2e

Figure 2.20 presents a long term trends of GHG emissions and removals from each subsector, separately, which are included in the inventory and discussed below in details.

2.4.4.1 Land

GHG removals from the land category were -30,332.00 Gg CO_2e in 2020 which is 4.79% higher than in 1990 (-28,944.50 Gg CO_2e) and almost same removal as in 2019 with -30,337.80 Gg CO_2e (Figure 2.21 (a)).

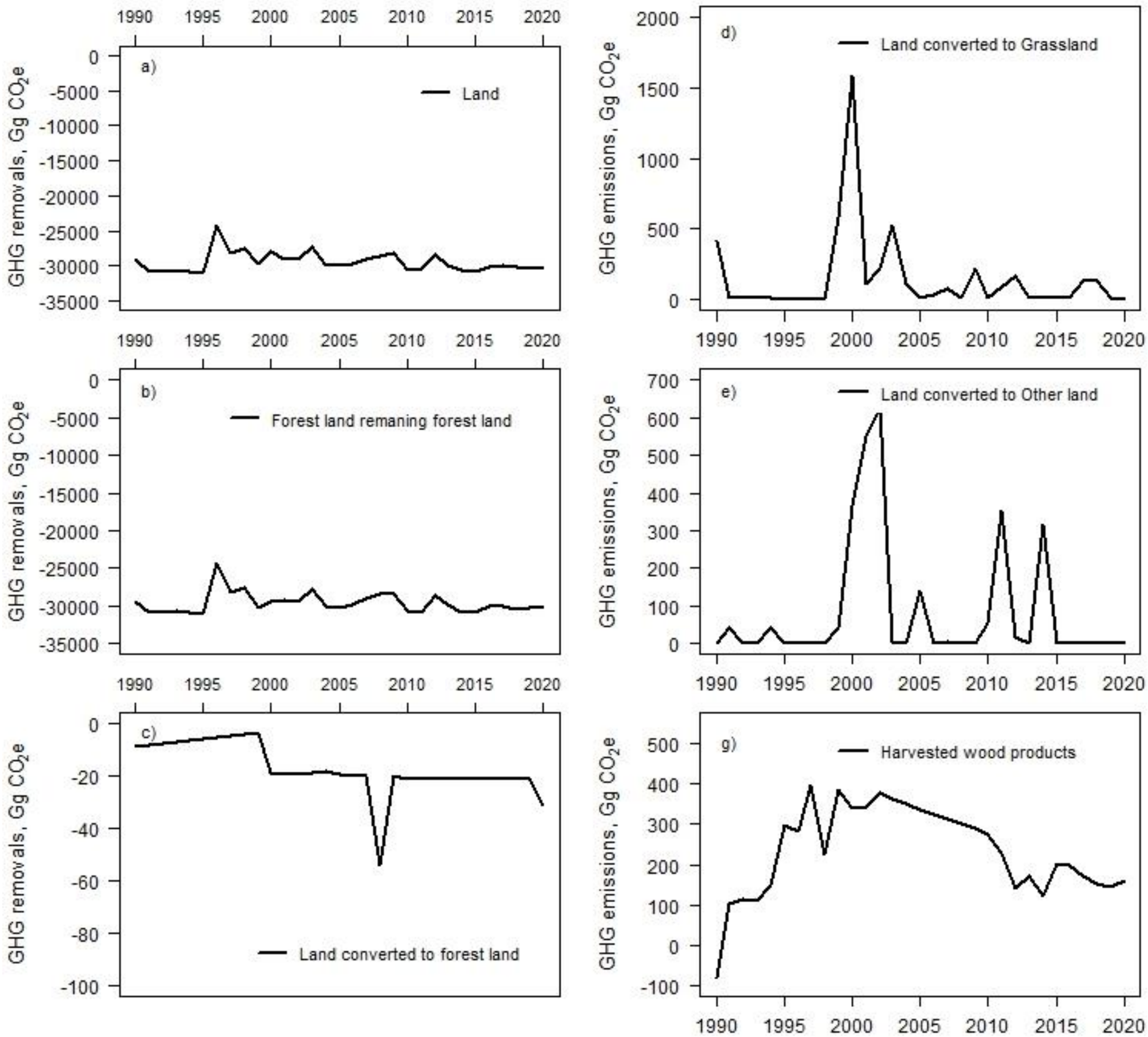

Figure 2.21 Long term trends of subsectoral GHG emissions and removals from the LULUCF sector, Gg CO_2e

Forest land: Forest land category includes both forest remaining forest and land converted to forest land subcategories which is one of the key categories of GHG removals of Mongolia.

As shown in Figure 2.21 (b) and 2.21 (c) and Table 2.13, GHG removals from forest land were -30,336.91 Gg CO_2e in 2020 compared with -29,367.35 Gg CO_2e in 1990, an increase by 3.20%. Changes in GHG emissions and removals occur mainly due to forest regeneration or/and annual harvest. For example, about 1.0 million hectares of forests that were affected by the great fires of the 1990s and early 2000s are regrowing naturally (MET, 2020).

Land use change: GHG emissions from the land converted to grassland was 422.9 Gg CO_2e and 4.89 Gg CO_2e in 1990 and 2020, respectively. The year-to-year changes in GHG emissions from this subsector varied depending on socio-economic conditions of Mongolia with the highest emissions of 1,588.10 Gg CO_2e in 2000 (Figure 2.21 (d)). Main reasons were intensified land privatization and the lowest GDP since transition to market economy. The emissions from the land converted to other land was the second net source in this category and randomly occurred over the years having the highest emission of 623.30 Gg CO_2e in 2002 (Figure 2.21 (e)).

2.4.4.2 Harvested wood products

As shown in Figure 2.21 (g), a long-term trend of GHG emissions and removals from the HWP category, GHG removals occurred with -82.7 Gg CO_2e only in 1990. In 2020, GHG emissions from HWP was 159.50 Gg CO_2e which is 16.50% higher compared with 2019 (136.90 Gg CO_2e). Emissions from HWP only estimated for sawnwood, hence no paper and paperboard production were found in Mongolia and all papers are considered imported. In Figure 2.22 shows that starting 1990s timber logging has been reduced almost tripled amount compared to the 1980s due to Mongolia's transition to a market economy. Wood was harvested 809.2 thousand m^3 in 2019 and 776.5 thousand m^3 in 2020 to meet consumptions of lumber, out of which 22.5% for domestic production and 77.5% for fuelwood.

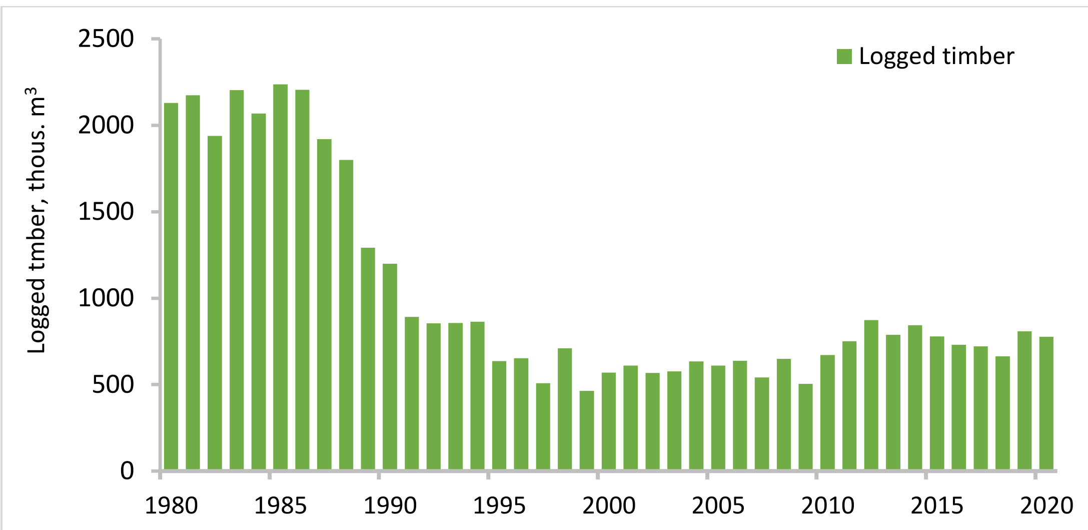

Figure 2.22 National level logging data, 1980-2020, thousand cubic meter

2.4.5 Waste

The waste sector of GHG inventory covers two main source categories, namely solid waste disposal and wastewater treatment and discharge. The GHG inventory estimation includes methane emissions from solid waste disposal sites and wastewater treatment and discharge; and nitrous oxide emissions from human sewage.

Figure 2.23 shows the share of each subsector in the total GHG emissions (excluding LULUCF) of the year 2020. The sectoral emission is an insignificant contributor to national total GHG emissions (excluding LULUCF) with its share of 0.58%, which is 50.82 Gg CO_2e in 2020.

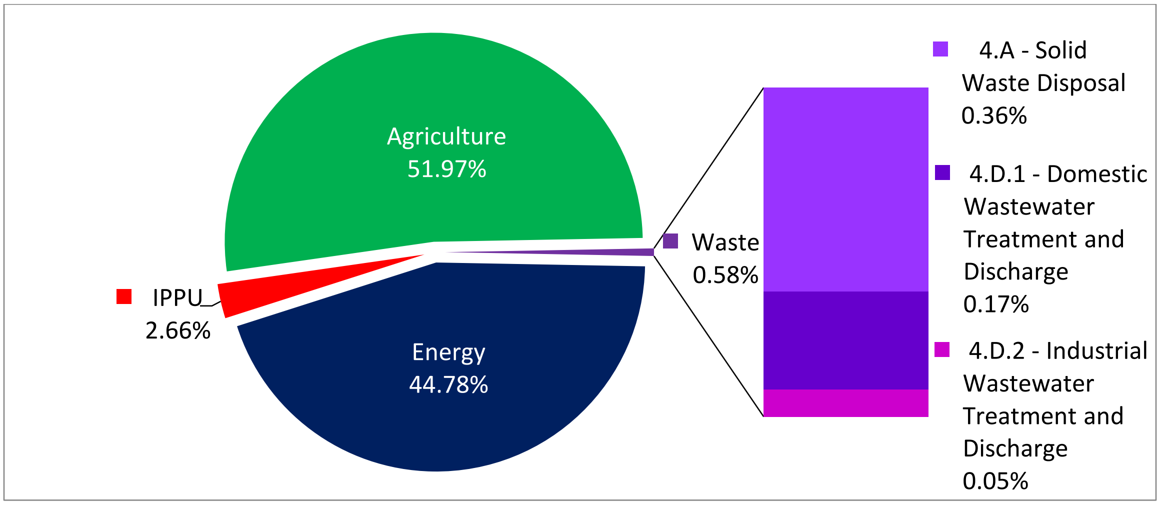

Figure 2.23 The share of each subsector of waste sector in total national GHG emissions (excl. LULUCF), 2020

In 2020, total aggregated emissions from the waste sector have been increased by 350.94% from 55.62 Gg CO_2e in 1990 to 250.82 Gg CO_2e, and 7.06% increase from the previous year.

Table 2.14 GHG emissions difference between 1990 and 2020 in waste sector

Subsector	*Gas*	*Emissions, Gg CO_2e*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
		1990	*2020*		
4.A - Solid waste disposal	CH_4	15.33	155.63	140.29	914.88%
4.D.1 - Domestic wastewater treatment and discharge	CH_4	19.45	47.11	27.66	142.28%
4.D.1 - Domestic wastewater treatment and discharge	N_2O	12.39	27.27	14.88	120.14%
4.D.2 - Industrial wastewater treatment and discharge	CH_4	8.46	20.82	12.36	146.19%
4. Total waste	CO_2e	55.62	250.82	195.20	350.94%

As seen from the Table 2.14, in 2020 compared to the base year, the methane emissions from solid waste disposal sites (SWDS) increased by 914.88% and the methane emissions from industrial wastewater treatment and discharge has increased by 146.19%, methane and nitrous oxide emissions from domestic wastewater treatment and discharge have been increased by 142.28% and 120.14%, separately.

Table 2.15 GHG emissions from waste sector by subsectors, Gg CO_2e

Subsector	Emissions	1990	1995	2000	2005	2010	2015	2020
4.A Solid waste disposal	(Gg)	15.33	19.60	22.92	34.00	45.27	95.94	155.63
	%	27.57	35.19	34.70	40.80	41.82	56.62	62.05
4.D.1 Domestic wastewater	(Gg)	31.83	33.49	39.24	45.03	52.14	58.72	74.38
	%	57.23	60.11	59.43	54.05	48.17	34.65	29.65
4.D.2 Industrial wastewater	(Gg)	8.46	2.62	3.87	4.29	10.85	14.80	20.82
	%	15.20	4.71	5.87	5.15	10.02	8.73	8.30
4 Total waste	Gg	55.62	55.71	66.03	83.32	108.26	169.46	250.82
	%	100	100	100	100	100	100	100

Within the waste sector, solid waste disposal sites (SWDS) was a dominant contributor to the GHG emissions and next two contributors were domestic and industrial wastewater treatment and discharge with 62.05%, 29.65%, and 8.30%, respectively, in 2020 (Table 2.15).

A long term trend of GHG emissions in waste sector is presented in Figure 2.24. Methane and nitrous oxide 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. Methane emissions have been rapidly increased last ten years due to waste was disposed to the well-managed landfills, which covered with soil in Ulaanbaatar. Meanwhile, the emission trend of methane from industrial wastewater treatment and discharge was fluctuating due to the certain year's economic conditions, for example, Mongolia's transition to a market economy since 1990.

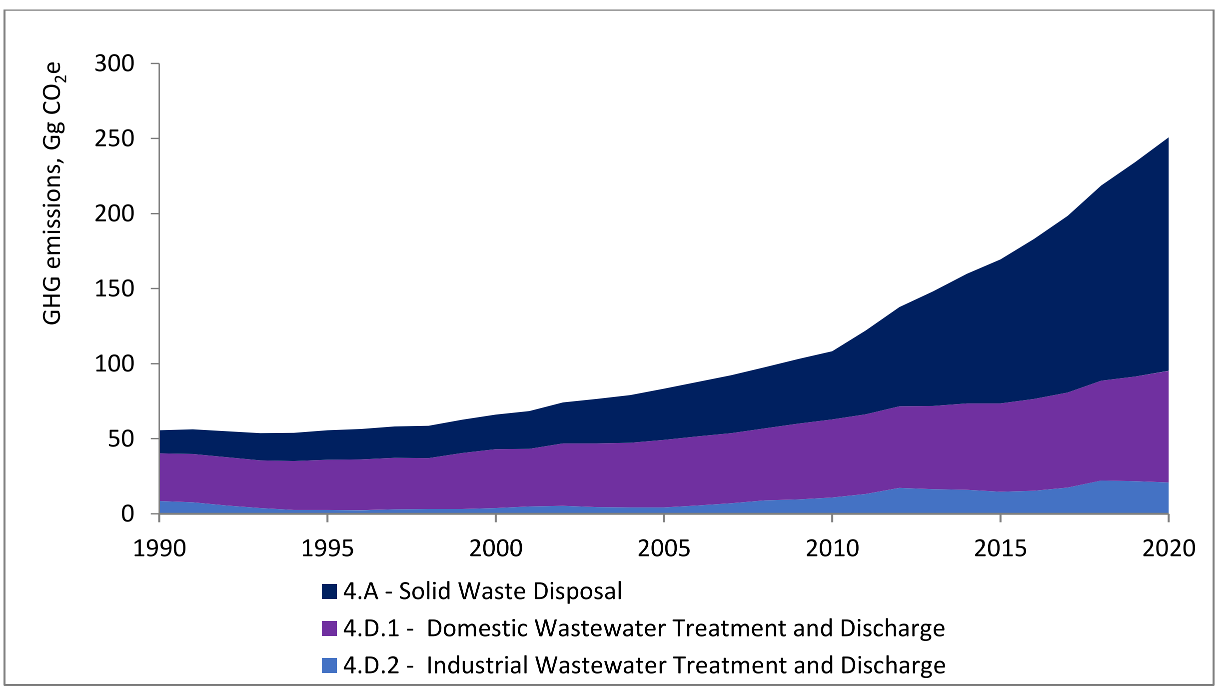

Figure 2.24 Trend of aggregated GHG emissions in the waste sector by source categories in 1990-2020, Gg CO_2e

2.4.5.1 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.

In 2020, total emissions from the SWDS have increased by 140.29 Gg CO_2e (914.88%) from the 1990 level of 15.33 Gg CO_2e. CH_4 emissions from SWDS are presented in Figure 2.25.

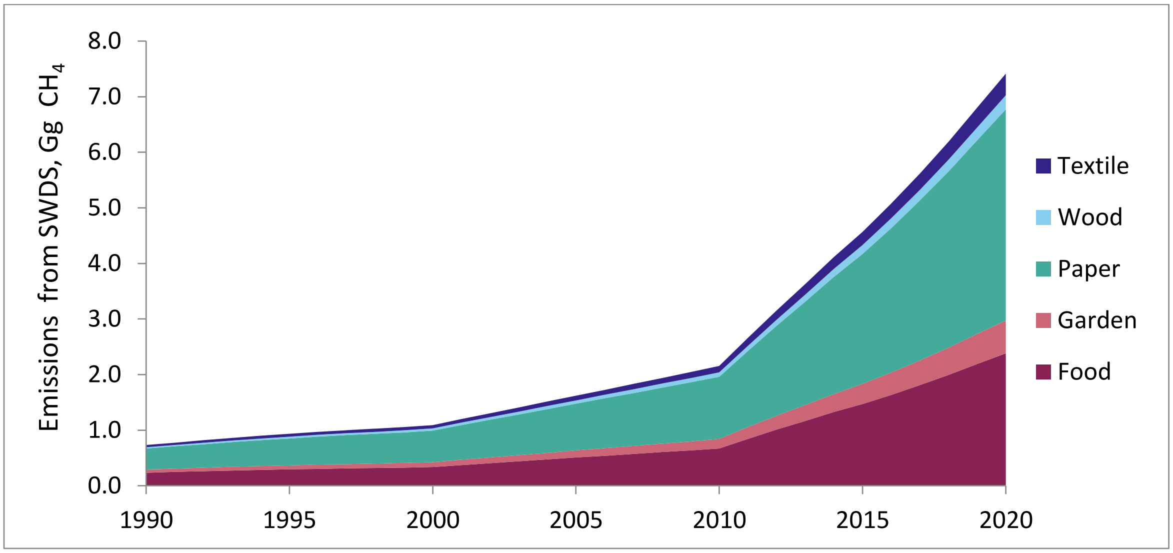

Figure 2.25 Quantities of CH_4 emission from biodegradable solid waste disposed in SWDS, 1990–2020

As seen from the Figure 2.25, the quantities of emitted methane from solid waste disposal (SWDS) has an increasing trend, and it depends on the population growth, especially in urban areas. The methane emissions have rapidly increased last 10 years, due to waste disposed to well-managed landfills which are covered with soil (where a degradation process is more intensive) in Ulaanbaatar. Another main factor which lead to the increase of emissions estimation is application of the FOD method for the SWD source category.

2.4.5.2 Wastewater Treatment and Discharge

This category covers emissions generated during municipal and industrial wastewater treatments. When the wastewater is treated anaerobically, methane is produced. Wastewater handling can also be a source of N_2O, which includes emissions from human sewage.

By 2020, share percentage of the each source contribution to the wastewater treament and discharge are changed as follows: CH_4 emissions from domestic wastewater treament and discharge (49.49%), N_2O emissions from domestic wastewater treament and discharge (28.65%) and CH_4 emissions from industrial wastewater treament and discharge (21.87%).

The emissions of methane and nitrous oxide from wastewater treatment by source categories are increasing year by year. In 2020, methane emissions from industrial wastewater treatment and discharge decreased by 3.94%, compared to 2019, due to the reduced industrial production during the COVID-19 pandemic (Figure 2.26).

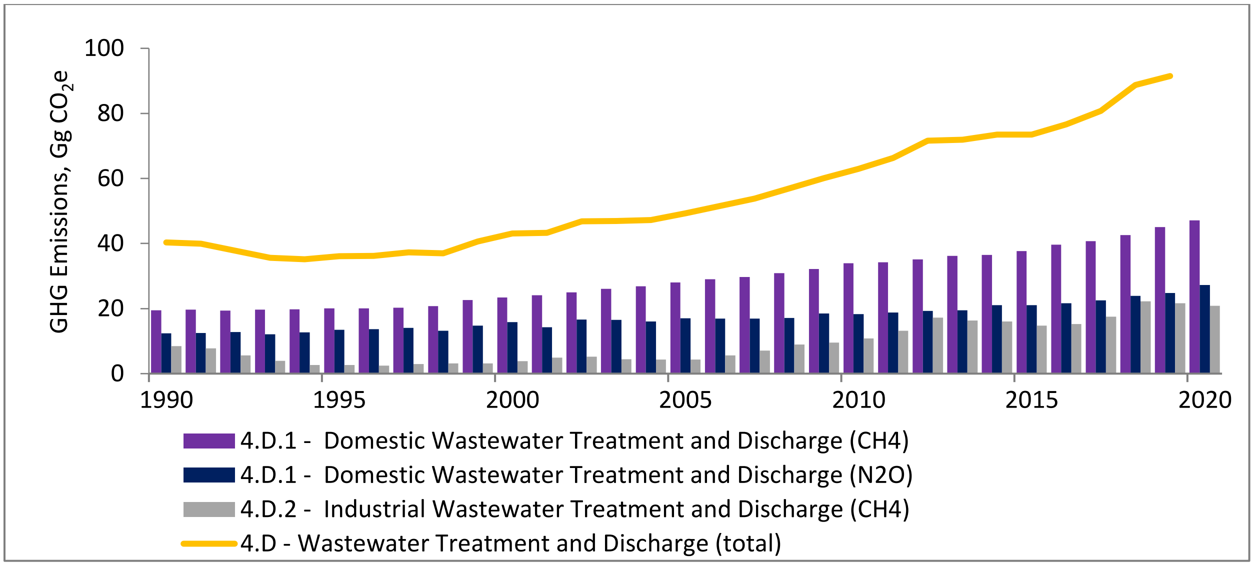

Figure 2.26 Emissions of methane and nitrous oxide from wastewater treatment by source categories

2.5 Summary of national GHG inventories for 1990-2020

The summary of the GHG inventory of Mongolia for the period of 1990 and 2020 is presented in Table 2.18. The main source of GHG emissions is the agriculture sector and its share in the national total was 47.45% in 1990 and slightly increased upto 51.97% in 2020. This shift was due to the number of animal (mostly, sheep and goat numbers) increased continually from 1990 to 2020. The second largest source is the energy sector with its share in the total emissions 51.11% in 1990 and 44.78% in 2020.

Table 2.16 Mongolia's GHG inventory in Gg CO_2e, 1990-2020

Sector	1990	1995	2000	2005	2010	2015	2020
Total emissions (source)	**23,648.79**	**20,534.44**	**20,862.04**	**21,010.83**	**24,462.03**	**36,597.14**	**43,081.62**
Net emissions (source and sink)	**-5,378.40**	**-10,286.19**	**-6,277.33**	**-8,673.41**	**-5,803.21**	**5,905.89**	**12,909.10**
1. Energy	12,086.55	8,752.15	8,792.39	9,833.17	13,344.88	16,313.23	19,292.48
1.A - Fuel Combustion Activities	11,955.64	8,660.34	8,690.46	9,674.46	12,648.41	14,961.81	18,157.11
1.A.1 - Energy Industries	6,408.20	5,734.65	6,361.32	6,740.47	8,102.31	9,934.12	11,095.40
1.A.2 - Manufacturing Industries and Construction	1,494.38	1,029.55	262.87	168.24	597.94	315.26	297.25
1.A.3 - Transport	2,277.86	1,074.46	1,320.03	1,698.12	2,448.87	3,343.24	4,896.88
1.A.4 - Other Sectors	1,098.43	361.66	607.83	856.99	1,082.79	882.73	964.08
1.A.5 - Non-Specified	676.77	460.02	138.42	210.64	416.49	486.45	903.51

1.B - Fugitive emissions from fuels	130.91	91.80	101.92	158.71	696.47	1,351.43	1,135.36
1.B.1 - Solid Fuels	130.91	91.80	94.84	137.47	461.17	406.34	692.75
1.B.2 - Oil and Natural Gas	NA	NA	7.09	21.24	235.30	945.09	442.61
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes and product use (IPPU)	284.98	88.50	70.55	116.83	222.85	326.58	1,147.75
2.A - Mineral Industry	272.08	86.64	68.28	110.36	180.20	220.49	575.18
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	NA	1.25	1.04	5.24	5.14	3.50	1.22
2.D - Non-Energy Products from Fuels and Solvent Use	12.89	0.62	1.23	1.23	1.85	0.62	0.04
2.E - Electronic Industry	NO	NO	NO	NO	NO	NO	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NA	35.67	101.97	571.30
2.G - Other Product Manufacture and Use	NA	NA	NA	NA	NA	NA	NA
2.H - Other	NA	NA	NA	NA	NA	NA	NA
3. Agriculture	**11,221.64**	**11,638.09**	**11,933.07**	**10,977.51**	**10,786.05**	**19,787.87**	**22,390.57**
3.A - Livestock	**6,485.90**	**7,155.29**	**7,098.80**	**5,850.27**	**6,273.15**	**10,702.39**	**13,075.15**
3.A.1 - Enteric Fermentation	6,310.67	6,965.65	6,910.68	5,697.09	6,112.71	10,429.36	12,741.16
3.A.2 - Manure Management	175.23	189.64	188.12	153.18	160.44	273.02	334.00
3.C - Aggregate sources and non-CO_2 emissions sources on land	**4,735.74**	**4,482.79**	**4,834.27**	**5,127.24**	**4,512.90**	**9,085.48**	**9,315.42**
3.C.1 - Emissions from biomass burning	731.39	34.72	305.49	1,095.21	139.20	1,621.40	142.25
3.C.2 - Liming	NO	NO	NO	NO	NO	NO	NO
3.C.3 - Urea application	NO	NO	NO	NO	NO	NO	NO
3.C.4 - Direct N_2O Emissions from managed soils	2,984.13	3,316.34	3,359.35	2,945.00	3,202.31	5,465.62	6,729.39
3.C.5 - Indirect N_2O Emissions from managed soils	1,020.23	1,131.73	1,169.42	1,087.03	1,171.40	1,998.47	2,443.77
3.C.6 - Indirect N_2O Emissions from manure management	NO	NO	NO	NO	NO	NO	NO
3.C.7 - Rice cultivations	NO	NO	NO	NO	NO	NO	NO
3.C.8 - Other	NA	NA	NA	NA	NA	NA	NA
4. Forestry and Other Land Use/(LULUCF)	**-29,027.19**	**-30,820.64**	**-27,139.37**	**-29,684.24**	**-30,265.24**	**-30,691.25**	**-30,172.52**
3.B - Land	**-28,944.49**	**-31,117.10**	**-27,477.48**	**-30,019.76**	**-30,533.45**	**-30,888.38**	**-30,332.02**
3.B.1 - Forest land	-29,367.35	-31,124.02	-29,432.74	-30,171.68	-30,598.34	-30,897.70	-30,336.91
3.B.2 - Grassland	NE	NE	NE	NE	NE	NE	NE
3.B.3 - Cropland	422.86	6.92	1,588.08	10.38	8.75	9.32	4.89
3.B.4 - Wetlands	NE	NE	NE	NE	NE	NE	NE

3.B.5 - Settlements	NE	NE	NE	NE	NE	NE	NE
3.B.6 - Other Land	-28,944.49	-31,117.10	-27,477.48	-30,019.76	-30,533.45	-30,888.38	-30,332.02
3.D - Other	**-82.70**	**296.46**	**338.11**	**335.52**	**268.21**	**197.13**	**159.50**
3.D.1 - Harvested Wood Products	-82.70	296.46	338.11	335.52	268.21	197.13	159.50
3.D.2 - Other	NA	NA	NA	NA	NA	NA	NA
4. Waste	55.62	55.71	66.03	83.32	108.25	169.46	250.82
4.A - Solid Waste Disposal	15.33	19.60	22.92	34.00	45.27	95.94	155.63
4.B - Biological Treatment of Solid Waste	NO	NO	NO	NO	NO	NO	NE
4.C - Incineration and Open Burning of Waste	NO	NO	NO	NO	NO	NO	NO
4.D - Wastewater Treatment and Discharge	40.29	36.11	43.12	49.32	62.98	73.52	95.19
5. Other	NA	NA	NA	NA	NA	NA	NA

Abbreviations: NE=not estimated, NO=not occurring, NA=not applicable

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CHAPTER 3. PRESENT CLIMATE CHANGE AND ITS FUTURE PROJECTION

3.1 Present climate change

Greenhouse gas (GHG). Since 1992, GHG sampling has been conducting by GMD, NOAA, USA jointly with Information and Research Institute of Meteorology, Hydrology and Environment of Mongolia at UUM site (Latitude: 44.4516° N, Longitude: 111.0956° E, Elevation: 1007.00 masl) in Erdene soum, Dornogobi province of Mongolia. The site is located in the east south side of Mongolia (Mongolian dessert -steppe region) far from any anthropogenic sources. It is a site of cooperative sampling network. Air samples are collected approximately weekly and analyzed for CO_2, CH_4, CO, N_2O, and SF_6 and other CO_2 isotopes in NOAA ESRL/GMD of USA.

According to this measurement, concentration of GHG has been increased such as CO_2 concentration were reached from 354.6 to 413.3 ppm (16.5%), and CH_4 concentration is 1808 to 1968 ppbv (8.8%) as respectevily for a period 1992-2020 (Figure 3.1).

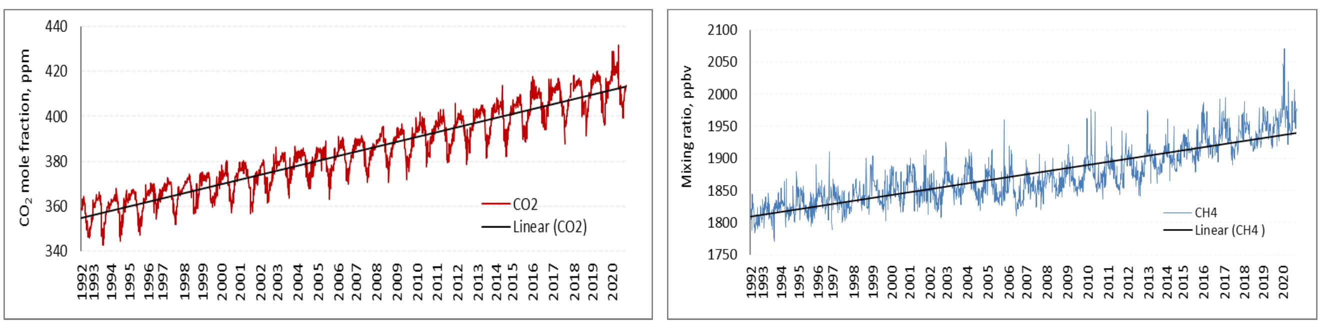


Figure 3.1 Trend of CO_2 and CH_4 concentration in atmosphere, ppm

Air temperature. Annual mean of near surface temperature over Mongolia has increased by 2.46°C between 1940-2022 periods according to 48 meteorological stations, which are evenly distributed over territory of the country. Intensity warming were detected since 1988 and their distribution is different depending on geographical location and altitude (Figure 3.2). Intensity warming is ranged between 2-3°C most of the country, and relative high intensity points are detected in Ulaanbaatar city and Khuvsgul, Sukhbaatar province, which is equal 3.4°C (Figure 3.3).

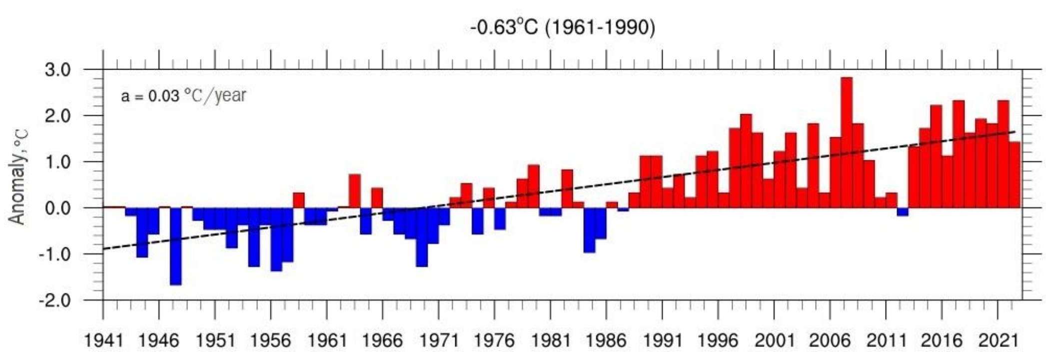


Figure 3.2 Annual mean air temperature trend over Mongolia (expressed by anomaly respect to 1961-1990 baseline)

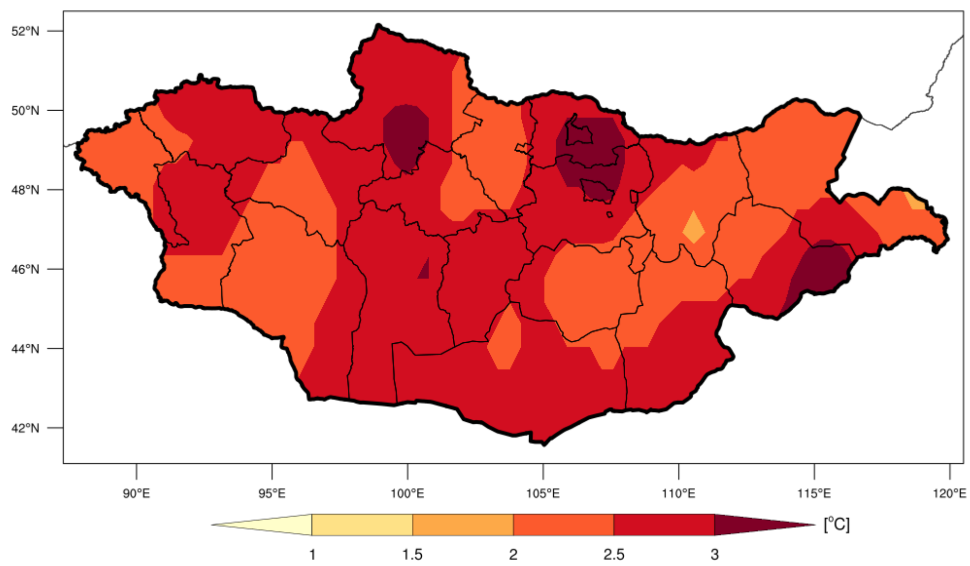


Figure 3.3 Geographical distribution of annual mean air temperature change

If consider seasonal temperature change, winter temperature has increased by 3.2°C during 1940-2022 period (Figure 3.4a), however its intensity was weakened since 2000, eventhough relative cold year was observed in some years. Summer temperature is incerased by 1.6°C and high intensity was detected since 1996 (Figure 3.4b).

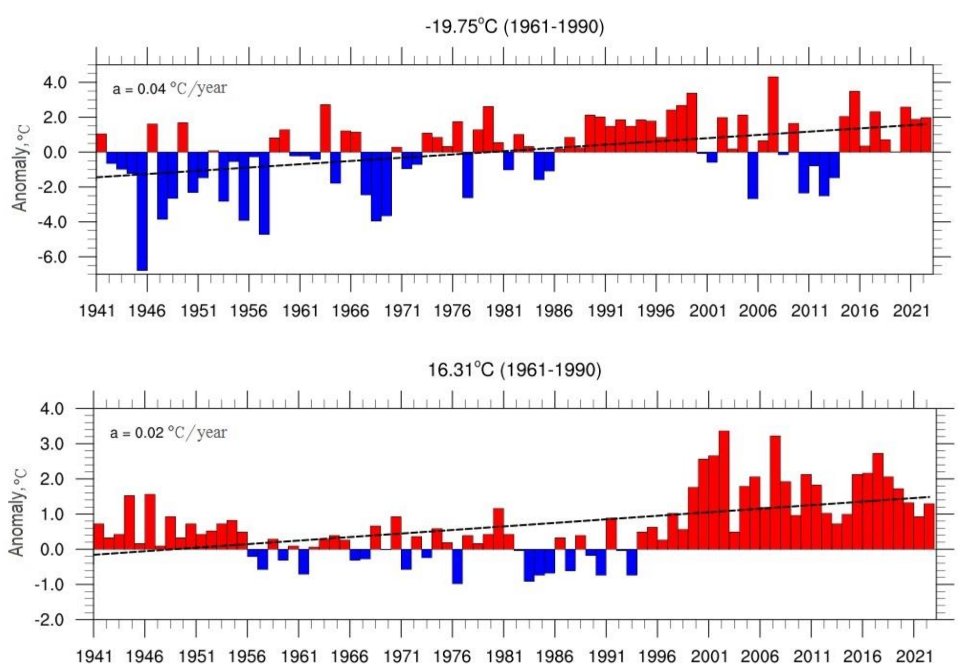


Figure 3.4 Trends of winter and summer temperature change over Mongolia (expressed by anomaly respect to 1961-1990 baseline)

Soil depth tempearture. According to soil depth temprature monitoring at 18 stations, annual mean temperature of shallow soil depth (20 and 40 cm) has increased by 2.2°C and deep soil tempearure has been increased by 2°C (80, 120, 160, 240 and 320 cm) within 1970-2020 period as respectivily (Figure 3.5). High intensity warming was detected by 3.7°C in 40 cm depth in Baruunturuun of Uvs province in 1968-2020 period.

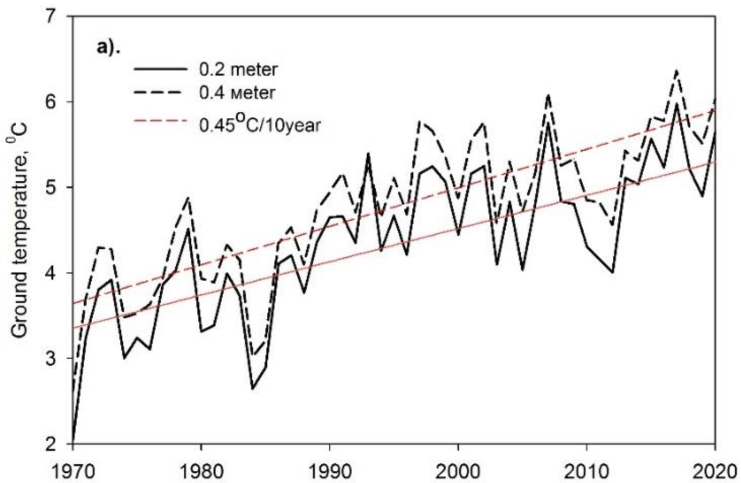
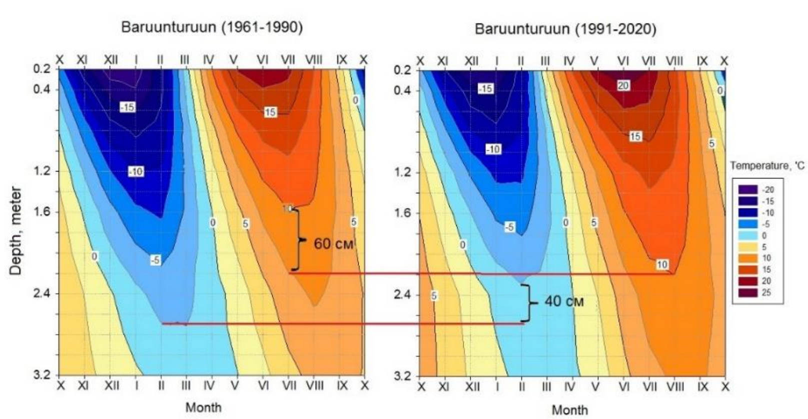


Figure 3.5 Trends of shallow and deep soil temperature change over Mongolia

In Mongolia, soil depth temperature penetration goes as symmetrically as to cool down from autumn to spring toward depth and warm up from spring to autumn as oppositely. Figure 3.6 shows comparison of soil depth temperature change at Baruunturuun (dry steppe) and Tsetserleg (forest steppe) meteorological station in different natural zone and periods.

In Baruunturrun soum, 0°C penetration depth is observed below 3.2 m. In cold season, -2.5°C depth were detected 2.7 m in 1961-1990 period and 2.3 m in 1991-2020 period as respectvielly, and its change is 40 cm as shifting to soil surface direction (Figure 3.6a). In warm season, +10°C penetration depth is observed in 1.6 m and it was become in 2.2 m as shifting 60 cm toward depth in above period. In Tsetserleg soum, 0°C penetration depth is shifted by 30 cm toward soil surface direction and +10°C depth is moved by 30 cm toward soil depth (Figure 3.6b). This condition brings permafrost meting, negative impact on rangeland and forest ecosystem, and futhuremore land degradation.



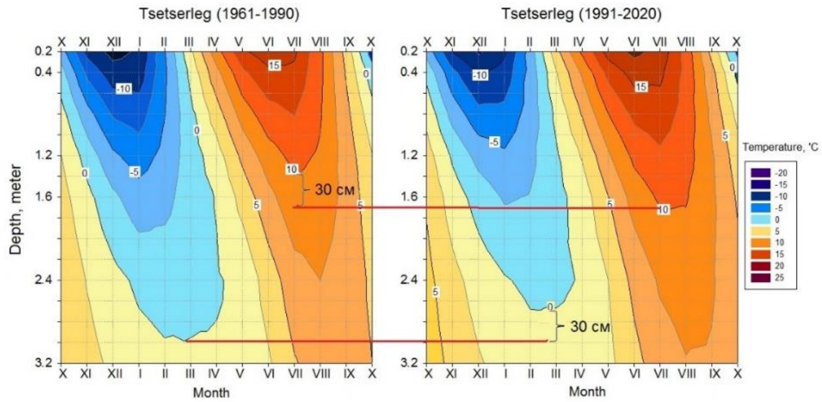


Figure 3.6 Soil depth temperature penetration at Batuunturuun and Tsetserleg station in 1961-1990 and 1991-2020 periods

Precipitation. Annual mean precipitation over Mongolia is slightly increasing in 1940-2022 period. However, if compare recent dry 1996-2011 period with 1977-1983 as prevously, length of dry period has been increased. Recently, precpitation is higher than norm in 2012-2013, 2016, 2018 and 2020 (Figure 3.7). In terms of geographical distribution for annual precipitation change, there is 10-30mm decreasing trend in central part and slightly increasing trend in remaining part of the country (Figure 3.8).

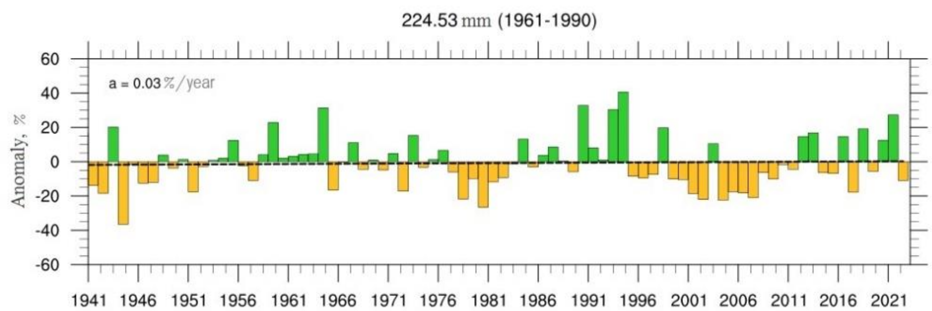


Figure 3.7 Trend of annual mean precpitation over Mongolia (expressed by anomaly respect to 1961-1990 baseline)

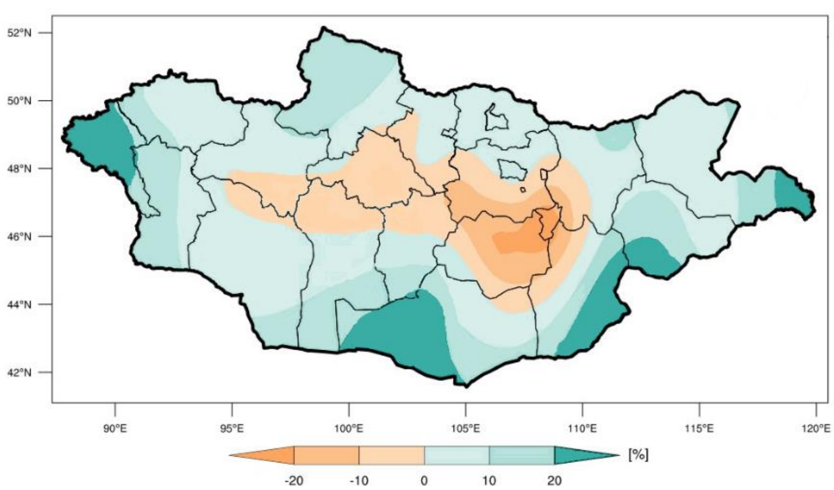


Figure 3.8 Geographical distribution of annual mean precpitation change

Warm season precipitation is main factor for particular year of summer condition, crop yield and livestock weight. General trend of cold season (Oct-Apr) and warm season (May-Sep) precipitation change is shown in Figure 3.9. Here, cold season precipitation is increased by 19% in 1940-2022 period (Figure 3.9a). There is no clear change in warm season precipitation, however less precipitation were occurred during 1998-2012 and consequently dry period was observed (Figure 3.9b).

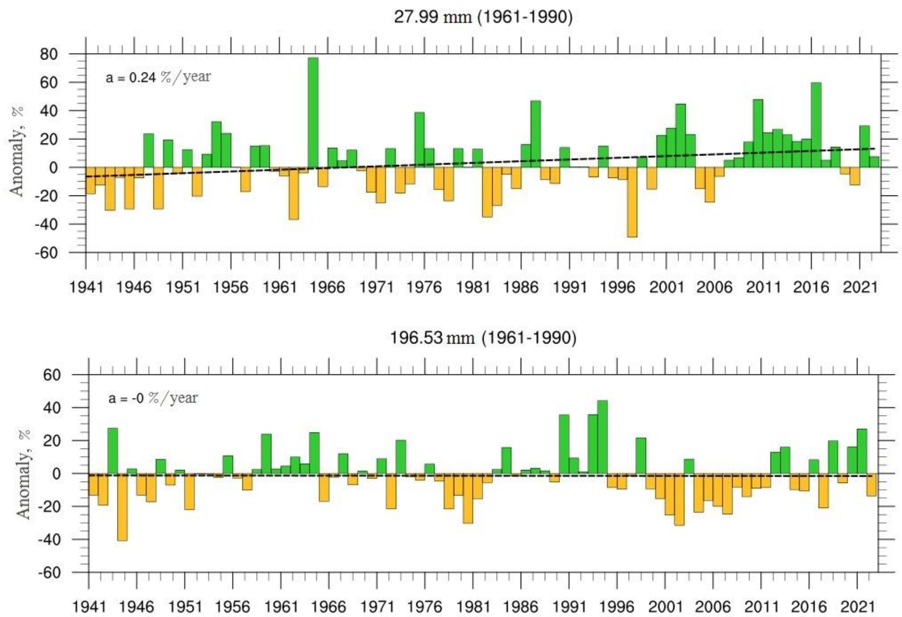


Figure 3.9 Cold and warm season precpitation change over Mongolia (expressed by anomaly respect to 1961-1990 baseline)

Change of climate extreme indicies. Climate extreme indices change is important for assessing climate change impact to socio-economic sectors. According to CCl/CLIVAR, WMO working group suggestion in 2013, key 11 extreme indices are monitored over Mongolia (Table 3.1).

Table 3.1 Definition of climate extreme indices

No	*Indices*	*Name*	*Definition*	*Impact sector*
		Temperature index		
TXx	Maximum of daily maximum temperature	Monthly maximum of daily maximum temperature	°C	Agriculture
TNn	Minimum of daily minimum temperature	Monthly minimum of daily minimum temperature	°C	Agriculture
F0	Frost days	Annual count when daily minimum temperature < 0°C	days	Agriculture and public health
SU30	Hot days	Annual count when daily maximum > 30°C	days	Agriculture and public health
Tn10p	Cool night	Number of days Tn<10 percentile	days	Agriculture and public health

Tx10p	Cool day	Number of days Tx<10 percentile	days	Agriculture and public health
Tn90p	Warm night	Number of days Tn>90 percentile	days	Water, agriculture and public health
Tx90p	Warm day	Number of days Tx>90 percentile	days	Water, agriculture and public health
		Precipitation index		
SDII	Daily precipitation intensity	Ratio of annual precipitation and number precipitated days	mm/day	Water, agriculture
R1	1 day maximum precipitation	Daily maximum precpitation	days	Water, agriculture
SPI	Dryness index	Standarised precipitation index 3, 6, 12 monthly	none	Water, agriculture

Maximum of daily maximum temperature (TXx) and minimum of daily minimum temperature (TNn) over Mongolia are increased by 1.56°C and 1.74°C in 1961-2020 period, and intensity of minimum of daily minimum temperature change is relative higher (Figure 3.10). Regarding to this change, extreme value of minimum of daily minimum temperature is broken in during recent years.

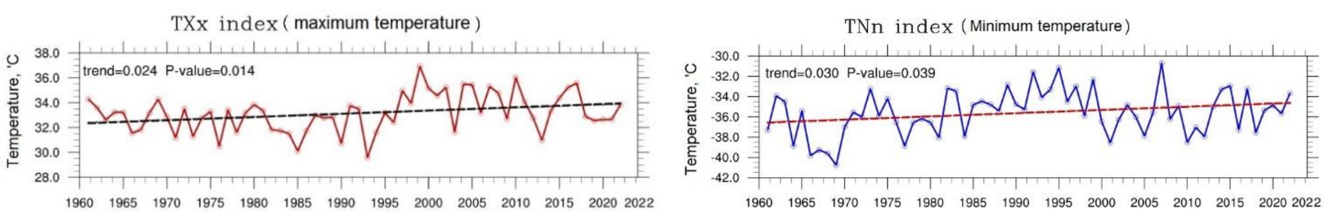


Figure 3.10 Maximum of daily maximum temperature and minimum of daily minimum temperature change over Mongolia

Figure 3.11 shows angle coefficient of linier trends of cold day and hot day, which are estimated at 67 meteorological stations in 1975-2020 period. Cold days are (Fd0) decreasing and its intensity is different depending on geographical location. For example, 28 days in Bayanbulag soum, Bayankhongor province. This is one of the positive impact of the global climate change on farming, construction and transportation activities and their time length.Hot days (SU30) are increasing over the country and highest intensity were observed in Tooroi, Gobi-Altai province (around 13 days).

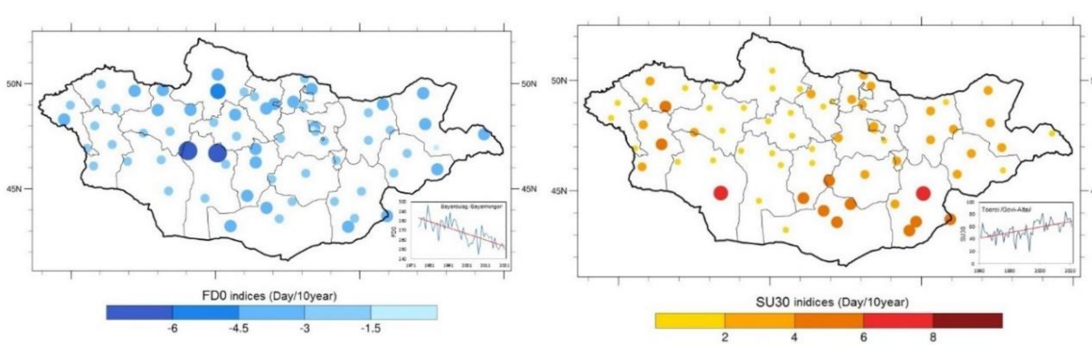


Figure 3.11 Cold and hot day change over Mongolia

The warm days (TX10p) are increasing by days, while warm nights by 11 days and cool night (TN10p) days are decreasing by 5 days, while cool days by 9 days as well. These changes over the country are shown in Figure 3.12 respect to 1961-1990 baseline.

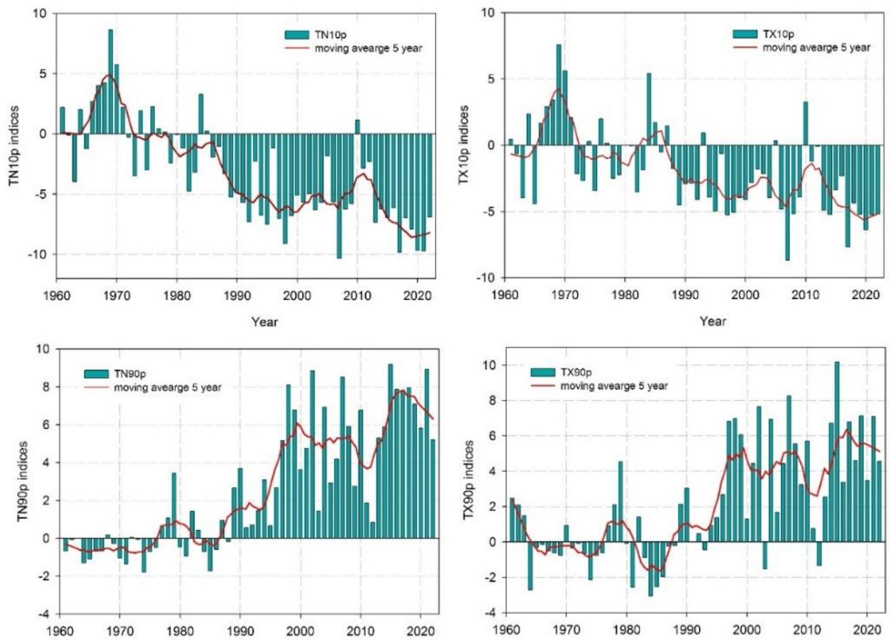


Figure 3.12 Trends of cool day and night, and warm day and night over Mongolia

There is no significant change annual precpitation over Mongolia, however winter precipitation is increasing, while summer precipitation is slightly decreasing. Daily precipitation intensity (SDII) has not systematic change in 1975-2020 period. Its value is decreasing at 36 meteorological stations, while increasing at 30 stations. High intensity increasing value 1.3-1.8 mm/days is observed with in Maanit, Ulaanbaatar region, while decreasing value 2.0-2.4 mm in Dashbalbar, Mandalgobi and Choir (Figure 3.13).

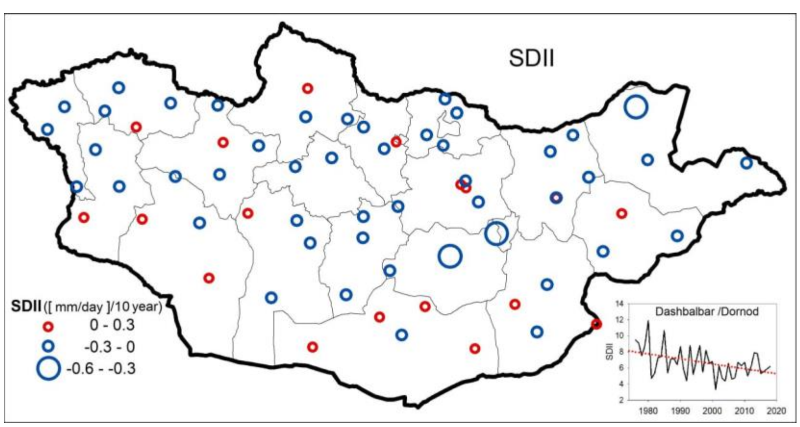


Figure 3.13 Change of daily precipitation intensity

High intensity precipitation causes significant loss and damage in socio-economic sectors. For example, 187 people was dead due to 45.5 mm/hour shower rain flush flood in Ulaanbaatar city in 2nd August, 1982, and totally 13.9 million tugrug loss have been occurred at this time.

According to historical measurement over territory of Mongolia during the period of 1939-2020, maximum daily precipitation was observed as 37-70 mm in western part and 70-120 mm in eastern part of the country (Figure 3.14). Maximum value was detected as 102.3 mm in Ulaangom, Uvs province on 24th June 1986, 128.3 mm in central part of the Bulgan province on 30th May 1976, and 120.1 mm in Bayandelger, Sukhbaatar province on 6th July 1998 as respectively.

In terms of observed timeline of daily maximum rainfall percentage as 54% was observed during the 2000-2020 period. It means that high intensity rainfall is increasing due to climate change.

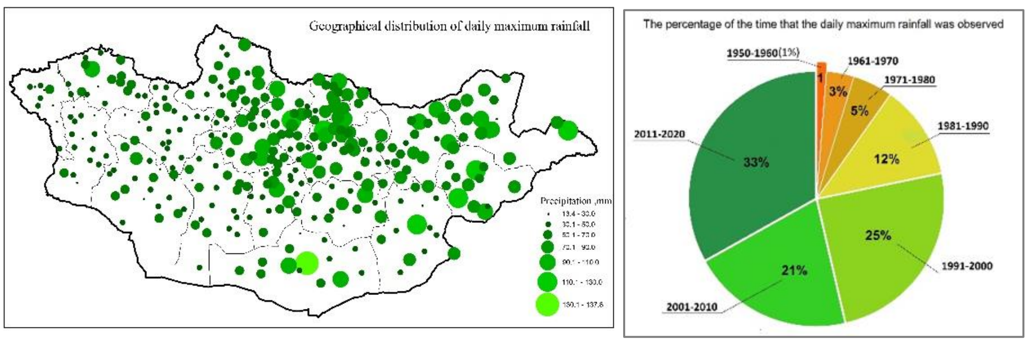


Figure 3.14 Geographical distribution of daily maximum rainfall and percentage of its occurrence in every 10 years

Meteorological drought (dryness index) are estimated by standartised precpitation index (SPI) as 12 months base. This case more represents hydrological drought as impacting to river and lake shrinking and dry up.

Figure 3.15 shows change of average dryness index for 44 meteorological stations from 1940 to 2020. The very dry years were occured during 1997-2011 period and the index value ranged from -0.5 to -1.0. Recent wet period years such as 2012-2014, 2016 and 2018, related index value was 0.6-0.8 and precpitation was higher than norm leading to flood in rivers and increase level of water in reservoirs.

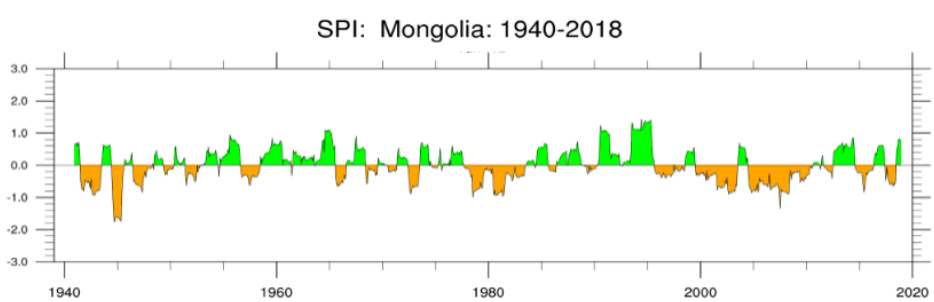


Figure 3.15 Trend of dryness index over Mongolia

3.2 Assessment of climate change and future projection

Twenty years ago, the coupled modeling working group of World Climate Research Program (WRCP), World Meteorological Organization (WMO) has been initialized comparison of global climate models to indicate climate system interaction between atmosphere, ocean, land surface and ice thermodynamic etc (Meehl et al., 1997). Since that time, research activity has been extended focusing on national and international climate change study not only climate but also climate change projection as well. Currently 6th Climate Model Intercomparison Project (CMIP6) is going on and some outputs are on the table.

The main purpose of this project was the study past, present and future climate based on natural climate variability, prediction and uncertainty, and response under change of radiation forcing using multiple climate models (V. Eyring et al, 2016).

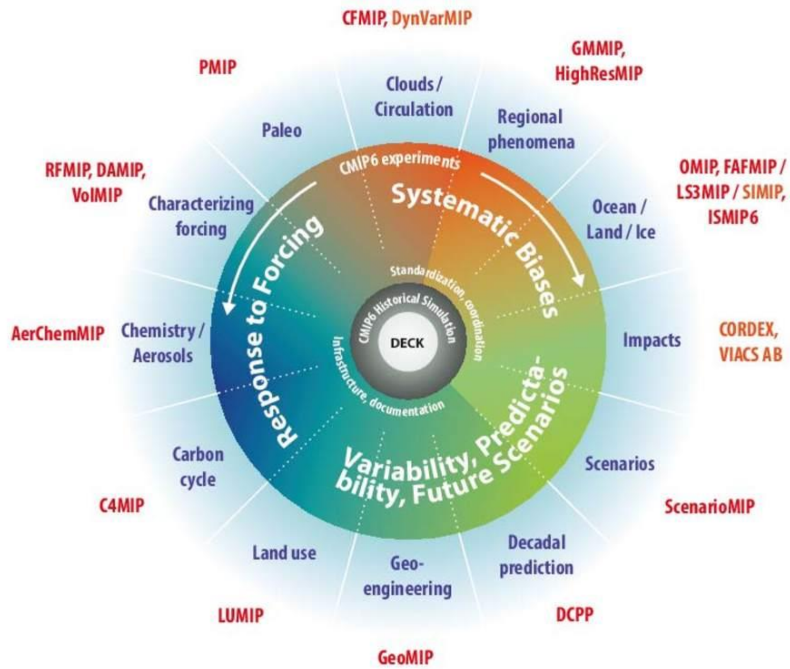
Previously, we have assessed future climate change scenarios over Mongolia based on CMIP5 (TNC, 2018). But within this study, most results of them have been updated by new CMIP6 modeling output based on 6th Assessment Report (AR6) of Intergovernmental Panel on Climate Change (IPCC).

This study has covering the assessment and comparison of climate models, how these models were simulated Mongolian historical climate in the past. Also, it covers results of future climate change projection of Mongolia under four principle GHG emissions scenarios. All these models have registered and participated in CMIP6 project.

Used model and data. Within CMIP6 international project, scientific question was raised including cloud, circulation and climate sensitivity, cryosphere change, climate extreme, regional sea level raise, water cycle, decadal climate prediction, biogeochemical cycle and other sensitive climate change topics(Figure 3.16). Among them , following three topics were in focus for future research:

- “Earth system” response under change radiation forcing
- Origin and consequence of model bias
- How predict and assess future climate change projection

In this regards number of numerical experiments have been done. In Mongolia for the time being it was used only CMIP6 historical simulation and CMIP6 scenario simulation.



Source: Eyring et al., GMD, 2016

Figure 3.16 Scheme for CMIP6 numerical experiments

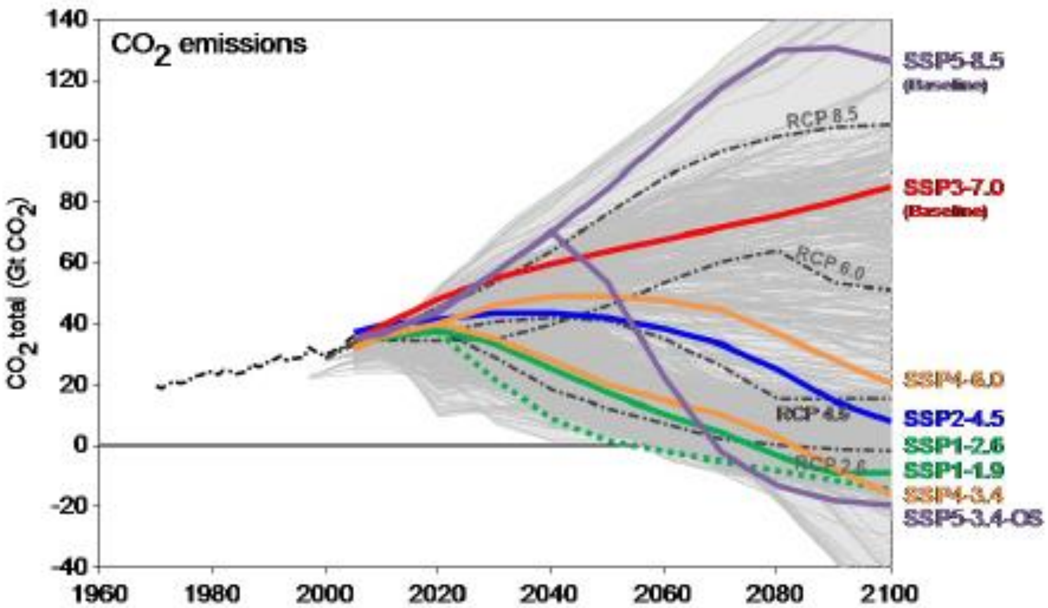
The climate models are currently available and numerical experimental raw data open for public, were used in assessment estimation (Table 3.2). Totally, 38 models of different university, international center and consortium from 7 countries have included. Their characteristics like spatial resolution or size of grid are not similar to each other and it should be taken into account during the study.

Table 3.2 Information of Global Climate Models participated on CMIP6 project

No	*Model name*	*Institution*	*Resolution/grid size*
1	ACCESS-CM2	Community Model, Australian Community Climate and Earth System Simulator, CSIRO	1.875×1.25 degree
2	ACCESS-ESM1-5	Earth System Model, Australian Community Climate and Earth System Simulator, CSIRO	1.875×1.25 degree
3	AWI-CM-1-1-MR	Alfred Wegener Institute Climate Model, Germany	384 x 192 longitude/latitude
4	AWI-ESM-1-1-LR	Alfred Wegener Institute Earth System Model, Germany	192 x 96 longitude/latitude
5	BCC-CSM2-MR	Beijing Climate Center Climate System Model, China	360 x 232 longitude/latitude
6	BCC-ESM1	Beijing Climate Center Earth System Model, China	360 x 232 longitude/latitude
7	CanESM5	Canadian Earth System Model version 5	361 x 290 longitude/latitude
8	CAS-ESM2-0	Chinese Academy of Sciences Earth System Model	362 x 196 longitude/latitude
9	CESM2-FV2	Community Earth System Model, National Center for Atmospheric Research, USA	144 x 96 longitude/latitude
10	CESM2-WACCM-FV2	Community Earth System Model, National Center for Atmospheric Research, USA	144 x 96 longitude/latitude
11	CESM2-WACCM	Community Earth System Model,	288 x 192 longitude/latitude

		National Center for Atmospheric Research, USA	
12	CIESM	Community Integrated Earth System Model, Tsinghua University, China	288 x 192 longitude/latitude
13	E3SM-1-0	Energy Exascale Earth System Model, Lawrence Livermore National Laboratory, USA	90 x 90 longitude/latitude
14	E3SM-1-1-ECA	Energy Exascale Earth System Model, Lawrence Livermore National Laboratory, USA	90 x 90 longitude/latitude
15	EC-Earth3	Europian Consortium-Earth	512 x 256 longitude/latitude
16	EC-Earth3-Veg	Europian Consortium-Earth	512 x 256 longitude/latitude
17	EC-Earth3-Veg-LR	Europian Consortium-Earth	512 x 256 longitude/latitude
18	FGOALS-f3-L	Flexible Global Ocean-Atmosphere-Land System, Chinese Academy of Sciences	360 x 180 longitude/latitude
19	FIO-ESM-2-0	First Institute of Oceanography, Ministry of Natural Resources, China	192 x 288 longitude/latitude
20	GFDL-ESM4	Geophysical Fluid Dynamics Laboratory, Earth System Model	360 x 180 longitude/latitude
21	GISS-E2-1-G-CC	Goddard Institute for Space Studies, NASA, USA	144 x 90 longitude/latitude
22	GISS-E2-1-G	Goddard Institute for Space Studies, NASA, USA	144 x 90 longitude/latitude
23	GISS-E2-1-H	Goddard Institute for Space Studies, NASA, USA	144 x 90 longitude/latitude
24	INM-CM4-8	Institute for Numerical Mathematics, Russian Academy of Science, Russia	180 x 120 longitude/latitude
25	INM-CM5-0	Institute for Numerical Mathematics, Russian Academy of Science, Russia	180 x 120 longitude/latitude
26	IPSL-CM6A-LR	Institute of Pierre Simon Laplace-Climate Modeling Center, France	144 x 143 longitude/latitude
27	KACE-1-0-G	National Institute of Meteorological Sciences (NIMS) and Korea Meteorological Administration (KMA)	192 x 144 longitude/latitude
28	MIROC6	Japan Agency for Marine-Earth Science and Technology, Japan	256 x 128 longitude/latitude
29	MPI-ESM-1-2-HAM	Max Planck Institute forr Meteorology, Germany	192 x 96 longitude/latitude
30	MPI-ESM1-2-HR	Max Planck Institute forr Meteorology, Germany	384 x 192 longitude/latitude
31	MPI-ESM1-2-LR	Max Planck Institute forr Meteorology, Germany	192 x 96 longitude/latitude
32	MRI-ESM2-0	Meteorological Research Institute, Japan	192 x 96 longitude/latitude
33	NESM3	Nanjing University of Information Science and Technology, China	192 x 96 longitude/latitude
34	NorCPM1	Norwegian Climate Prediction Model	144 x 96 longitude/latitude
35	NorESM2-LM	Norwegian Earth System Model	144 x 96 longitude/latitude
36	NorESM2-MM	Norwegian Earth System Model	144 x 96 longitude/latitude
37	SAM0-UNICON	Seoul National University, Republic of Korea	288 x 192 longitude/latitude
38	TaiESM1	Taiwan Earth System Model	288 x 192 longitude/latitude

Above mentioned climate models have simulated historical climate for the period 1850-2014 and future scenarios 2015-2100 period. The simulation is based on new GHG emission scenarios (ssp-shared socioeconomic pathways). Gaps filled in comparison to previous emission scenarios (rcp-representative concentration pathways) related to land use, short live air pollution gas, peak and down impact and 2°C scenarios consequence of Paris Agreement (Figure 3.17).



Source: O'Neill et al., Scenario MIP for CMIP6, GMD, 2016

Figure 3.17 Future Green House Gas emission

Assessment and comparison of the models skill. Table 3.2 shows that climate model spatial resolution is different each other, therefore, their monthly temperature and precipitation data need to interpolate to 0.5x0.5° grid data using bilinear regidding method. Then comparison is done against observation data based on historical simulation of monthly and seasonal temperature and precipitation between 1961-2014 period as considering their statistic measures.

Figure 3.18 depicts spatial correlation and ratio of standardized deviation of seasonal temperature between observation and model simulation results in Tailor diagram (here, observed grid data is selected as same resolution from Climate Research Unit, CRU East Anglia, UK).

Models spatial correlation is 0.58-0.96 compared with observation. Here, generally all 38 models have its relative low value of spatial correlation and overestimation of winter precipitation (Note: if points are close to REF=1 means low bias, while it is far away means high cold and warm bias). On the other hand, there is systematic warm bias in winter season. Remaining seasons have relative small bias and high correlation.

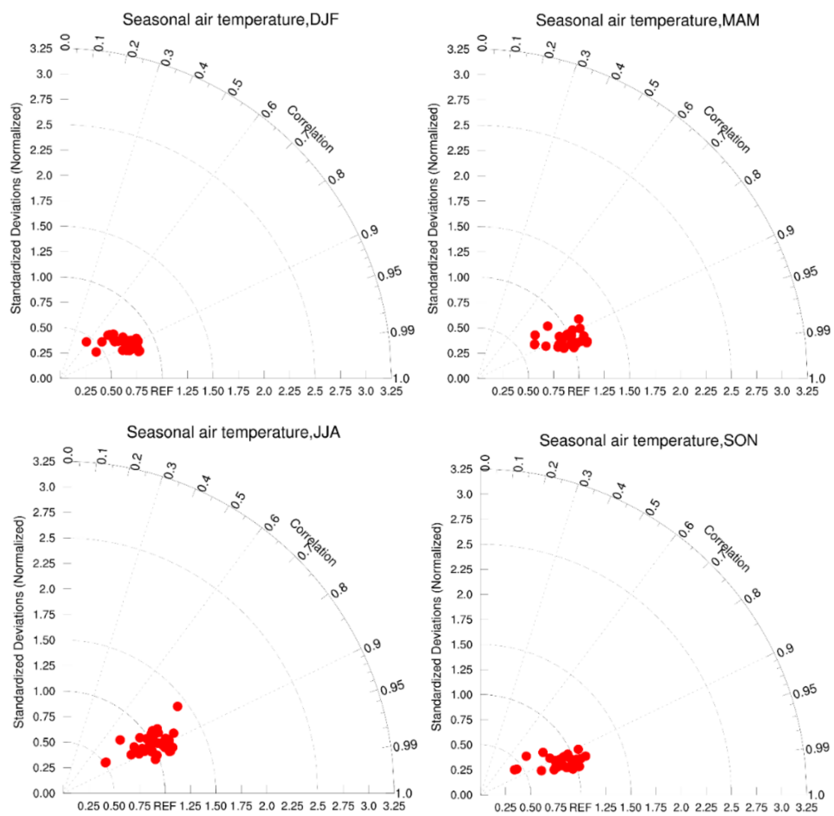
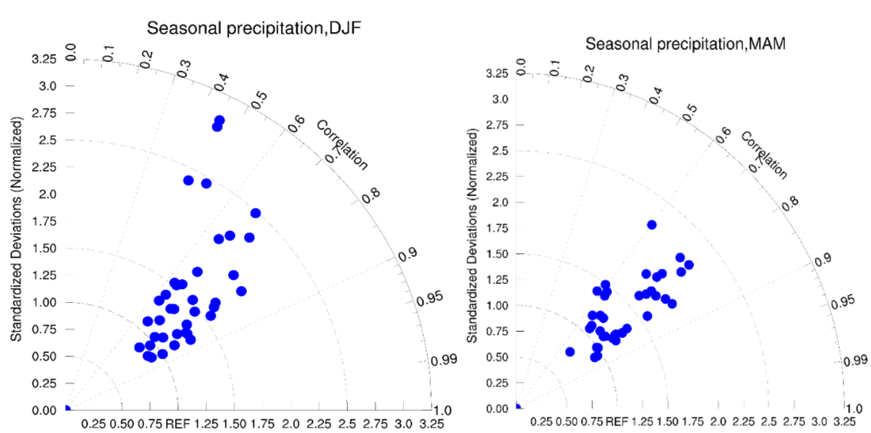


Figure 3.18 Assessment model skills of simulated seasonal temperature

Models skill statistic measures of simulated seasonal precipitation are shown in Figure 3.19. Spatial correlation is 0.45-0.94. From figures, it could possible to see that models have overestimation in all seasons, which means wet bias. Especially, the bias is 3 times higher in some models and spatial correlation is decreased to reach 0.45 in winter season. Summer season has relative small bias compare to others.



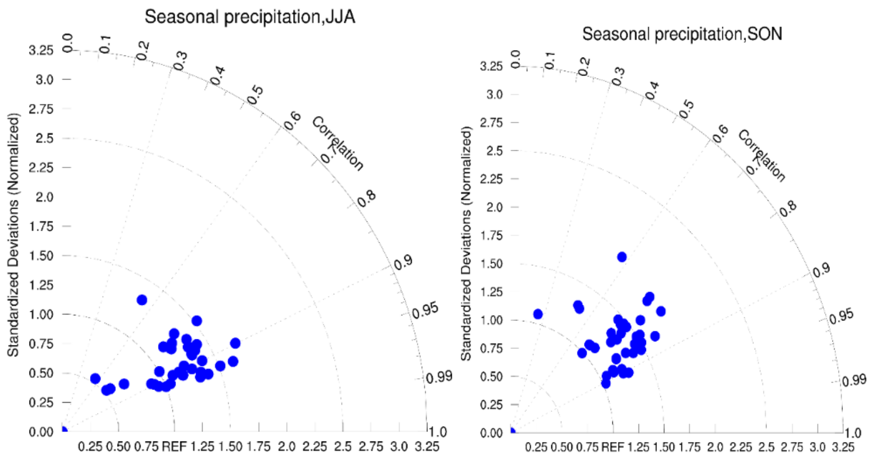


Figure 3.19 Assessment model skills of simulated seasonal precipitation

Statistic measures of the model skill are normalizaed and converted to 0-1 value using normalization for each season and their value is averaged and ranked. Purpose of this ranking is to see the model, which has relative small bias.

The model gives different result, when simulates historical climate of Mongolia depending on its physics, dynamics, numerical scheme, resolution etc. Table 3.3 shows ranked value for each seasons of the temperature and precpitation, and its value is 0.43-0.93.

Table 3.3 Rank of Global Climate Models based on statistic measures of the model skills

No	*Model name*	*Temperature*				*Precipitation*				*Average*
		DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	
1	NorESM2-MM	0.90	0.91	0.82	0.92	0.93	0.97	0.99	0.99	0.93
2	CESM2	0.83	0.93	0.76	0.91	0.95	0.93	0.83	0.91	0.88
3	CESM2-WACCM	0.86	0.84	0.75	0.92	0.90	0.92	0.87	0.88	0.87
4	EC-Earth3-Veg-LR	0.96	0.74	0.83	0.95	0.89	0.84	0.88	0.84	0.87
5	EC-Earth3	0.96	0.80	0.86	0.98	0.74	0.84	0.88	0.66	0.84
6	EC-Earth3-Veg	0.97	0.78	0.85	0.97	0.73	0.81	0.88	0.65	0.83
7	NorESM2-LM	0.74	0.80	0.69	0.72	0.72	0.98	0.91	0.91	0.81
8	KACE-1-0-G	0.91	0.66	0.60	0.72	0.99	0.73	0.96	0.87	0.81
9	GFDL-ESM4	0.83	1.00	0.84	0.97	0.78	0.54	0.84	0.64	0.80
10	E3SM-1-0	0.59	0.78	0.88	0.77	0.89	0.85	0.91	0.73	0.80
11	ACCESS-CM2	0.93	0.84	0.73	0.87	0.93	0.55	0.81	0.73	0.80
12	E3SM-1-1-ECA	0.57	0.75	0.88	0.79	0.89	0.90	0.89	0.70	0.80
13	FIO-ESM-2-0	0.94	0.82	0.79	0.92	0.61	0.68	0.70	0.82	0.78
14	BCC-CSM2-MR	0.64	0.72	0.83	0.75	0.72	0.87	0.94	0.79	0.78
15	CESM2-FV2	0.79	0.82	0.65	0.72	0.82	0.83	0.72	0.84	0.77
16	CESM2-WACCM-FV2	0.82	0.80	0.65	0.73	0.76	0.83	0.75	0.77	0.77
17	IPSL-CM6A-LR	0.79	0.75	0.97	0.77	0.79	0.61	0.76	0.67	0.76

18	SAM0-UNICON	0.71	0.93	0.74	0.89	0.59	0.76	0.74	0.74	0.76
19	MRI-ESM2-0	0.80	0.97	0.80	0.97	0.65	0.58	0.72	0.51	0.75
20	TaiESM1	0.93	0.80	0.62	0.84	0.62	0.60	0.69	0.77	0.73
21	MPI-ESM1-2-HR	0.84	0.93	0.83	0.96	0.47	0.43	0.82	0.50	0.72
22	AWI-CM-1-1-MR	0.84	0.93	0.84	0.93	0.47	0.38	0.83	0.47	0.71
23	AWI-ESM-1-1-LR	0.84	0.84	0.74	0.76	0.63	0.44	0.72	0.66	0.70
24	NESM3	0.77	0.81	0.71	0.79	0.64	0.42	0.76	0.71	0.70
25	FGOALS-f3-L	0.46	0.83	0.97	0.89	0.41	0.56	0.68	0.64	0.68
26	MPI-ESM-1-2-HAM	0.79	0.73	0.61	0.83	0.77	0.40	0.60	0.69	0.68
27	ACCESS-ESM1-5	0.31	0.48	0.83	0.62	0.95	0.64	0.68	0.89	0.67
28	MPI-ESM1-2-LR	0.78	0.84	0.67	0.80	0.59	0.33	0.73	0.60	0.67
29	CIESM	0.85	0.94	0.82	0.95	0.51	0.37	0.40	0.41	0.66
30	MIROC6	0.36	0.65	0.24	0.79	0.85	0.84	0.73	0.73	0.65
31	NorCPM1	0.55	0.48	0.62	0.61	0.50	0.66	0.74	0.80	0.62
32	BCC-ESM1	0.58	0.31	0.26	0.45	0.87	0.63	0.90	0.95	0.62
33	GISS-E2-1-G	0.73	0.82	0.78	0.84	0.02	0.41	0.56	0.57	0.59
34	GISS-E2-1-G-CC	0.72	0.81	0.73	0.83	0.00	0.43	0.53	0.54	0.57
35	GISS-E2-1-H	0.71	0.72	0.72	0.81	0.16	0.55	0.28	0.46	0.55
36	CAS-ESM2-0	0.90	0.93	0.82	0.85	0.21	0.05	0.34	0.30	0.55
37	Amon_INM-CM4-8	0.54	0.20	0.20	0.15	0.89	0.33	0.64	0.85	0.47
38	INM-CM5-0	0.49	0.20	0.19	0.10	0.83	0.34	0.67	0.80	0.45
39	CanESM5	0.01	0.08	0.59	0.15	0.73	0.64	0.55	0.72	0.43

Simulated seasonal temperature and precipitation and their geographical distribution is shown and compared with observed distribution (Figure 3.20-3.27) for 1st ranked model NorESM2-MM (Figure 3.21, 3.25), mid ranked MPI-ESM1-2-HR (Figure 3.22, 3.26) model and low ranked CanESM5 (Figure 3.23, 3.27) model. Here, it could be seen that how the model simulates seasonal climate of the Mongolia in the different geographical region and how their spatial pattern is and bias in terms of high, mid and low ranked models.

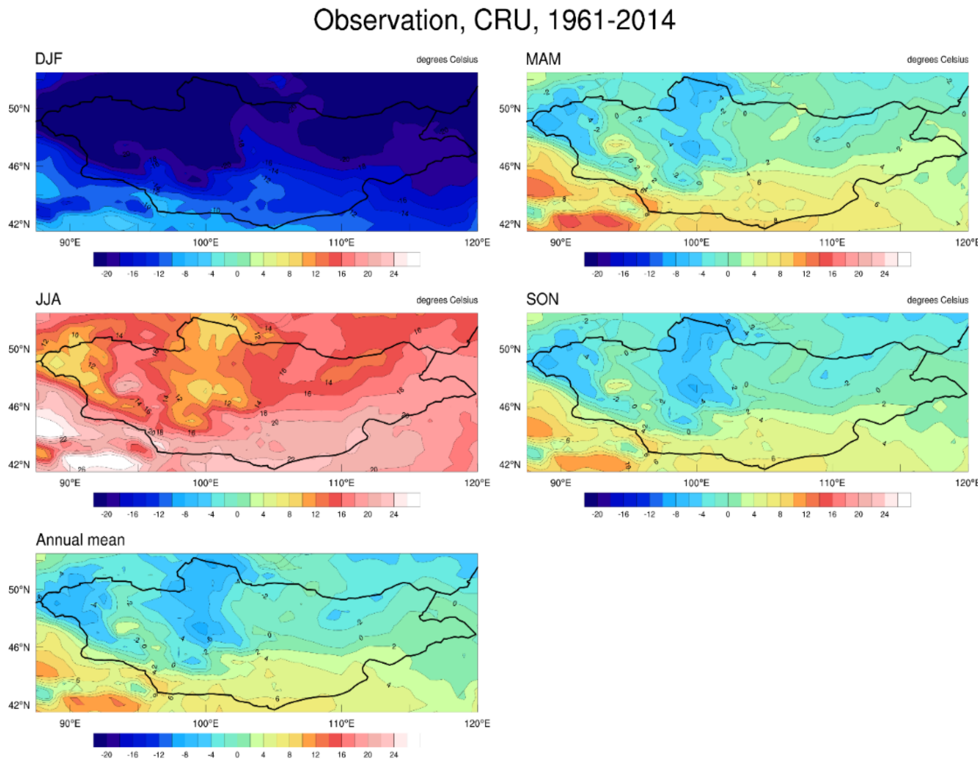


Figure 3.20 Geographical distribution of seasonal temperature estimated by observed data, °C

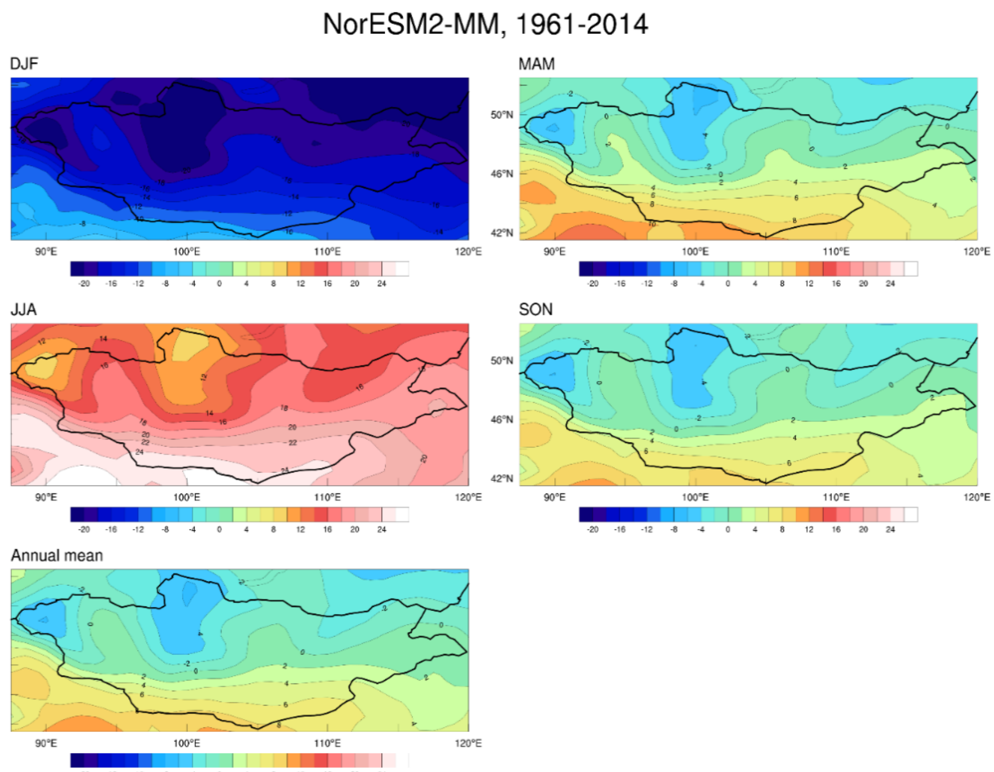


Figure 3.21 Geographical distribution of seasonal temperature estimated by NorESM2-MM model, °C NorESM2-MM

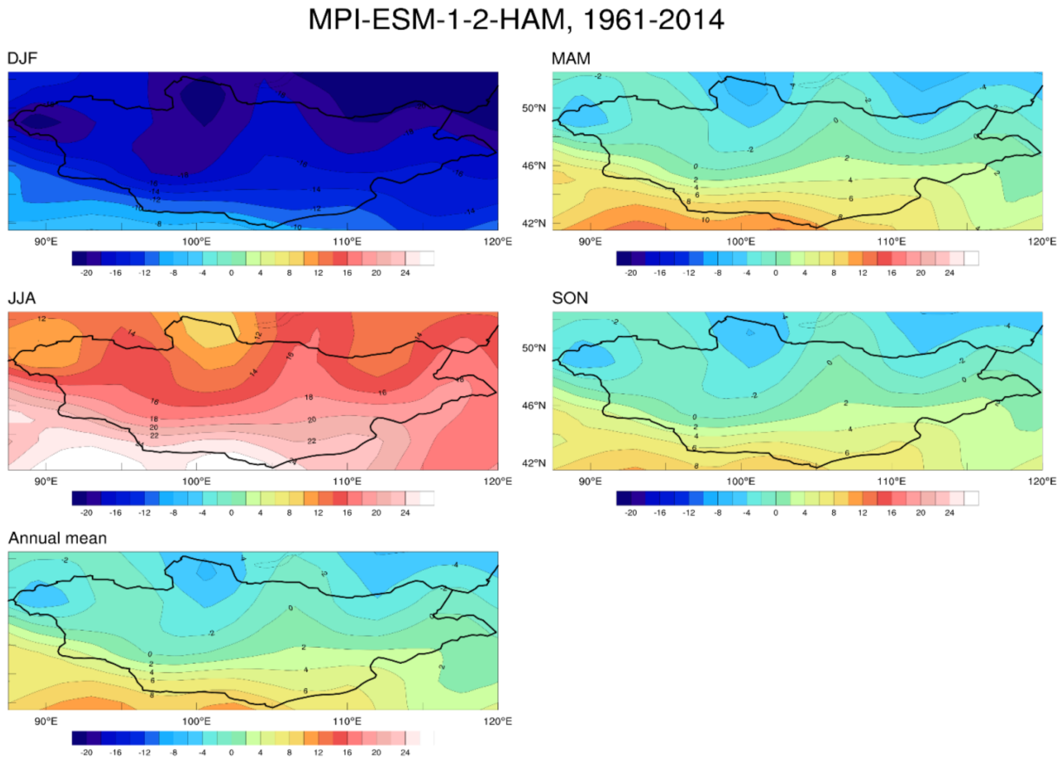


Figure 3.22 Geographical distribution of seasonal temperature estimated by MPI-ESM1-2-HR model, °C

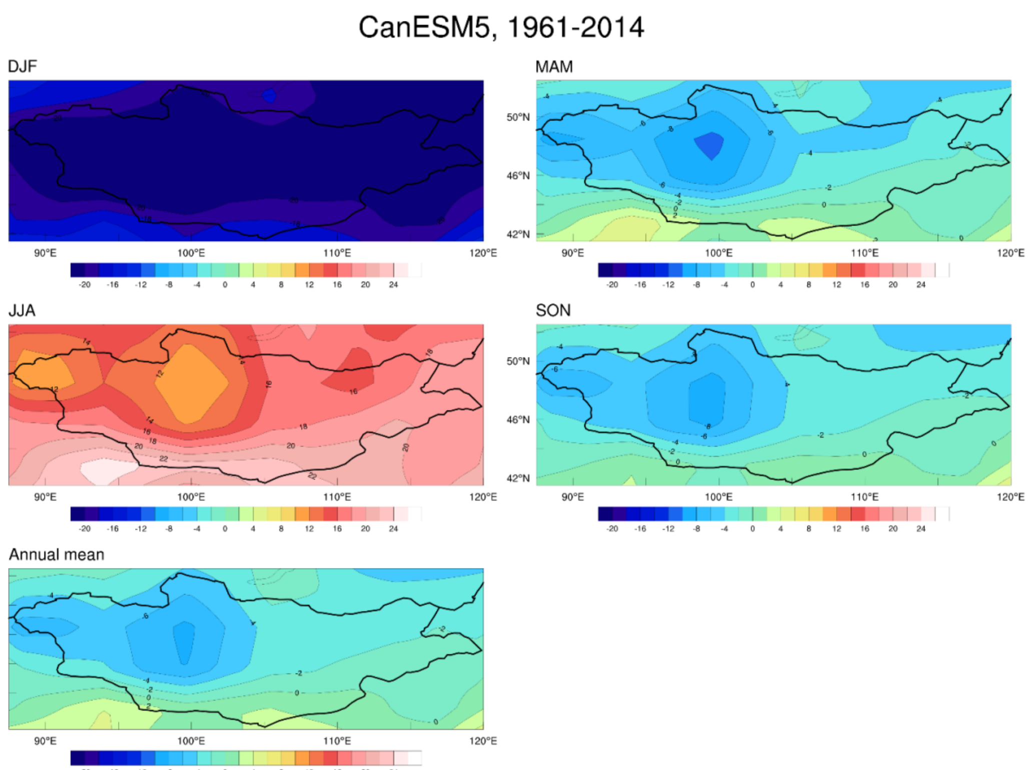


Figure 3.23 Geographical distribution of seasonal temperature estimated by CanESM5 model, °C

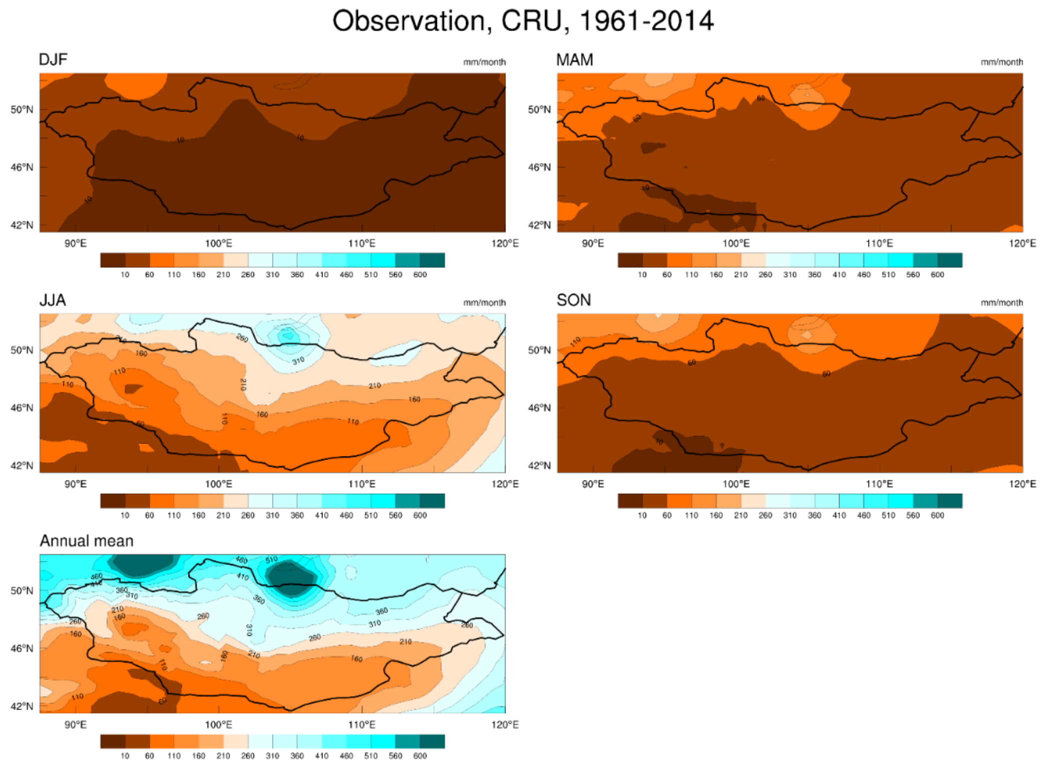


Figure 3.24 Geographical distribution of seasonal precipitation estimated by observed data, mm

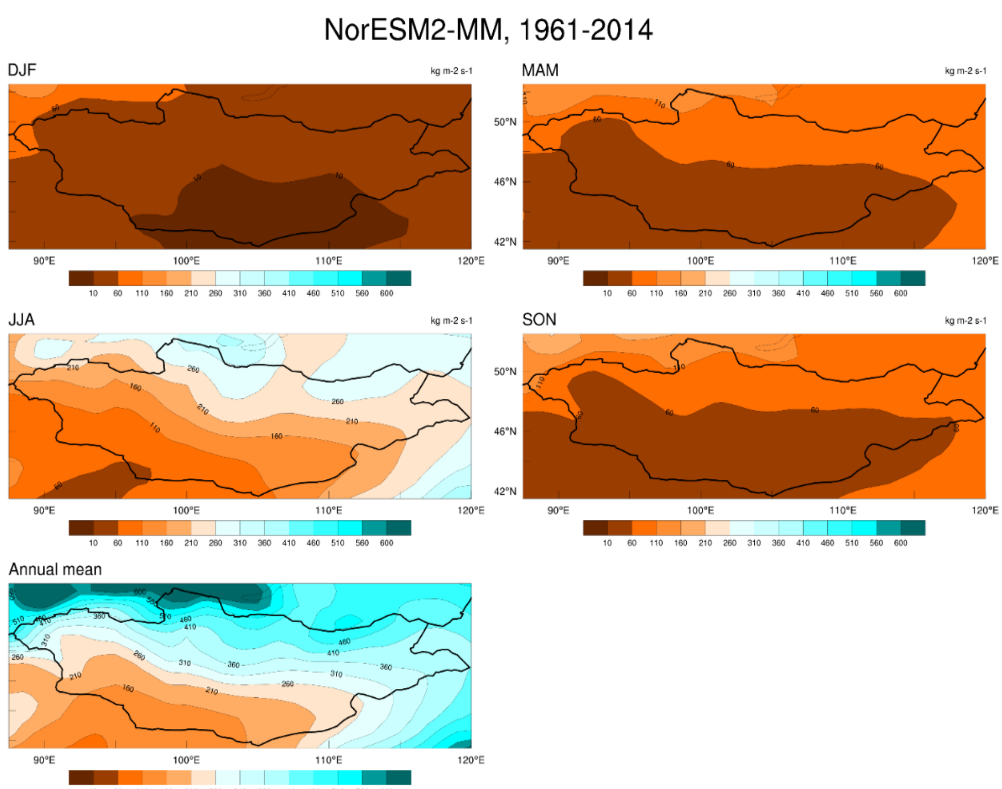


Figure 3.25 Geographical distribution of seasonal precipitation estimated by NorESM2-MM model, mm

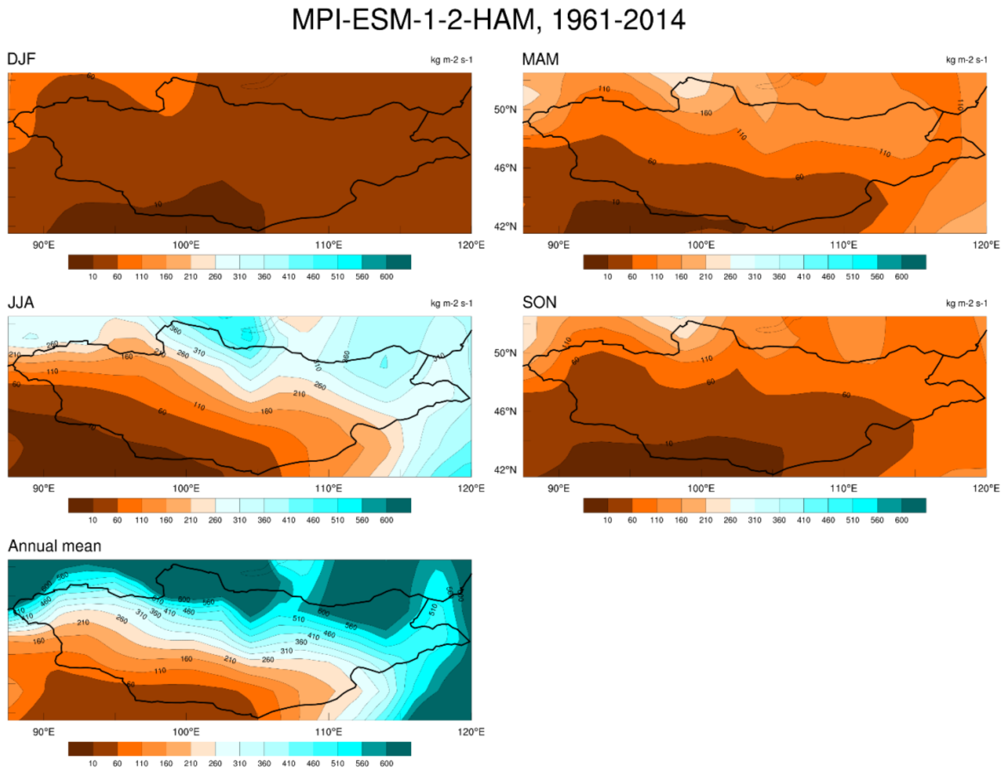


Figure 3.26 Geographical distribution of seasonal precipitation estimated by MPI-ESM1-2-HR model, mm

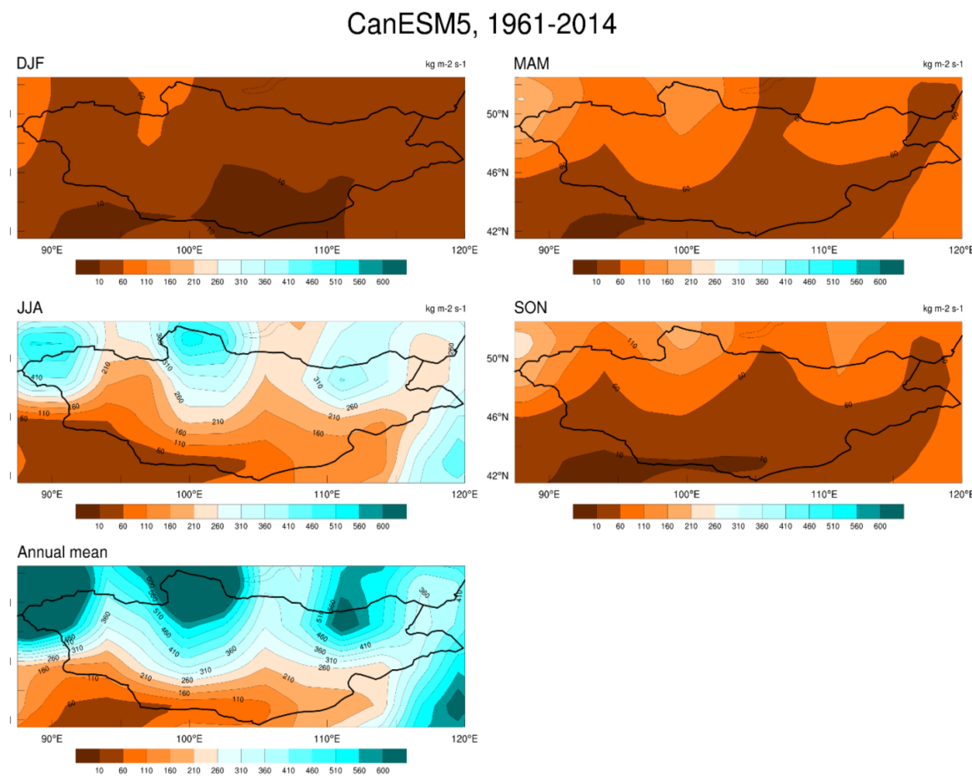


Figure 3.27 Geographical distribution of seasonal precipitation estimated by CanESM5 model, mm

Updated climate change scenarios over Mongolia. In this study, a future trends of the climate change of Mongolia is estimated by area average of monthly and seasonal temperature and precipitation, which limited by 41.5-52.5° latitude and 87.5-120.0° longitude domain within 2015-2100 period. After then it was compared with relative to the baseline climate 1995-2014 and finding standard deviation (anomaly).

Geographical distribution of these changes are considered in timeline window as similar as 6th Assessment Report, Intergovernmental Panel on Climate Change (AR6, IPCC) such as beginning of this century 2030 (2021-2040), mid of century 2050 (2041-2060) and end of the century 2090 (2081-2100) respect to baseline climate. Here, temperature change is defined by Celsius (°C) and precipitation is estimated by percent (%), which is change value divided by baseline climate and multiplied by 100%. The estimation is done by every GHG emission scenarios including ssp126, ssp245, ssp370 and ssp585 based on ensemble mean of all climate models.

Figure 3.28 is shown general trends of seasonal air temperature projection over Mongolia for all emissions scenarios as mentioned above. All seasonal temperature will be increased as monotonically. However, cold season temperature (DJF and MAM) has high fluctuation of interannual variable. It means that harsh condition will be intensified like one year became cold and another year become relative warm, even general trend is getting to increase. Seasonal temperature change values are shown in Table 3.4.

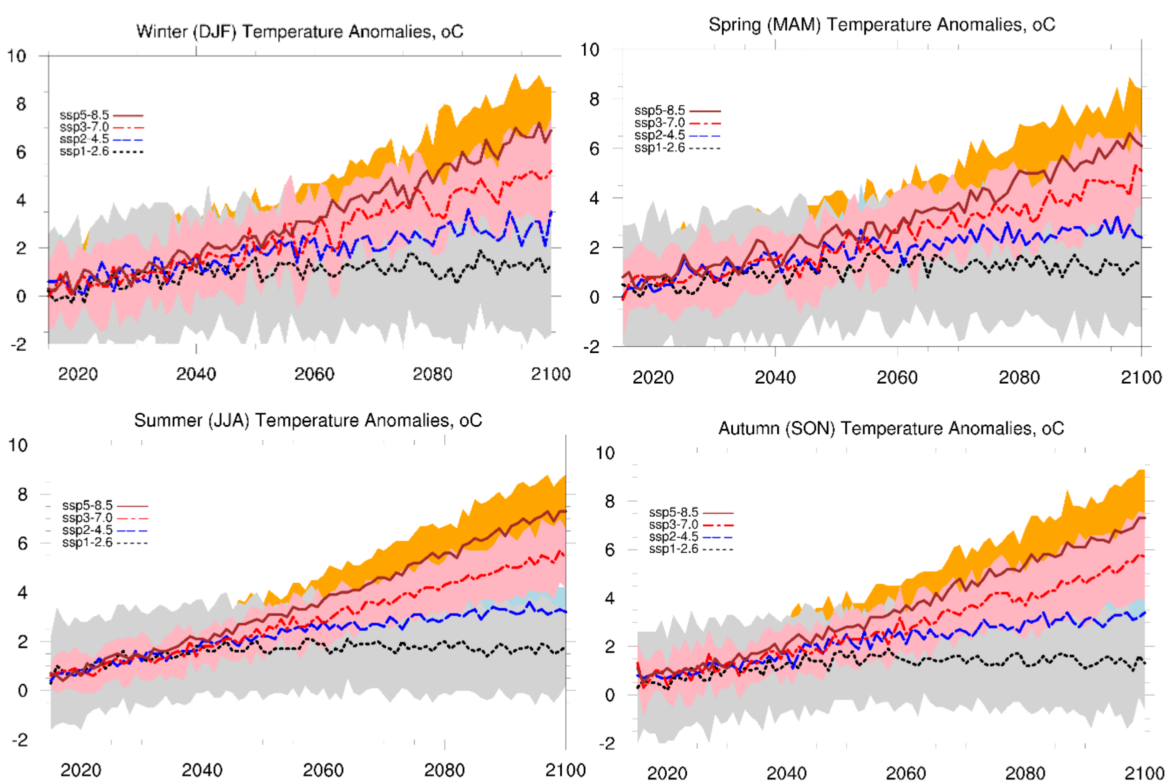
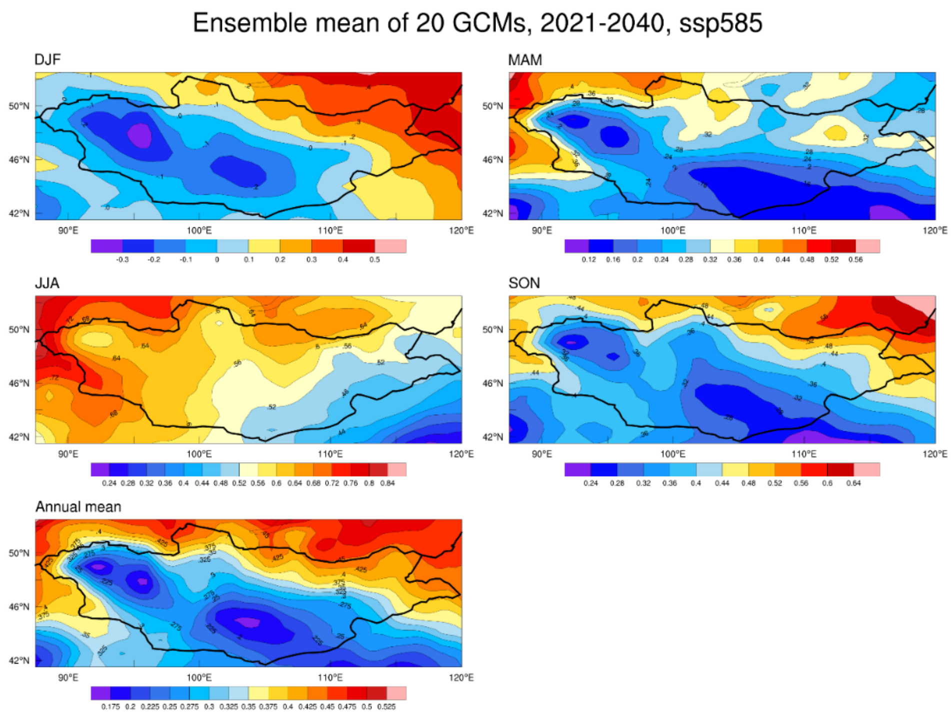
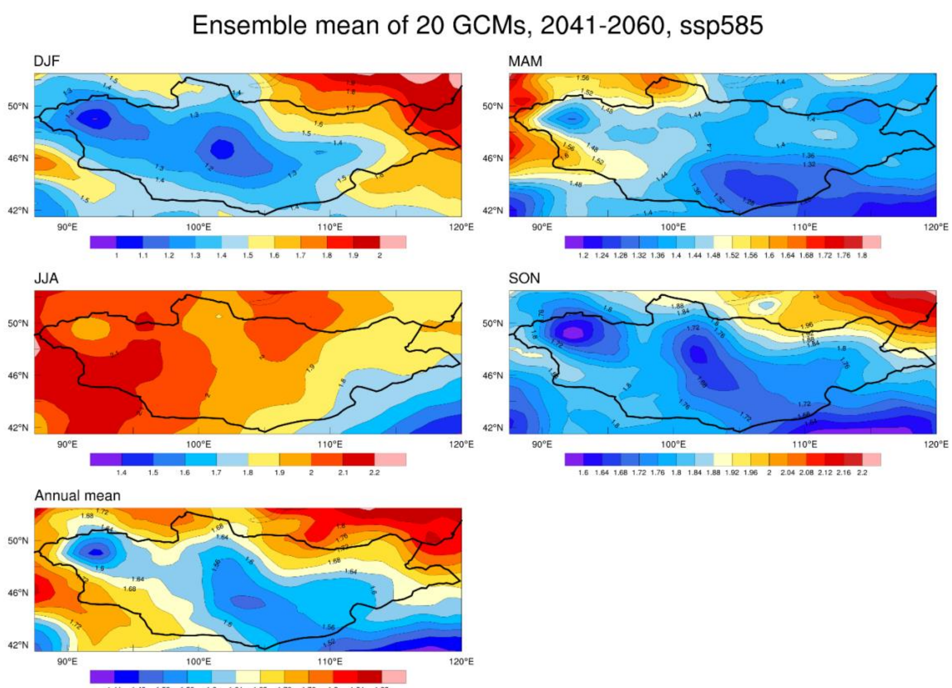


Figure 3.28 Projection of seasonal air temperature change over Mongolia: a) winter b) spring c) summer and d) autumn

Geographical distribution of seasonal air temperature of Mongolia is shown as covering the beginning, mid and end of this century as based on ensemble mean all climate models in Figure 3.29 (Note: only currently available data of the global climate model were averaged). Relative intensity warming is projected to occur in north-eastern region of Mongolia in autumn and winter, while western part in the country in spring and summer season. This warming will be accelerated until end of this century.





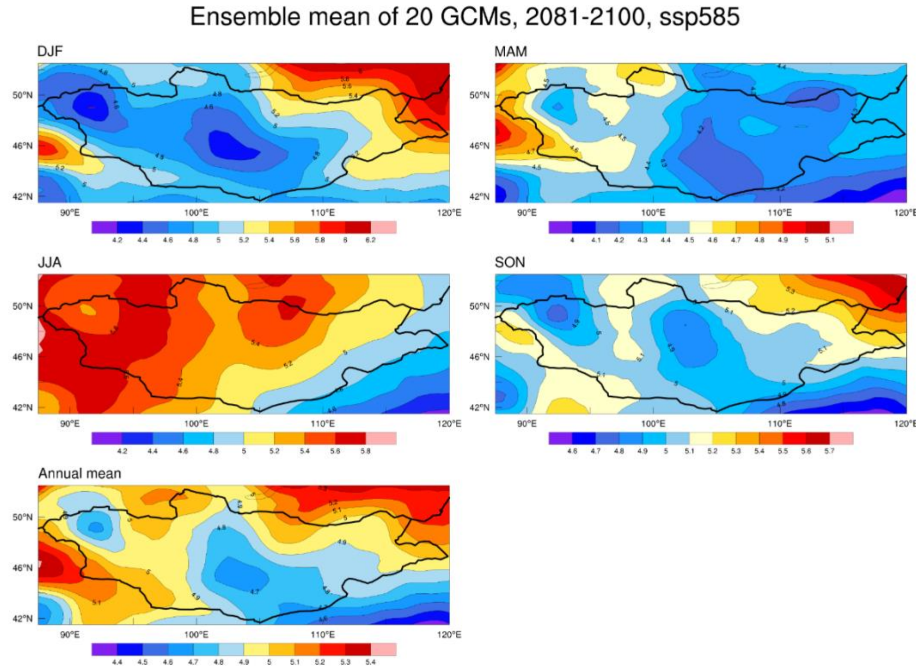


Figure 3.29 Geographical distribution of air temperature change over Mongolia, °C a) 2030 b) 2050 and c) 2080

Projection of seasonal precpitation change over Mongolia is shown based on ensemble mean of climate models in Figure 3.30. From figure, winter precipitation will be increased relatively high and spring and autumn precipitation is little high and summer rainfall will be projected to have almost no change. Seasonal precipitation change values are shown in Table 3.4.

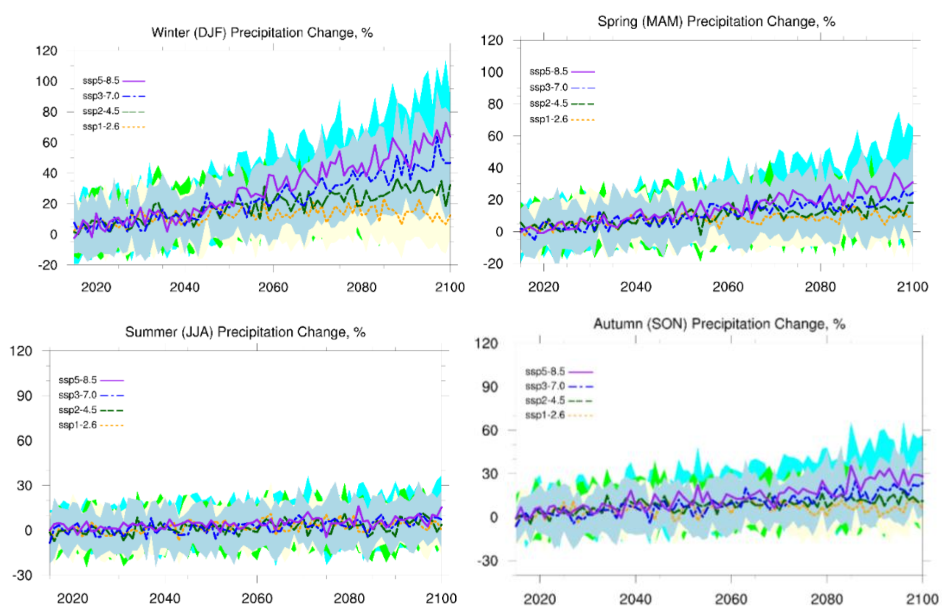
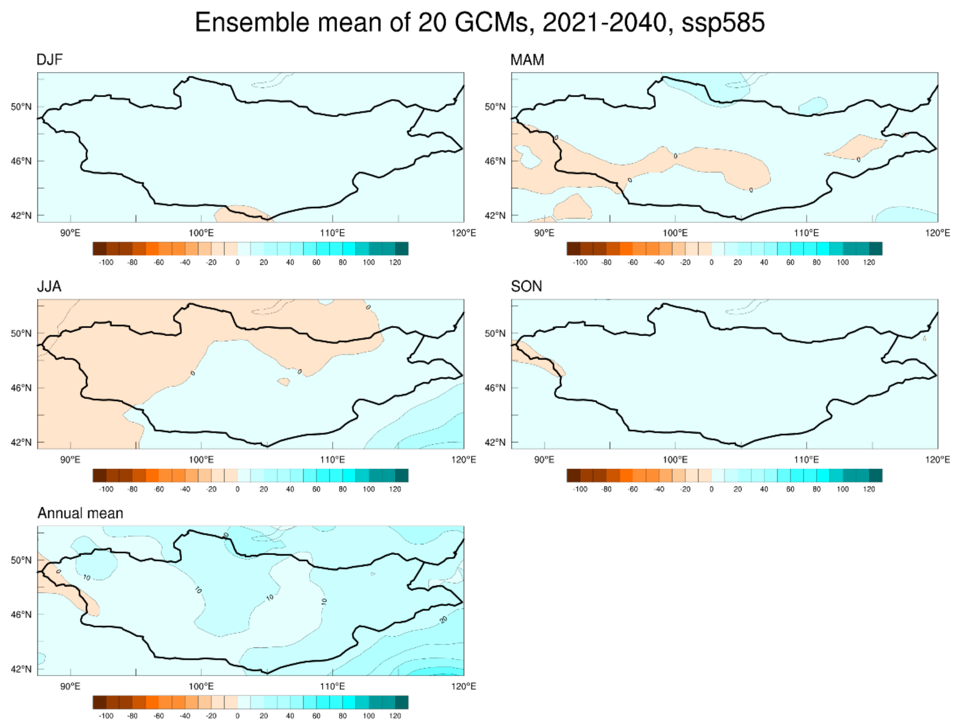
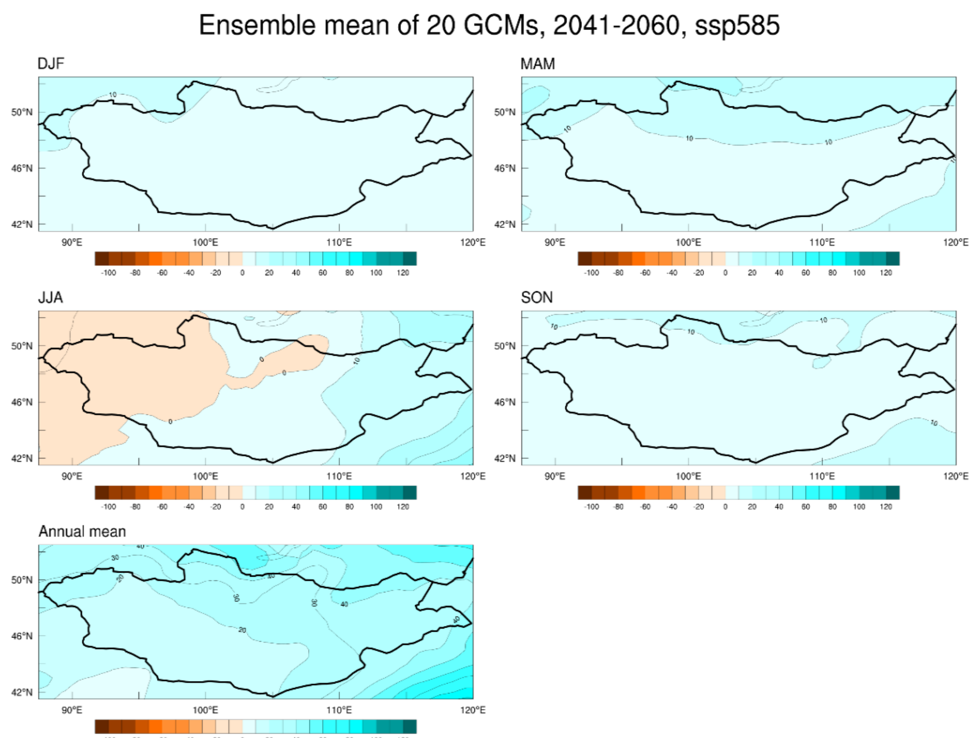


Figure 3.30 Projection of seasonal precipitation change over Mongolia: a) winter b) spring c) summer and d) autumn

Geographical distribution of seasonal precpitation over Mongolia is shown as covering the beginning, mid and end of this century as based on ensemble mean all climate models in Figure 3.31. Here, generally, precipitation will be increased with small amount of percent, however, there is decreasing in north-western and northern part of central region of the country as varying as 10-20% in summer season.





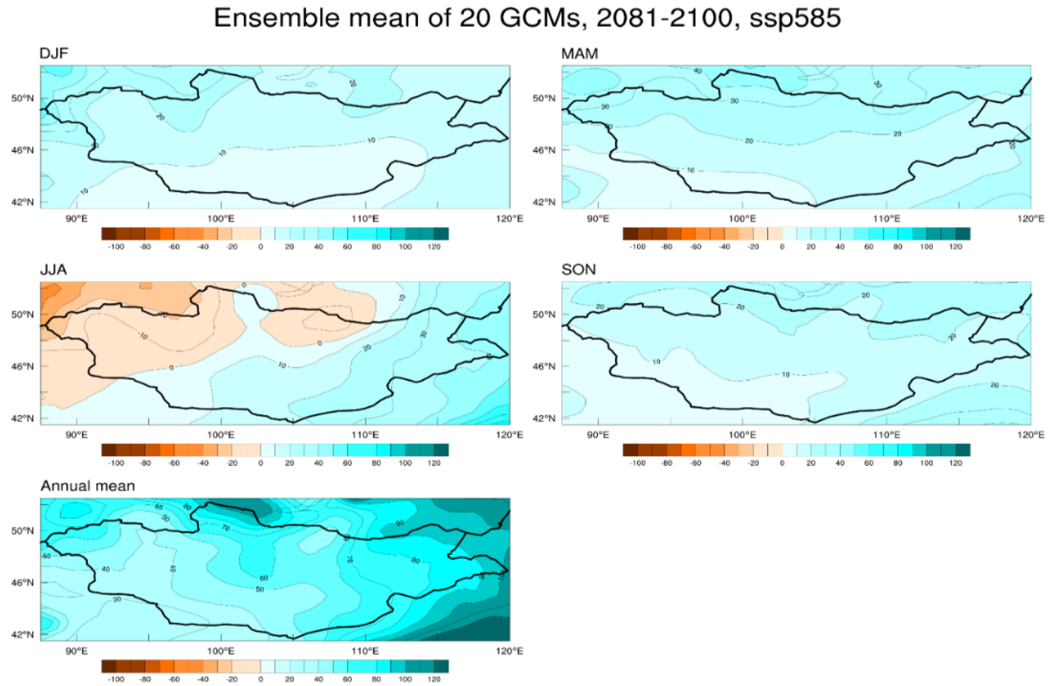


Figure 3.31 Geographical distribution of precipitation change over Mongolia, mm a) 2030 b) 2050 and c) 2080

Mean air temperature and precipitation change value averaged over the territory of Mongolia is shown in 2030, 2050 and 2090 period under 4 GHG scenarios in Table 3.4 as based on ensemble mean of all climate models.

Table 3.4 Climate change scenarios of Mongolia projected by ensemble mean of the multiple climate models

Periods	*GHG*	*Temperature, °C*					*Precipitation,%*				
		Winter	Spring	Summer	Autumn	Annual	Winter	Spring	Summer	Autumn	Annual
2030	ssp585	1.1	1.3	1.5	1.4	1.4	9.8	5.4	1.8	6.0	5.7
	ssp370	0.9	1.1	1.3	1.2	1.1	8.7	4.6	0.7	3.2	4.3
	ssp245	1.0	1.1	1.4	1.2	1.2	9.6	5.0	0.0	5.6	5.1
	ssp126	0.7	0.7	1.4	1.0	0.9	9.3	5.7	-0.3	4.2	4.7
2050	ssp585	2.4	2.4	2.9	2.8	2.7	22.7	12.1	4.1	11.2	12.5
	ssp370	2.0	1.9	2.4	2.2	2.1	18.1	9.5	0.7	6.5	8.7
	ssp245	1.8	1.8	2.3	2.1	2.0	16.9	9.1	1.1	8.4	8.9
	ssp126	1.1	1.2	1.8	1.5	1.4	13.0	8.5	2.3	5.5	7.3
2080	ssp585	6.1	5.6	6.5	6.3	6.1	55.4	26.2	7.2	25.3	28.5
	ssp370	4.5	4.2	5.0	4.8	4.6	43.3	18.5	5.8	18.1	21.4
	ssp245	2.8	2.6	3.3	3.1	2.9	28.2	14.1	3.5	12.3	14.5
	ssp126	1.2	1.3	1.7	1.4	1.4	13.9	10.4	3.8	6.9	8.8

Dynamic downscaling of climate change and projection of climate extreme indices. Whitin this study, global climate models (GCM) output was dynamically downscaled from coarse global spatial scale into regional fine scale using regional climate model (RCM) driven by two (ECHAM5 and HadGEM2) Coupled Models Intercomparison Project Phase 5 (CMIP5) under greenhouse gas (GHG) emission scenarios RCP4.5 and RCP8.5. The downscaled results are explored by daily variables at 59 points of meteorological stations and systematic error was corrected by quartile delta mapping (QDM) for removing bias correction. Finally, future projection change of 10 core climate indices have been analyzed over the country.

Present change and future projection under high GHG emission scenarios (RCP8.5) of these key indices over Mongolia are shown in Table 3.5 and as statistic box plot in Figure 3.32.

In Future 2030, 2050 and 2080, maximum temperature of summer season will be projected to increase by 1.6-5.3°C and minimum temperature of winter season will be projected to increase by 1.4-5.3°C, while frost day will be decreased by 8.8-36.9 days as annually. Heat wave duration in summer will be increased by up to 2.8 days, while cold wave duration decreased by up to 2.6 days as respectively. Daily precipitation intensity has no change. Consecutive dry days in summer and consecutive wet/snow days in winter season will be slightly increased. Maximum of 1 day and 5 days precipitation will be projected to increase (Table 3.5).

Table 3.5 Present and future change of extreme climate indicies

ID	*Name of index*	*Unit*	*Present (1986-2005)*	*2030*	*2050*	*2080*
			Temperature index			
Txq90	90th percentile of maximum temperature in summer season	°C	29.1 (±3.0)	30.7 (±2.9)	32.4 (±2.8)	34.4 (±2.8)
Tnq10	10th percentile of minimum temperature in winter season	°C	-30.3 (±4.7)	-28.9 (±4.5)	-27.2 (±4.4)	-25.0(±4.4)
fnfd	Number of frost day, Tx<0	day	216.7 (±22.1)	207.2 (±21.9)	197.7 (±21.3)	179.8 (±20.2)
txhw90	Heat wave duration, tx<Tx90	day	3.2 (±0.3)	1.6 (±0.4)	3.5 (±0.5)	6.0 (±0.6)
tncw10	Cold wave duration, tn>Tx10	day	3.7 (±0.5)	3.8 (±0.4)	2.8 (±0.4)	1.1 (±0.5)
			Precipitation index			
pav	Daily precipitation intensity	mm	0.6 (±0.2)	0.6 (±0.2)	0.6 (±0.2)	0.7 (±0.2)
pxcdd	Maximum number of consecutive dry days in summer	day	16.8 (±5.7)	16.3 (±5.6)	16.4 (±5.5)	17.4 (±5.7)
pxcwd	Maximum number of consecutive wet days in winter	day	1.1 (±0.3)	0.4 (±0.4)	0.4 (±0.4)	0.6 (±0.4)
px1d	Maximum daily precipitation	mm	26.4 (±7.2)	26.3 (±7.2)	28.2 (±7.7)	31.2 (±9.5)
px5d	5 days maximum precipitation	mm	41.0 (±11.8)	43.0 (±12.1)	46.3 (±13.4)	50.7 (±16.1)

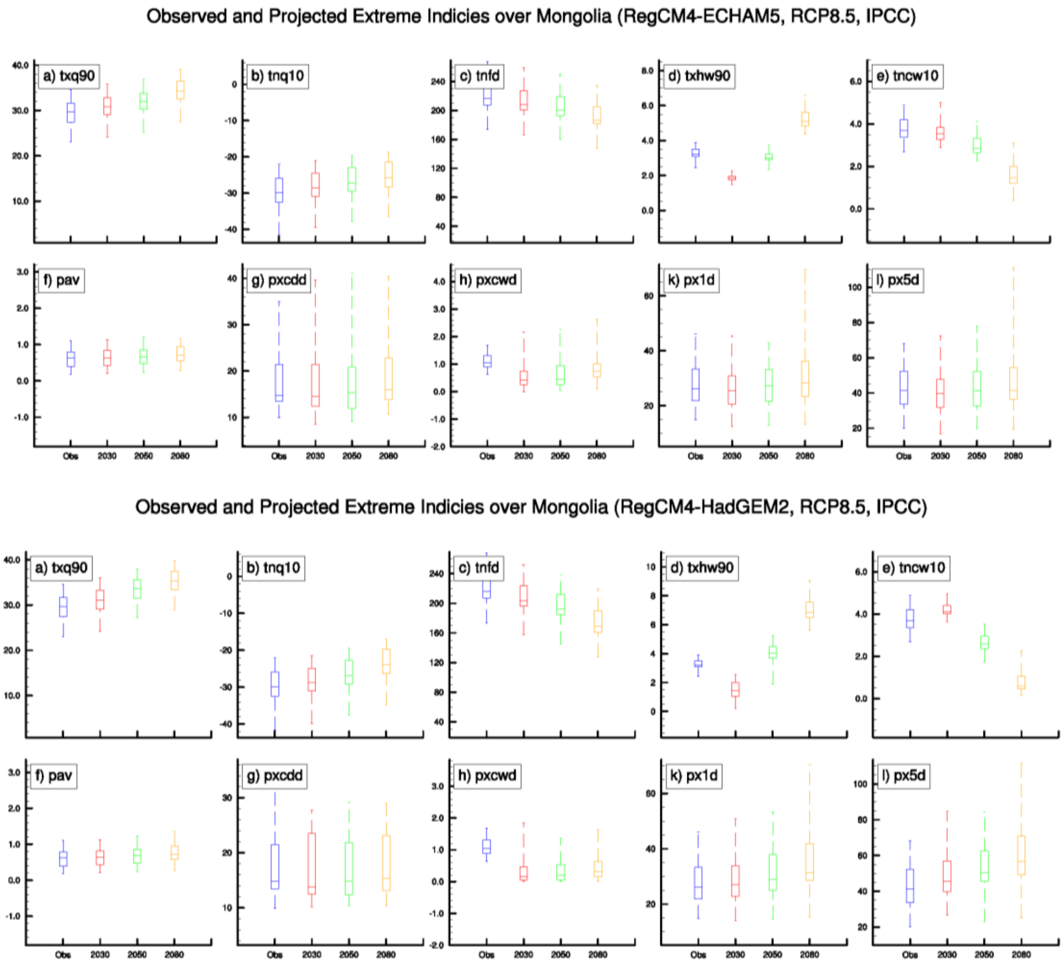


Figure 3.32 Present and future change of climate extreme indicies a) RegCM4-ECHAM5 and b) RegCM4-HadGEM2

Output trend and change of dynamic downscaling results are very similar for both GCMs model (Figure 3.32). Therefore, ensemble mean of climate extreme indices and their geographical distribution is shown in Figure 3.33 for high emission GHG scenarios (RCP8.5) in 2050 period.

High intensity of maximum and minimum temperature change is detected in more northern part in high latitude of the country (Figure 3.33a-b). Heat wave duration is intensified in central of Mongolia, while cold wave duration is decreased in eastern part of the country (Figure 3.33c-d). Frost days will decrease with high intensity in western part of country (Figure 3.33e).

Daily precipitation will slightly increase in Mongolia in a year (Figure 3.33f). Maximum number of consecutive dry day in the western part in summer and wet day in the central part of the country in winter will slightly increase (Figure 3.33g-h). Maximum precipitation of 1 day and 5 days will increase in north and sourthern part of Mongolia (Figure 3.33m-l). In Figure -99.0 noted as opposite result and could not be averaged.

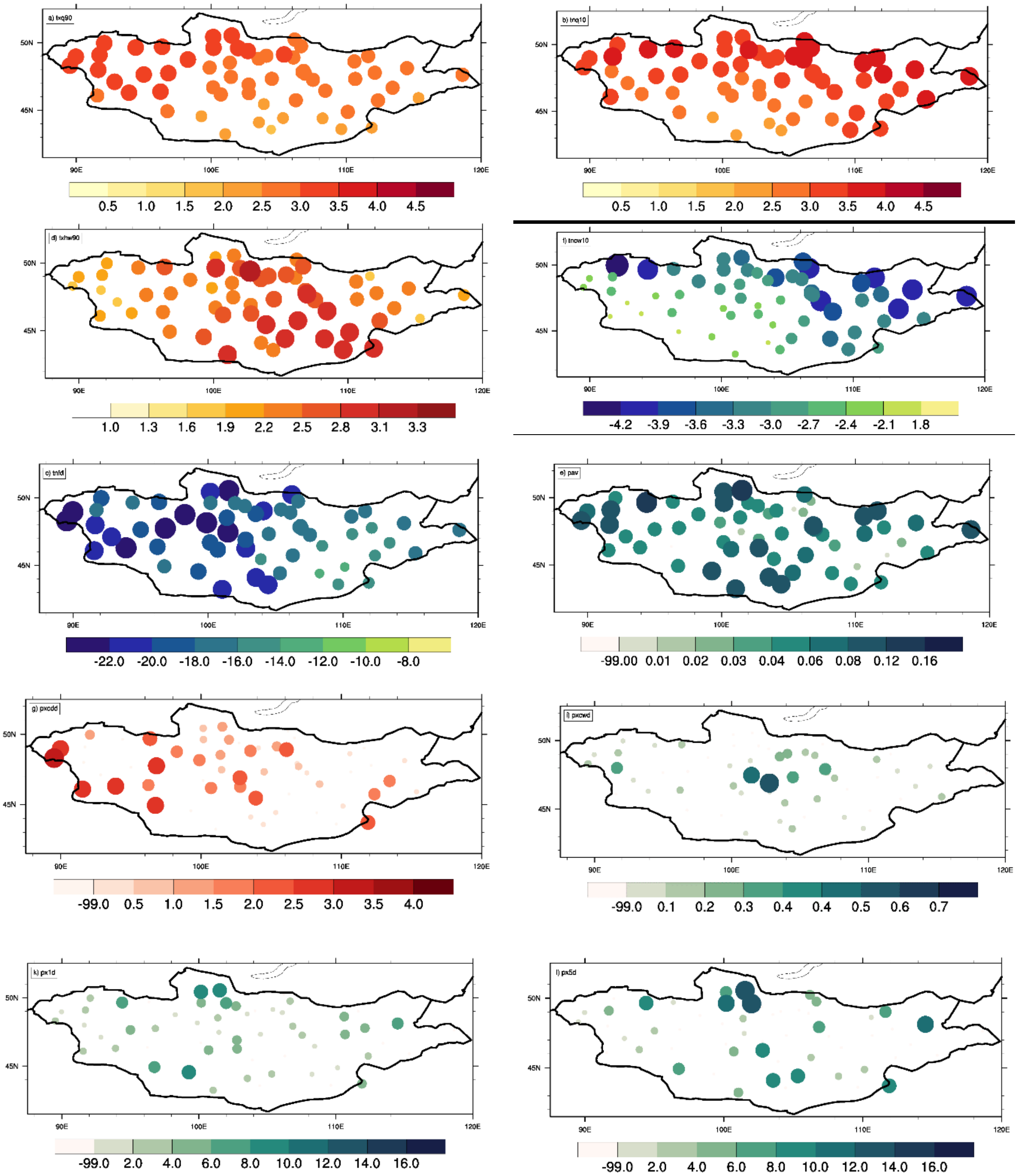


Figure 3.33 Geographical distribution of extreme climate indicies and their change over Mongolia in 2050

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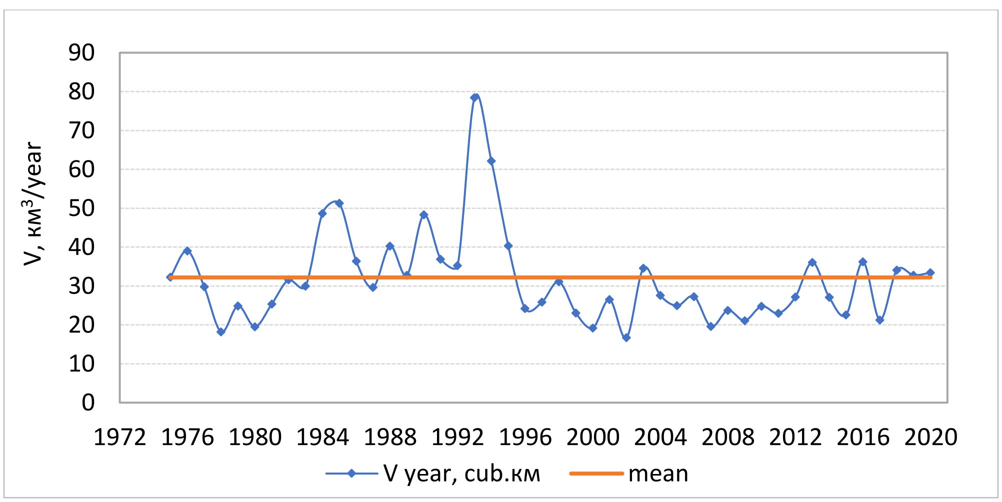
CHAPTER 4. ASSESSMENT OF CLIMATE CHANGE IMPACT, VULNERABILITY AND RISK

4.1 Impact on Natural Resource

4.1.1 Water resource

Present change of surface water resource and regime. According to the historical records on frequencies of drought and dzud for the period from 1740 to 1940, there was occurrence of drought in 72 years and occurrence of dzud in 110 years (D.Tsedevsuren, 1988).

Since 1978, the annual total river flow gradually increased and reached its maximum value of 78.4 km^3 per year in 1993, by records from hydrological post measurement. Long lasting low flow period steadily continued since 1996 and reached its minimum of 16.7 km^3 per year in 2002. The duration of the low flow continued for 23 years from 1996 to 2017, but from 2018, the river flow start increasing. In 2020, the flow of the Selenge River increased by 4.9%, the Onon river, which originated from left side of the Khentii range increased by 100.3%, the Kherlen River increased by 22.5%, and the Halh River, which origins from the Ikh Khyangan range increased by 16.9%. However, river flow the Orkhon and Baidrag rivers originated from the Khangai range reduced by 13.8% and 40.3%, and the Bulgan river which origins from the front side of Altai range reduced by 1.1%, the Hovd river which origins from the back side of Altai range reduced by 9.5% (Figure 4.1).



Source: IRIMHE, 2021

Figure 4.1 Fluctuations in river flow in Mongolia, km^3

The total flow norm of the rivers of Mongolia is updated for the period of 1991-2020 as recommended by the WMO. The new norm estimation according to the updated period is 30.6 km^3 per year, which is 10% less compared with previous norm of 34.6 km^3 per year and which was related to the low flow period which continued from mid-1990s to the early of 2010s (Table 4.1).

Table 4.1 Value of total river flow of Mongolia estimated in different time period, km^3/year

Statistic parameters	*1975-1990*	*1981-2010*	*1991-2020*	*1975-2020*	*Average*
Long term mean	33.63	33.25	30.57	31.63	32.27
Standard deviation	9.88	13.49	12.57	11.68	11.90
Coefficient	0.29	0.41	0.41	0.37	0.37

In the rainy years of 2016 and 2018-2020, the total flow of rivers in Mongolia was exceeded the updated norm. Tendency of the flow norm to decrease is an indicator of climate change impacts defined by the annual mean flow norm of rivers by hydrological posts with a long series of observations and measurements, which are representing three main basins. (Table 4.2).

Table 4.2 Some flow norm representing three river basins, m^3/s

No	River-Gauging station	Duration of observation	Total period	1961-1990	1981-2010	1991-2020
		I. Arctic ocean basin				
1	Selenge-Khutag	1934-2020	128.43	136.55	129.67	117.35
2	Delgermurun-Murun	1947-2020	36.21	36.37	39.27	37.10
3	Orkhon-Orkhon	1945-2020	38.71	46.49	36.93	30.15
4	Kherlen-Choibalsan	1945-2020	24.54	29.39	26.04	21.30
5	Kherlen-Undurkhaan	1951-2020	10.11	10.84	10.29	10.15
6	Khalkh gol- Sumber	1959-2020	34.44	36.71	34.08	31.69
7	Onon-Binder	1959-2020	95.03	93.90	99.55	96.23
		II. Pacific ocean basin				
1	Kherlen-Choibalsan	1947-2020	18.15	21.08	18.36	15.01
2	Kherlen-Undurkhaan	1959-2020	20.16	23.53	18.21	15.65
3	Khalkh gol- Sumber	1974-2020	33.39	41.65	34.86	28.98
4	Onon-Binder	1971-2020	29.64	27.29	28.91	31.20
5	Eg-Batshireet	1985-2020	2.69	4.31	2.69	2.36
		III. Central Asian internal basin				
1	Ongi-Uynga	1973-2020	1.60	1.59	1.47	1.60
2	Tui-Bayankhongor	1972-2020	3.09	3.33	2.81	2.93
3	Baidrag-Baidrag	1967-2020	9.81	9.93	9.79	9.75
4	Khovd-Ulgii	1959-2020	54.44	58.10	51.67	52.35
5	Buynt-Deluun	1974-2020	1.54	1.58	1.65	1.52

6	Bulgan-Baitag	1967-2020	9.87	9.42	9.16	10.21
7	Borshoo-Borshoo	1972-2020	0.94	0.80	1.01	1.02
8	Kharkhiraa-Tarialan	1963-2020	4.87	4.56	5.97	5.14
9	Bogd-Uliastai	1966-2020	6.51	6.35	6.85	6.67
10	Chigestei-Uliastai	1952-2020	4.03	4.81	2.86	2.66

Comparing some statistical parameters such as standard deviation and flow coefficient in the WMO-1961-1990 and WMO-1991-2020 periods, the both statistical parameters were high in the Arctic Ocean basin, but the standard deviation tends to decrease in the rivers of the Pacific Ocean basin. In Mongolia, both the standard deviation and flow coefficient tend to increase in Khovd river basin which belongs to the Central Asian internal basin, Uvs lake, and Zavkhan river basins. In the basin of Uvs lake and Zavkhan river, it is different and in case of the rivers that flow into lakes in the Great lakes valley are generally tend to increase. Figure 4.2 shows annual mean flow and its fluctuation of some main rivers of Mongolia.

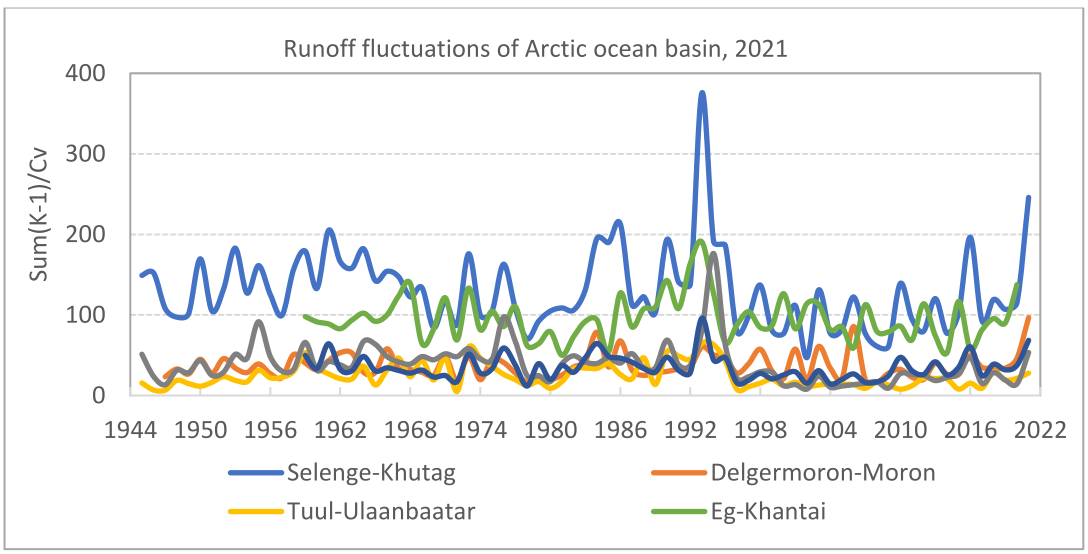


Figure 4.2 Annual mean flow and its fluctuation of some main rivers of Mongolia

Total annual runoff of rivers in Mongolia is as estimated 69.5 km^3 per year in 5% of probability to occur, and 23 km^3 per year in 75% of probability to occur. The annual runoff of main rivers such as Selenge, Orkhon, Kherlen, Onon, Bulgan, Hovd, Baidrag, and Khalkh rivers, are constituted the main part of river runoff. To determine of total annual runoff with 5%, 50% and 75% of probability of occurrence of runoff of the main rivers was compared with the total flow in Mongolia (Figure 4.3).

Total river runoff of Mongolia is 36.2% of probability to occur in 2019 which is higher than the longterm mean of runoff. In 2019, 32.8 km^3 per year of runoff was formed on the territory of Mongolia, which is 3.7% higher than the longterm mean, and 1.2 km^3 per year higher runoff. In 2020, 34% of probability to occur of runoff and 33.3 km^3 of runoff was formed as 5.4% higher than longterm mean and 1.7 km^3 per year high runoff (Figure 4.3).

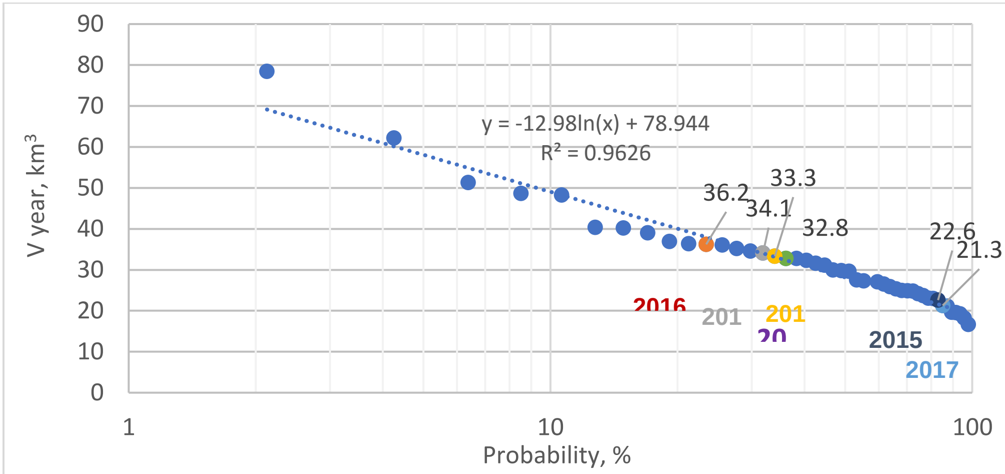


Figure 4.3 Probability of occurrence curve of annual volume of the total runoff of rivers in Mongolia

Lake. In Mongolia, 4,355 lakes with an area greater than 0.0027 km^2 covering total water surface area of 15,502.5 km^2, acquired from a topographic map scaled as 1:100000 which compiled based on air photos taken in the 1940s. The lake area retrieved from the LANDSAT ETM, TM and L8 satellite images show that there were 4,069 lakes with total surface area of 15,384.3 km^2 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; and 3,147 lakes with total surface area of 14,171.8 km^2 in 2016; and 3,508 lakes with total surface area of 14,179.9 km^2 in 2017; and 3,603 lakes with total surface area of 14,306.3 km^2 in 2018; and 3,464 lakes with total surface area of 14,312.6 km^2 in 2019; and 3,718 lakes with total surface area of 14,355.9 km^2 in 2020, 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 1,121.5s km^2 and 597 lakes were dried out in 2010; by 7.8% or 1,209.1 km^2 and 569 lakes were dried out in 2014; by 7.8% or 1,201.9 km^2 and 832 lakes were dried out in 2015; by 1,330.7 km^2 and 800 lakes were dried out in 2016; by 1,334.6 km^2 and 788 lakes were dried out in 2017; by 1,208.5 km^2 and 693 lakes were dried out in 2018; by 1,201.9 km^2 and by 7.7 % or 832 lakes were dried out in 2019; and by 7.4 % or 1,158.6 km^2 and 578 lakes were dried out in 2020, respectively. In comparisons with data of 1945, the total number and area of lakes of Mongolia were decreased by 13.4% and 7.4 % from 1945 to 2020, respectively (Figure 4.4).

The water levels of large, big and bigger lakes have tendancy to decrease in the last 25 years from 1996 to 2020. 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 desert steppe and Gobi desert such as Khyargas, Buuntsagaan, Orog lake and others, steadily decreased (Figure 4.5).

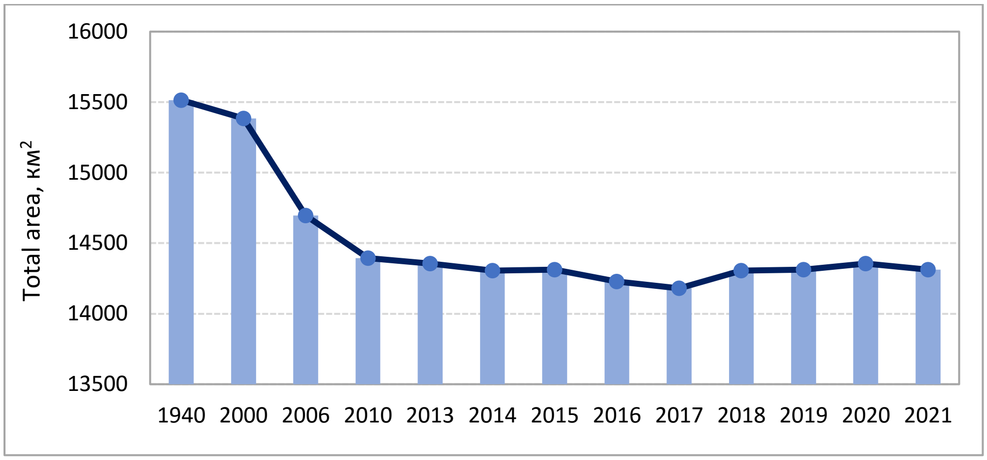


Figure 4.4 Trend of total lake area

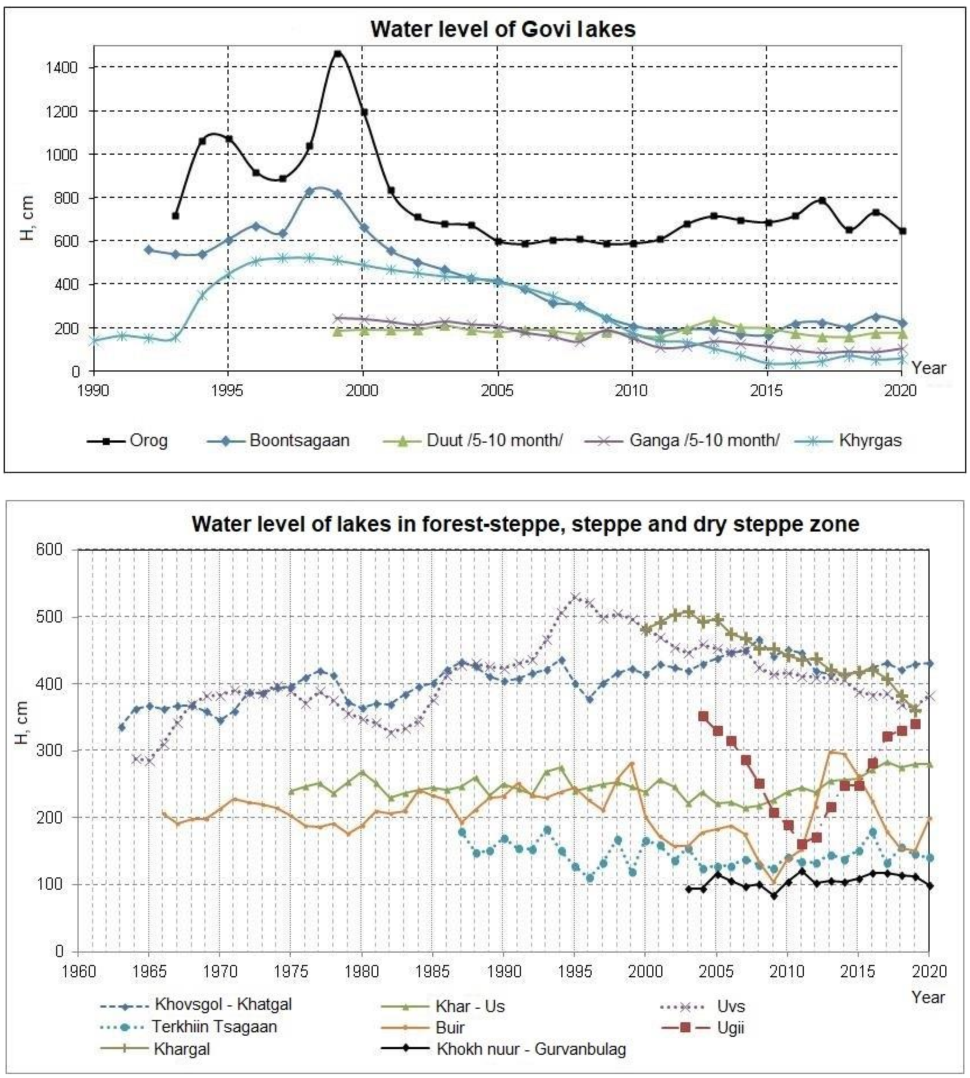


Figure 4.5 Fluctuation of lake water level

According to the LANDSAT L8 satelite data, total area of lakes is 14,179.9 $км^2$ in 2017. The number of dried lake was decreased down to 788 with total area of 1,334.6 $км^2$, which resulted the decrease of 8.6%. In 2018, number of 3,603 lakes were detected and their total area was 14,306.0 $км^2$, out of which 692 lakes with area 12,08.5 $км^2$ were dried up, which is an increase by 2.6%. In comparison these results with the map of 1:100000 scale in 1945, number of lakes were decreased 16.1% and total area decreased by 7.79% (B.Erdenbayar, 2020). (Figure 4.6).

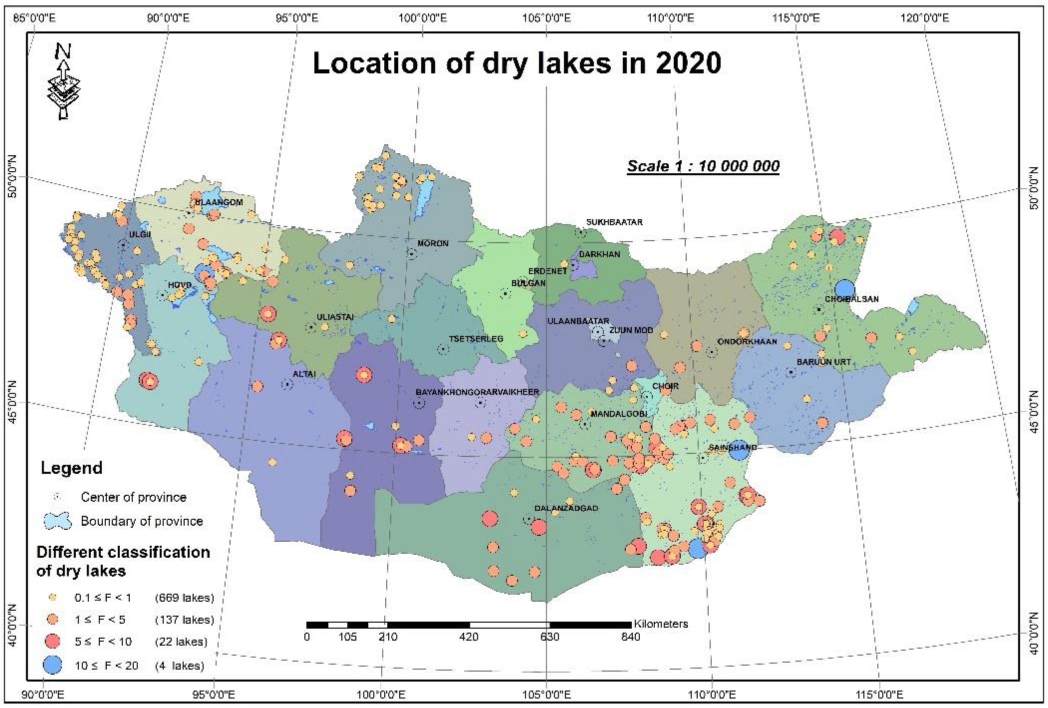


Figure 4.6 Location of dry up lake over Mongolia, 2020

Ground water. Since 2015, the rate of reduction of ground water level is desceding and some places it started to stabilize, and some rise of water level has been observed in last few years. In particular, the such tendency of ground water level were observed from 1997 to 2019 in Murun of Khuvsgul province, Arvaikheer of Uvurhangai province, Ekhiin gol of Bayankhongor province. Although the water level in Arvaikheer recovered in 2019, it was 1.24 m lower than the longterm mean and in Ekhin-gol it was close to the long-term mean and 0.03 m more than that in 2019. In terms of Murun annual ground water level has been stabilized in last 5 years and its water level is close or 0.02 m higher than longterm mean (Figure 4.7).

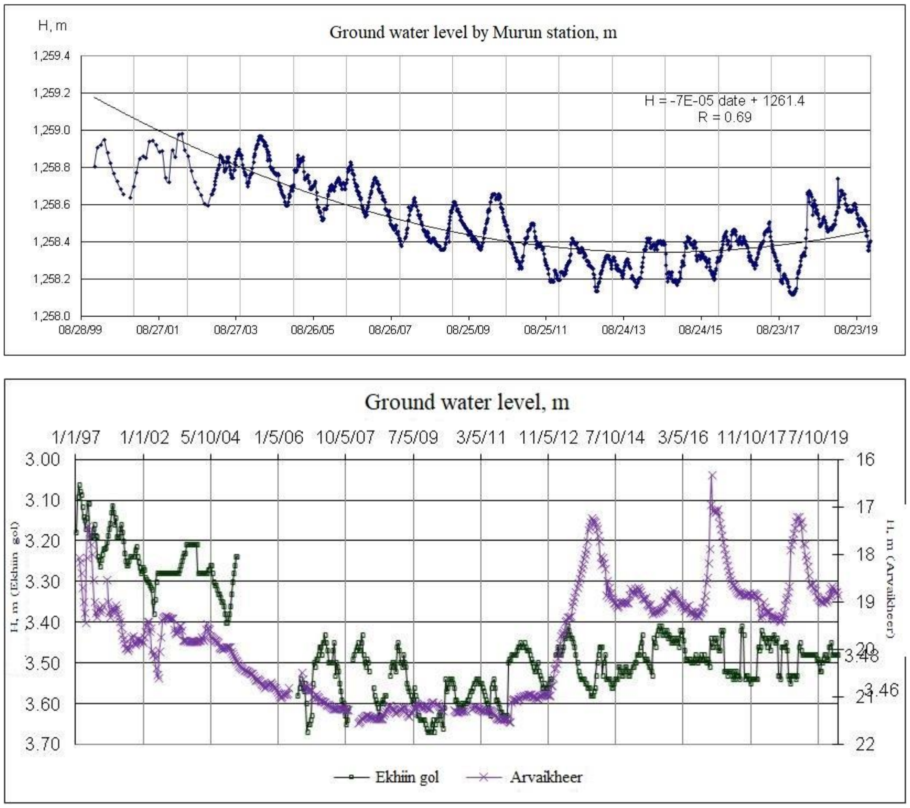


Figure 4.7 Tendency of ground water level: a. Murun, b. Ekhiin gol and Arvaikheer

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

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

One hundred years later, in summer 2010, a USA – Mongolia joint expedition retraced portions of the 1910 expedition routes. Analyses of field data and photographs taking at same side of glacier in 1910 and 2010, the topographic maps from 1970, and the 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 showed a significant recession and ablation. From 1910 to 2010, the West Turgen Glacier receded by c. 600 m and down-wasted by c. 70 m (Ulrich Kamp et al., 2013).

The total area of glaciers in Mongolia was nearly 535 km^2 in 1940th, which acquired from a topographic map scaled as 1:100,000. However, according to the LANDSAT satellite data the total area of the ice massif spread over 42 mountains was 451 km^2 in the 2000 (Figure 4.8). The total glacier area of Mongolia is rapidly decreasing since 1940th, it was 470 km^2 in 1990, 451 km^2 in 2000 (Surface water regime and resources in Mongolia, 2015, editor G.Davaa) and 338 km^2 in 2019, respectively (Figure 4.9). It demonstrated the area of the glacier has decreased by 12.1% from the 1940th to 1990, 15.7% to 2000, 36.8 to 2019 that was total area decreased about 37.0 % in the last over 70 years.

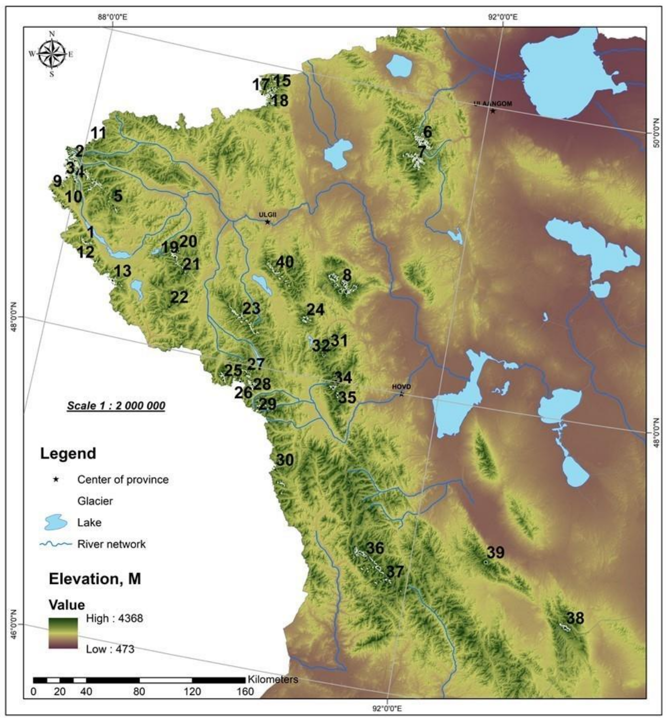


Figure 4.8 Glacier distribution

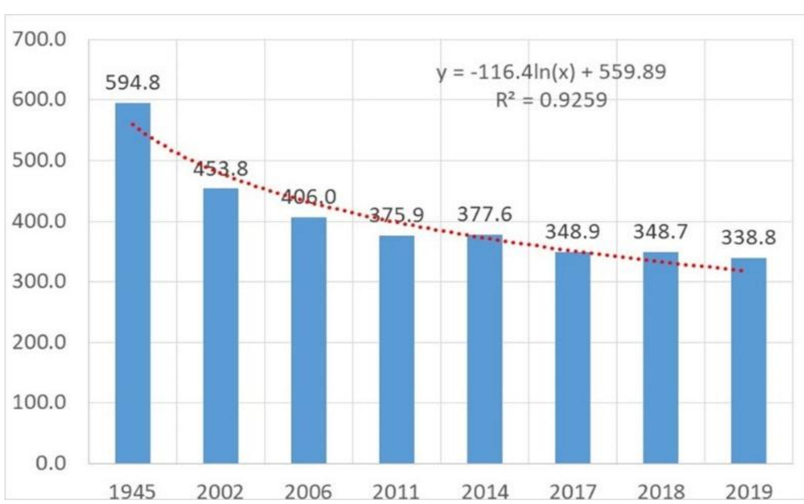


Figure 4.9 Changes of total area of glacier, km^2

We installed mass-balance stakes at 50–100 m elevation intervals on the Potanin (14 stakes), Tsambagarav (5 stakes), Turgen (7 stakes), and Sutai (4 stakes) glaciers, and acquired annual measurements in 2003, 2010, 2013, and 2015, respectively. We obtained the stake height measurements from the ice surface and reinstalled the stakes when it is necessary (Figure 4.10). The total melting of the Potanin glacier between 2003-2020 was 67.5m thick of ice at elevation zone of 2,900-3,400 m. Specifically, 60 m of ice melting at elevation zone of 3,000-3,050 m, 52.4 m thick of ice melting at elevation zone of 3,050-3,100 m, 42.8 m thick of ice melted at elevation zone of 3,100-3,200 m and 35.3 m thick of ice melted at elevation zone of 3,250-3,350 m, respectively.

In Tsambagarav, total amount of ice melting in 2005-2020 was 9 m thick of ice at elevation zone of 3,600-3,700 m, 5.5 m thick of ice melting at elevation zone of 3,700-3,750 m, 3.6 m thick of ice melting at elevation zone of 3,750-3,800 m and 1.3 m thick of ice melting at elevation zone of 3,850 m, respectively.

In Sutay, the total amount of ice melting in 2015-2020 was 7 m thick of ice at elevation 3,900 m, 4.6 m thick of ice melting at elevation 4,000 m and 3.9 m thick of ice melting at elevation zone of 4,000m-4,100 m, respectively.

In Turgen, the total amount of ice melting in 2013-2020 was 17.5 m thick of ice melting at elevation 3,100 m, 19.2 m thick of ice melting at elevation 3,100 m, 16 m thick of ice melting at elevation 3,170 m and 14.6 m thick of ice melting at elevation 3,250 m, respectively.

In terms of glacier retreat, the greatest retreat observed in Aleksandar glacier was 948 m and neighboring glacier Potanin which is the largest glacier of Mongolia was observed 670 m in the last 45 years (Figure 4.11).

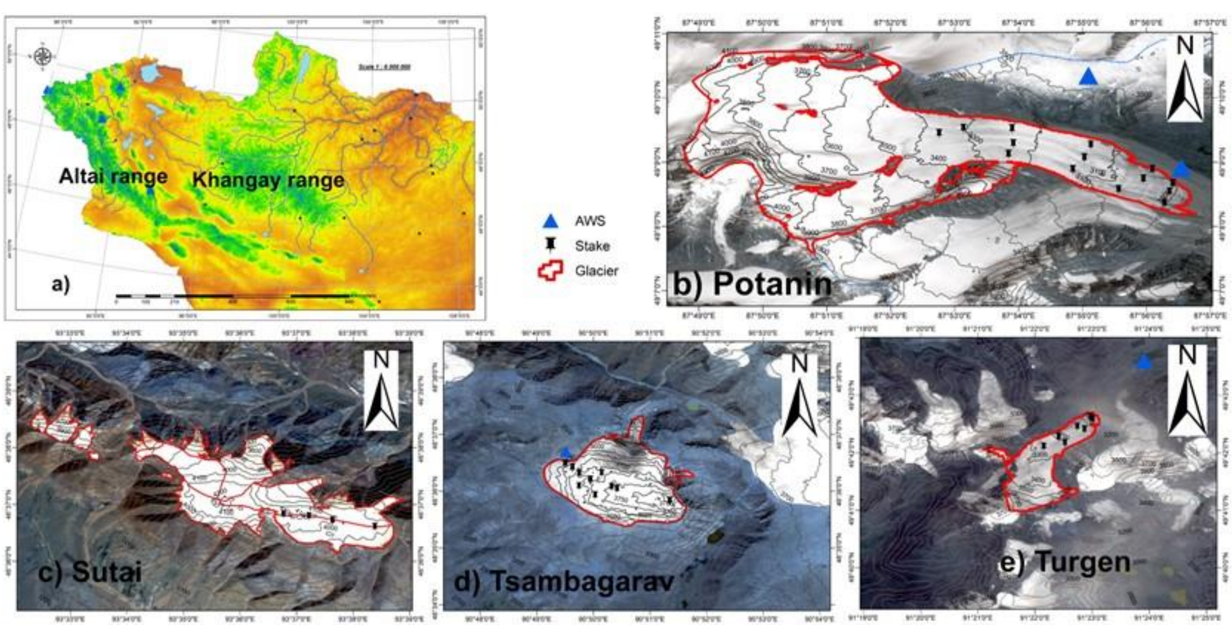


Figure 4.10 Site study of four glaciers and its stake positions

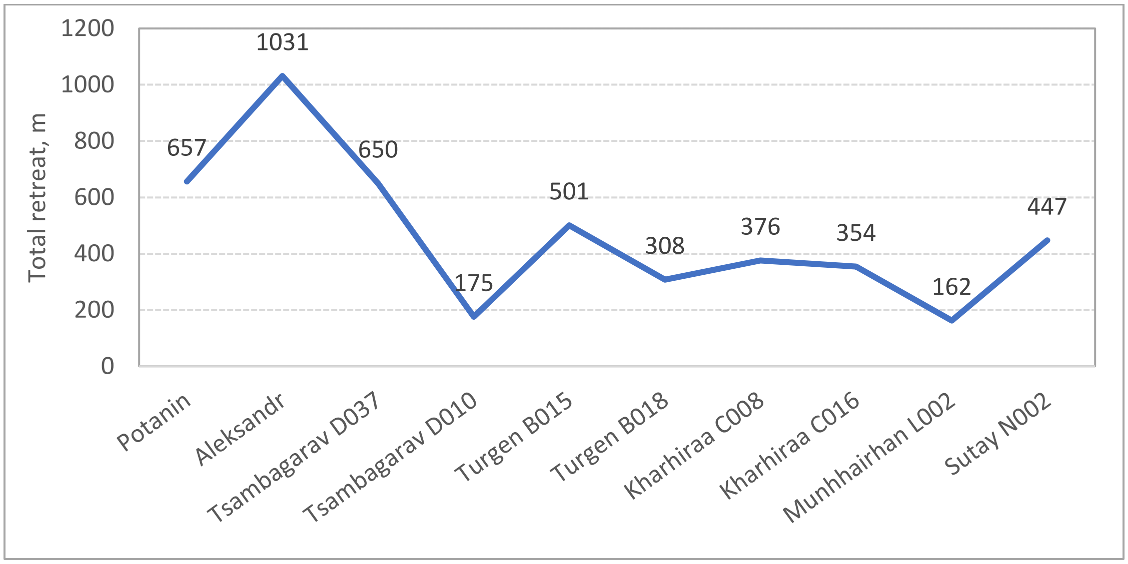


Figure 4.11 Glacier retreat, m

Annual mass balance estimation of 2017 shows that maximum melting rate at the Potanin glacier is 3,473.79 mm.w.e, while in the Turgen and the Sutai Mountain massif were 3,021.39 mm.w.e and 1,218.73 mm.w.e, respectively. In case of the Tsambagarav mountain, melting rate in 2017 was the 2nd biggest in the past. In 2012, the highest melting rate of the Tsambagarav glacier was observed as 1,427.77 mm.w.e. The lowest melting rate in the Potanin mountain was 303.63 mm w.e in 2005, in the Turgen mountain was 1,215.51 mm w.e. in 2014, and in the Sutai mountain 215.32 mm w.e in 2015 (Figure 4.12).

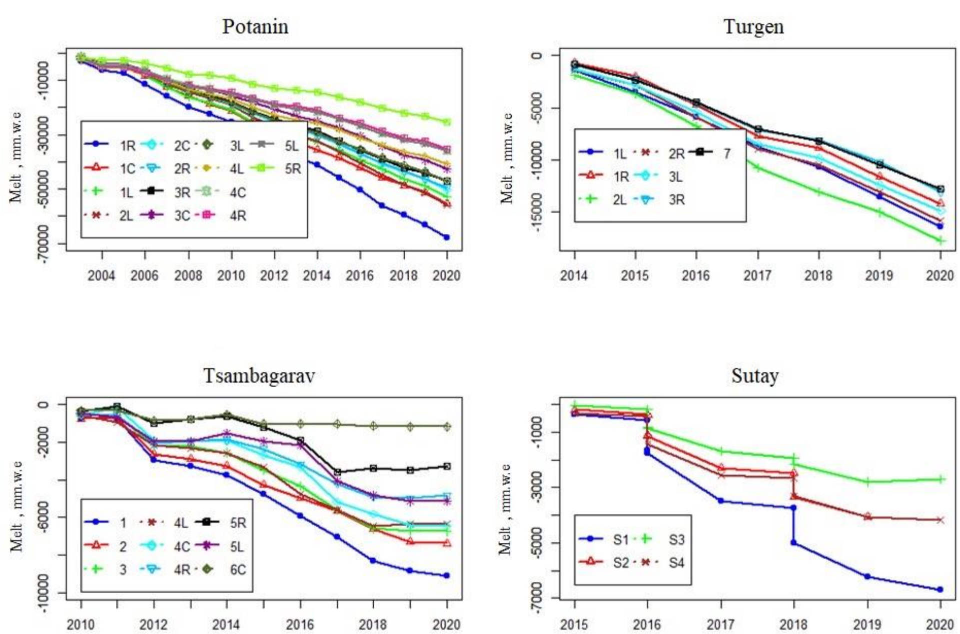


Figure 4.12 Annual melt of each stakes, mm

Future climate impact on water resource and glacier

River runoff. The river runoff model HBV has been used in Mongolian 10 major river basins (Eg, Chuluut, Ider, Orkhon, Tuul, Kharaa, Kherlen, Hovd, Bulgan, Tes) and the model was calibrated and verified by comparing with actual observation data for 11 years from 2010 to 2020 (Figure 4.13). Result showed the average linear correlation was 70% which implies that this model can be used to determine the future state of river and river runoff.

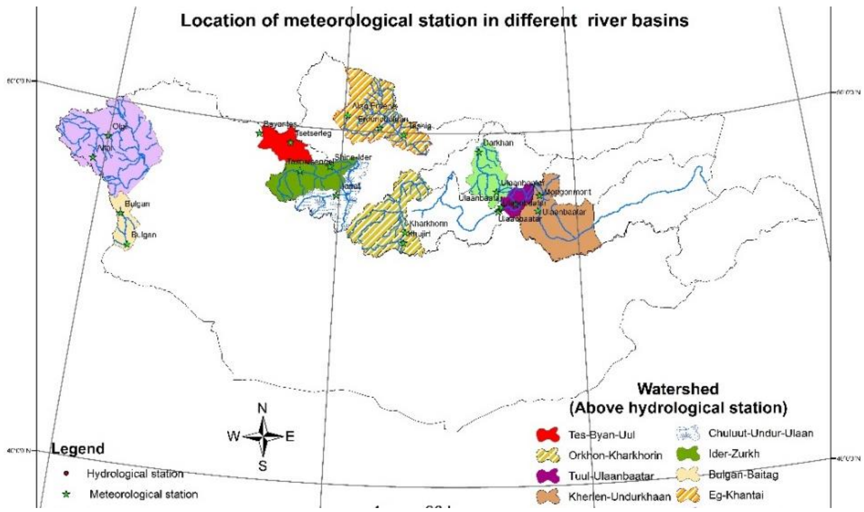


Figure 4.13 Location of meteorological stations in the river basins

In Figure 4.14 shows an example of the observed and modeled daily average of discharge at the Chuluut-Undur-Ulaan hydrological post.

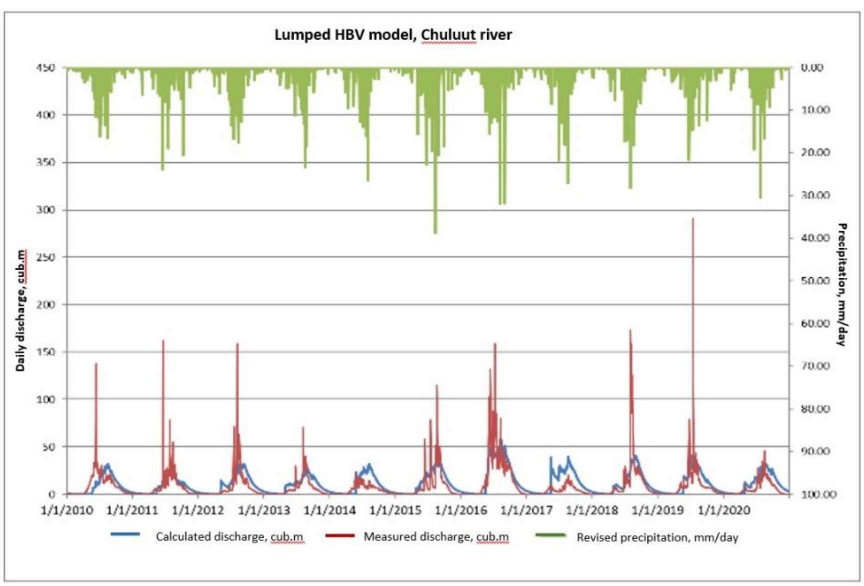


Figure 4.14 Observed and modeled average daily discharge of Chuluut-Undur-Ulaan, m^3/sec

For the input of HBV model have been performed for projected meteorological stations data (removed system error) which are situated in the river basins including daily maximum, minimum and mean of air temperature, precipitation, evapotranspiration under estimated by high emission scenario RCP8.5 of regional model RegCM4-HadGEM2. The model calculated future trend of runoff for all rivers during four periods covering 1986-2005, 2016-2035, 2046-2065, and 2080-2099.

According to average climatic data from 1986 to 2005, the average precipitation in the Arctic Ocean basin is 27%, the runoff depth is 1.95 times higher, the total evaporation is 11% higher compared with the Pacific Ocean basin; and the precipitation is 80%, runoff of rivers is 4.7 times higher, the total evaporation is 44% lower compared with the Central Asian Internal basin. The water temperature (monthly average April-October) in the Arctic Ocean basin is 3.1-3.3^{o}C and water surface evaporation is 30%-39% lower compared with the Pacific Ocean and the Central Asian internal basin, respectively (Table 4.3).

Table 4.3 Water balance elements, 1986-2005, mm

Basin	Precipitation	River runoff	Total evaporation	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
Central Asian internal basin	137.0	15.0	122.0	738.5	11.5

According to the results of the HBV model, the runoff of rivers that origins from the Altai Mountains and its branch mountains is expected to increase by an average of 9% between 2065 and 2100. In particular, it is expected to increase by 5%-8% in the Khovd river, 5%-15% in the Bulgan river and 6%-13% in the Tes river. In the Chuluut river which origins from back of Khangai mountain and Kharaa, Kherlen which origins from Khentii mountain there are have no significant change in the runoff of the rivers during the above period. But 7% increased runoff at the Egiin gol is expected. In terms of Kherlen river which origins from east side of Khentii mountain and representing rivers of eastern part of Mongolia the runoff of river expected to decrease by 40% in the middle of this century, and but it will be recovered by 20% by near end of period. The study results showed, runoff and water level will decrease of rivers and lakes of central and eastern part of Mongolia due to drought that triggered by increased evapotranspiration. Whereas, water level and runoff of lakes and rivers are expected to will increase for those origins from glaciers are situated in western part of Mongolia and those origins forest regions with permafrost such as Khuvsgul lake (Figure 4.15).

Figure 4.16 shows projected changes of annual and monthly runoff of the Chuluut river calculated by HBV model.

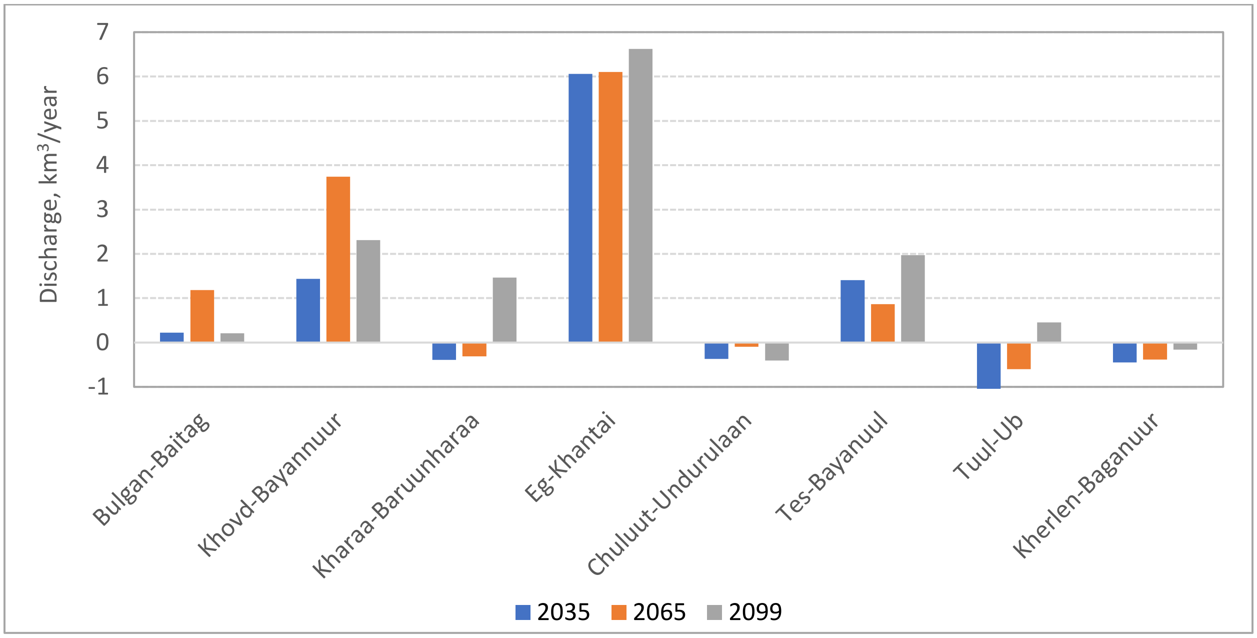


Figure 4.15 Future projection of river runoff

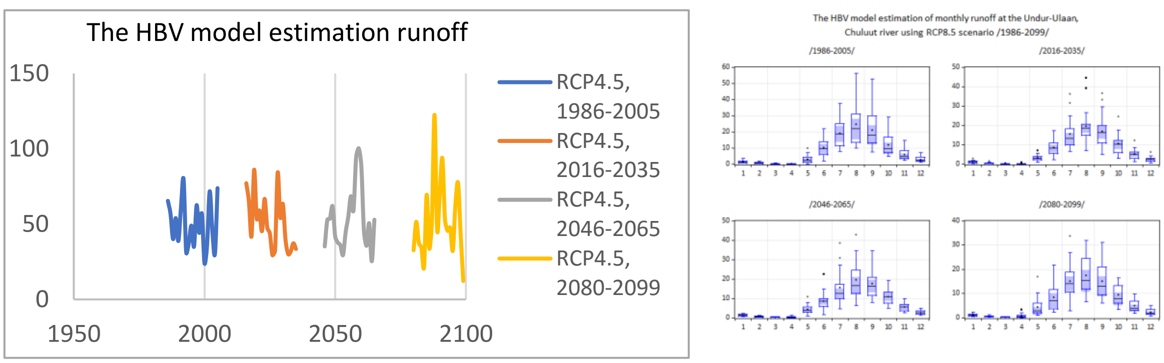


Figure 4.16 Future projection of annual and monthly discharge of Chuluut river, m^3/s

Glacier. Air temperature data at Khovd, Ulgii, Ulaangom, Altai meteorological stations was highly correlated (R^2=0.8) with the reanalysis data of ERA-5 which were corrected when calculating the long term mass balance. It gives opportunity to calculate the future mass balance (balance of ablation and accumulation) of four galciers namely Potanin, Tsambagarav, Sutay and Turgen using a projected air temperature data obtained from the high-GHG emission (ssp8.5) scenario.

According to this scenario air temperature of warmer season will be increased by 2.4^{o}C in middle of this century, and in the end of period or 2081-2100 air temperature will be increased by 5.8-5.9^{o}C. That means average air temperature of warmer season expected to reach 18.7^{o}C, 23.2^{o}C, 22.6^{o}C and 20.6^{o}C in the Altai, Khovd, Ulgii and Ulaangom stations, respectively. These expected changes are used to calculate future trend of glaciers mass balance by the model of energy-balance. According to the calculation result, the melting of the Turgen glacier which belongs to the category of valley type glacier has an increasing trendency of 72% in 2021-2040, 86% in 2041-2060 and 94% in 2081-2099, which is the most intensive compared to others. But melting of the Potanin glacier, which is the biggest valley type glacier in Mongolia, will be increased by 57% in 2021-2040, 76% in 2041-2060 and 89% in 2081-2099. In terms of melting of the Tsambagarav will be increased by 38% in 2021-2040, 57% in 2041-2060, and 77% in 2081-2099, while melting of the Sutay will grow by 24% in 2021-2040, 40% in 2041-2060 and 62% in 2081-2099. The Tsambagarav and the Sutay glaciers are belong to category of the ice-cap type of glacier and situated in relatively high elevations, therefore tend to have the lowest melting intensity in the future (Figure 4.17).

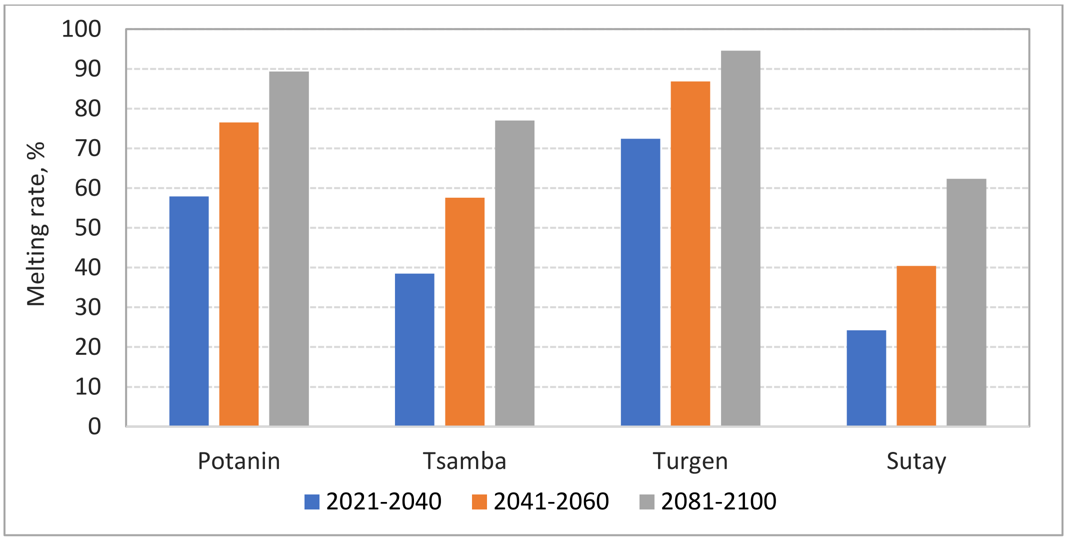


Figure 4.17 Future projection of glacier mass balance

Water balance elements. According to annual average evapotranspiration data from June to August (period is usually highest evapotranspiration observed of year) of 1991-2020 was 112.7 mm in the Arctic ocean basin, 124.4 mm in the Pacific ocean basin and the highest evapotranspiration of 126.9 mm observed in the Central Asian internal basin.

The projected total evapotranspiration from June to August, calculated by models ensemble that notified in sixth report of climate change, is 114.5 mm in 2040 which 1.8 mm above the average, 119.6 mm in 2060 that 6.9 mm above the average, 137.3 mm in 2100 that 24.6 mm above the average in the Arctic ocean basin; and 126.6 mm that 2.25 mm above the average, 133.2 mm that 8.8 mm above the average, 154 mm that 29.6 mm above the average in the Pacific Ocean; whereas in the Central Asian internal basin, with maximum evaporation, during these period is 129.8 mm that 2.9 mm above the average, 137.1 mm that 10.2 mm above the average and 161.2 mm that 34.3 mm from the average, respectively, it is expected to be more than the average for 1991-2020 (Figure 4.18-4.19).

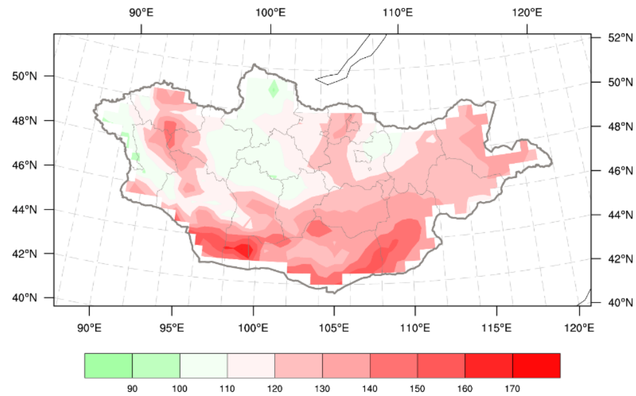


Figure 4.18 Distribution of mean evapotranspiration, Jun-Aug of 1991-2020, mm

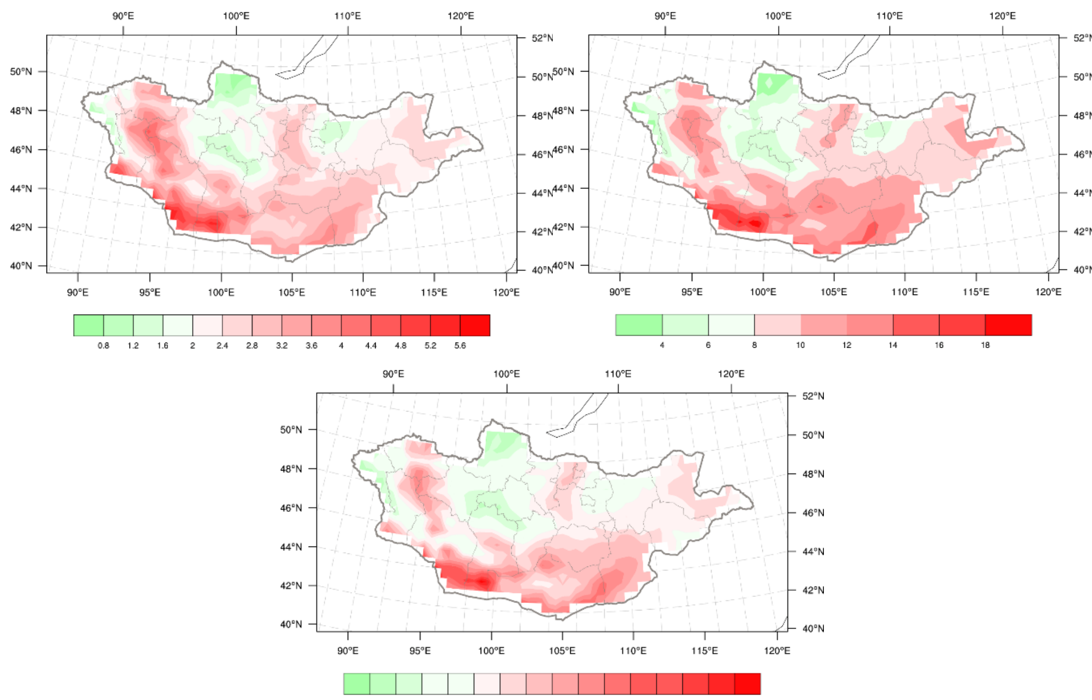


Figure 4.19 Future changes of distribution of mean evapotranspiration, Jun-Aug of 2021-2040, 2041-2060, 2081-2100, mm

Annual total precipitation in the Arctic Ocean Basin will be on average 11 mm in 2040, 28.3 mm in 2060, and 60.6 mm in 2100. In the Pacific Ocean basin it will be 12 mm, 35.1 mm, and 78.5 mm in 2040, 2060 and 2100, respectively. Whereas, in the Central Asian internal basin will be 8.21 mm, 20.4 mm, and 50 mm in these periods, respectively, more than the average of 1991-2020.

Based on the model result, beginning of the projection period, around 2040, no significant changes for precipitation in the Altay range that located in the western part of Mongolia. But, amount of precipitation will be increased by 4-10 mm in the Uvs lake basin and Great lakes valley, and 25-50 mm in the Central and the Eastern part of Mongolia in same period above.

Whereas, later in the projected period, around 2100, the amount of precipitation will increase by 70 mm in the Altay range, by 50-60 mm in the central part, and by 70-100 mm in the eastern part of Mongolia, respectively.

The average precipitation and evapotranspiration of June-August is relatively same level in around 2040s, and during 2060s precipitation is 5 mm higher than evapotranspiration in the Pacific ocean basin, while evapotranspiration will higher than precipitation by 6-7.5 mm in the other two basins.

In the end of this century, around 2100, the water balance to be preserved in the Pacific ocean basin, but in the Arctic ocean and the Central Asian internal basins, those occupied 84% of Mongolian territory, evapotranspiration will be 25-35 mm higher compared with precipitation, which leads to increase in frequency of drought in the future (Table 4.4). Eventhough prediction of precipitation shows an increasing trend for all over the Mongolia, evapotranspiration will increase significantly during these periods, thus, the frequency of droughts will trend to increase in the future.

Table 4.4 Future projection of precipitation and evapotranspiration

Basin	Element	2021-2040	2041-2060	2081-2100
Pacific ocean	Precipitation	4.31	14.12	31.34
	Evapotranspiration	2.25	8.8	29.6
Arctic ocean	Precipitation	-1.06	0.38	-2.87
	Evapotranspiration	1.88	6.9	24.6
Central Asian internal	Precipitation	1.37	2.77	8.44
	Evapotranspiration	2.9	10.2	34.3

4.1.2 Permafrost

Permafrost distribution and its spatial change: Permafrost in Mongolia delineates the southern margin of the permafrost region of the Western Siberia, and permafrost is concentrated in the northern part of the country on the high elevations of four large mountains and the south part of the country does not have permafrost (Jambaljav et al., 2017).

In Mongolia, permafrost has a sporadic to discontinuous distribution and is complicated not only by climate conditions, but also by mosaic land cover, surface geology, surface waters, hydrogeology and geotectonic activity (Jambaljav et al., 2022, Jambaljav et al., 2017, Sharkhuu et al., 2001, Gravis et al., 1974). Permafrost is classified in its type of extention as continuous, discontinuous, sporadic and isolated. Both continuous and discontinuous permafrost distributions are present in the north (Darkhad depression, Huvsgul Lake area) and high-elevation locations of the Altay, Hangai, Hovsgol and Khentii mountains; and sporadic and isolated permafrost occurrences are present at lower elevations, for example, in intermountain valleys, along the small river valleys where there are springs and wetlands (Jambaljav et al., 2022, Jambaljav et al., 2017, Gravis et al., 1974).

Permafrost distribution and its southern limit attracted the attention of many scientists, thus, it were drawn in different ways (Luvsandavga, 1978, Sharkhuu et al., 1975). Firstly, the southern limit of Mongolian permafrost was drawn by M.I.Sumgin based on their data and it is located approximately 60-

100 km south of Ulaanbaatar (Luvsandavga, 1978) (Figure 4.20). Subsequently, several maps of permafrost distribution were compiled, including a geocryological map that was compiled at a scale of 1:1,500,000 based on the results from the joint Soviet-Mongolian geocryological expedition in 1968-1970 (Gravis et al,. 1974). This map was used as a baseline data for the National Atlas of Mongolia published in 1990 and for a circum-Arctic map of permafrost and ground ice conditions published in 1999 (National Atlas of Mongolia, 2009, Brown J et al., 1999). As shown in Figure 4.20, this permafrost map of Mongolia, permafrost is characterized by discontinuous or sporadic distribution and covers 63% of the entire country (Gravis et al., 1974).

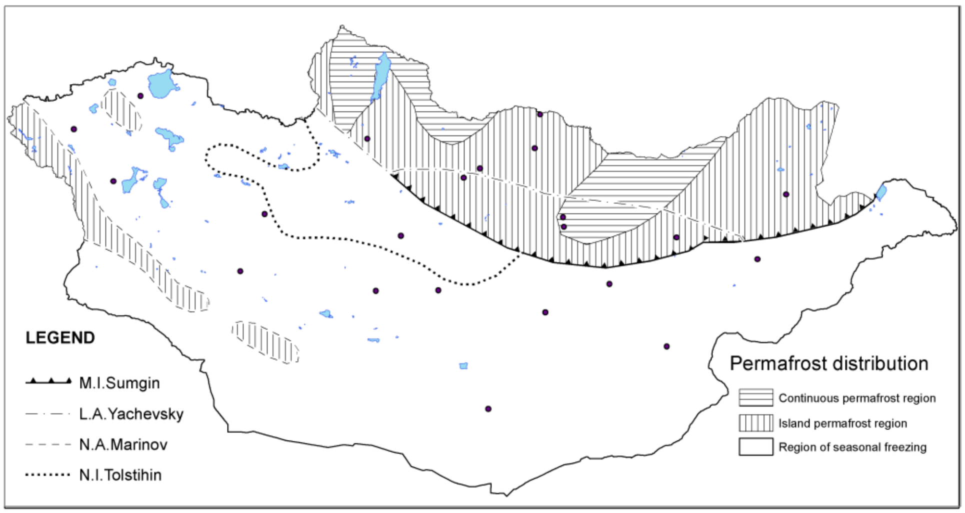


Figure 4.20 Permafrost distribution map of Mongolia before 1971

Several local and regional permafrost maps have subsequently been produced, but all have used for the lower elevation and southern limits of permafrost presented on the Gravis map (Sharkhuu, 2001).

In 2016, a 1:1,000,000 scale map of permafrost distribution was compiled based on the TTOP (temperature on top of permafrost) model (Permafrost distribution map of Mongolia, 2016). This map divided Mongolia into 5 permafrost zones: continuous, discontinuous, sporadic, and isolated and zones of seasonally frozen ground. These permafrost zones cover an area of 29.3% of Mongolian territory with the distribution zones from isolated to discontinuous in extent. In Figures 4.21 and 4.22, shown a comparison of permafrost distribution maps compiled in 1971 and 2016, respectively, where permafrost zones covered 63% of country's territory in 1971, and after 45 years this cover became 29.3% of the county's territory with the potential area of permafrost distribution has decreased by 33.7% over 45 years (1971-2016).

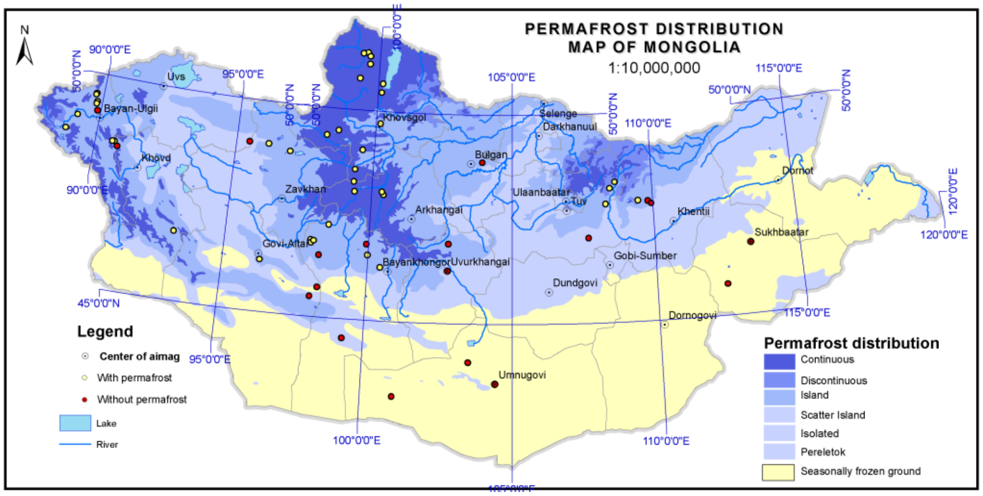


Figure 4.21 Permafrost distribution in Mongolia, 1971

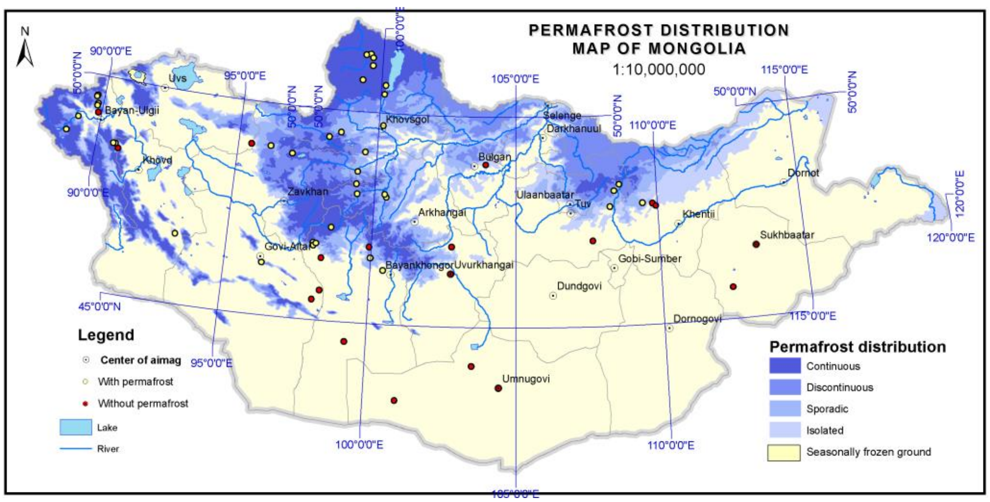


Figure 4.22 Permafrost distribution in Mongolia, 2016

The southern limits of the permafrost have accordingly shifted to the north at different distances. For example, the southern permafrost limit has shifted to the north by 178 km in the Khentii mountain range, while there is displacement of only 94 km in Khangai mountain range, and in the Altai mountain range the elevational permafrost limit has been elevated by 240-900 m.

Permafrost monitoring and its temperature change. Permafrost is divided into a cold permafrost and a warm permafrost. The cold permafrost with temperatures bellow -2°C occurs in the continuous permafrost zone of high latitudes and high elevations. The warm permafrost with temperatures above -2°C is found on the southern fringes of permafrost regions. The cold permafrost is mainly distributed in the Darkhad basin and on the high-elevated main ridges of the Altai, Khangai, Khuvsgul and Khentii mountains, while the warm permafrost fringes these high mountains is found in the depressed areas and along the vast valleys. In Mongolia, the distribution of permafrost is complicated not only due to cold air temperature, but also by mountainous terrain, mosaic land cover, surface geology, hydrogeology, and geotectonic.

In Figure 4.23, according to physical-geographic zones of Mongolia is divided into 6 permafrost regions: Mongolian Altai, Gobi-Altai, Khangai, Khuvsgul, Khentii and Khyangan zones categorized by the landscape, and permafrost distribution pattern (Tsegmid, 1969 and Dash, 2010).

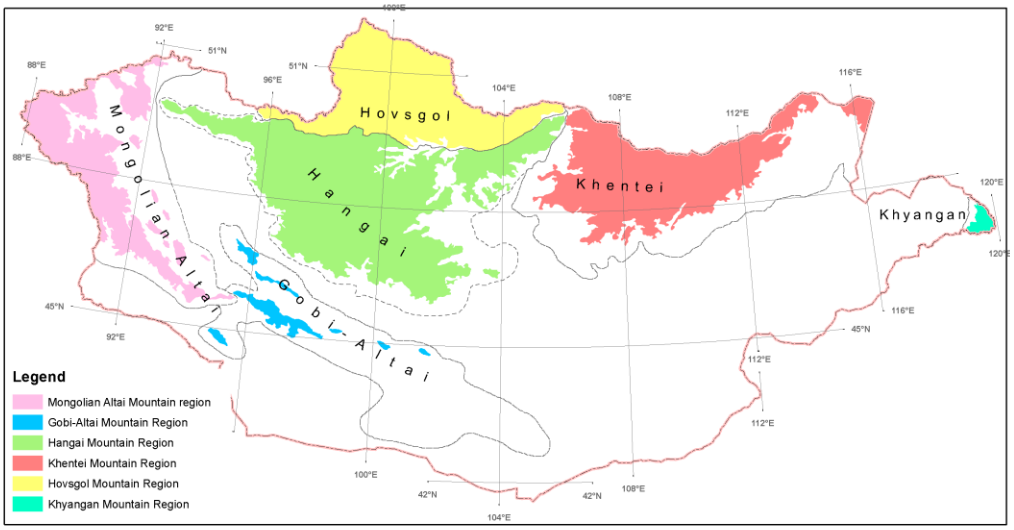


Figure 4.23 Permafrost regions of Mongolia

Permafrost degradation is manifested in a thickness change and its extent, as well as in deepening in an active layer thickness, detachment of active layer (formation of a talik), thermokarst hollow and lakes, changes in lake area, landslides and rock falls in highlands. Main parameters of change in permafrost are its temperature at some depth and its thickness. Permafrost is the product of climate change and it is more sensitive to climate change. Due to climate change, the southern or lower limits of permafrost have shifted to the north and up; taliks have formed in the Altai and Khangai ranges; and the disappearance of shallow permafrost is observed in the Khentii range (Ya.Jambabaljav et al., 2017).

Permafrost changes in the Mongolian Altai Mountain. The geographic position of the Mongolian Altai, its climate and high-elevation are global characteristics of its geocryological features. Surface shallow loose deposits, sparse vegetation cover, sharp elevation changes are formed the topo-microclimatic features of permafrost occurrence. In other words, the main dominant factors in develop and existence of permafrost are elevation above sea level and mountainous relief.

The permafrost distribution, its thickness and temperature were determined in a number of research studies conducted in the Mongolian Altai. The permafrost study was carried out in Tsagaannuur village of Nogoonnuur soum, Bayan-Ulgii province, and temperature was measured in the Asgat mine, and the depth of permafrost was 364.5 m (Bat-Erdene, 1995).

There are 33 permafrost-monitoring sites in the Mongolian Altai, and changes in permafrost temperature at 10 m-depth are measured since 1980s. The permafrost temperature at 10 m- depth was -0.8°C in 1985, and -0.4°C in 2016 and 2021 in borehole “Tsagaannuur1” on south-facing slope near Tsagaannuur village; while it was -1.2°C in 1983, -0.65°C in 2016, and -0.51°C in 2021 in borehole “Tsagaannuur2” on north-facing slope near Tsagaannuur village, respectively. The permafrost temperatures have warmed by 0.114°C - 0.175°C per 10 years since 1980s (Figure 4.24).

Permafrost changes in Gobi-Altai Mountain. Gobi-Altai mountain range extends from northwest to southeast covering territories of Gobi-Altai, Bayankhongor, Uvurkhangai, and Umnu-Gobi provinces.

There are 8 permafrost monitoring sites in the Gobi-Altai province and temperature at 8 m-depth was -0.3°C in 1982; -0.1°C in 2015; +0.024°C in 2019; and -0.17°C in 2020 covering a vast intermountain valley near Erdene soum of Gobi-Altai province, respectively. Since the 1980s, permafrost temperature has risen by 0.072°C per 10 years (Figure 4.24). Here, permafrost temperature is close to 0°C, and the warming trend is weak.

Permafrost changes in Khangai Mountain. Permafrost temperature at 15 m-depth was -3.7°C in 1981, -3.0°C in 2016, -2.77°C in 2020 in Gurvanbulag soum located at elevation of 2,500 m above see level (a.s.l); and -1.3°C in 1981, -0.54°C in 2015, and -0.45°C in 2020 in Bayanbulag soum of Baynhongor province located at elevation of 2,400 m a.s.l, respectively. Permafrost temperature has increased by 0.85°C -0.93°C in south of Khangai at an elevation of 2,400-2,500 m a.s.l, by recods over the last 39 years. Permafrost temperature at 15 m-depth was -2.04°C in 1969, -1.85°C in 1986, -1.55°C in 2002, and -1.2°C in 2015, and -1.04°C in 2020 at Terkh valley of northern Khangai; and at 10-m-depth was -2.35°C in 1968, -1.70°C in 2002, -1.30°C in 2015, -1.1°C in 2018 at the Sharga valley of north of Bulnai mountain, near the Tsagaan-Uul soum of Khuvgul province. Permafrost temperature has risen by 1°C -1.25°C over the past 50 years in the northern part of Khangai (Figure 4.24). This means that the permafrost temperature trend is 0.22°C per 10 years.

Permafrost changes in Hentii mountain. Khentii Mountain lies in the northeast of Mongolia and is located between the ecotone from the taiga of Baigal Lake to the dry steppes of the Central Asia (Tumurbaatar et al., 1975) completed a 1:25,000 scale map of permafrost and seasonally frozen ground of the urban area of Uaanbaatar (Jambaljav et al., 2009) compiled a 100,000 scale permafrost map of the Terelj, Nalaikh and Ulaanbaatar areas with based on a modeling approach. In valleys of the Selbe, Gachuurt, Uliastai, Tolgoit and Khol rivers the ice-rich valley permafrost is common, and there is a relict permafrost with disagree with current climate in the Nailaikh depression. Mountain permafrost lies in the north of the mountain range beneath the forest.

The results of 28 permafrost monitoring sites in the Khentii Mountain and 3 temperatures monitoring boreholes are presented. The temperature at 10 m-depth was -0.1°C in 1978, +1.2°C in 2011 at “Gurvanturuu” borehole in Bayan soum of Tov province; and was -0.1°C in 1984, +1.37° in 2010, +1.53°C in 2015, and +1.8°C in 2021 at Airag lake in Umnudelger soum of Khentii province (Figure 4.24).

Permafrost with depth of 7 m was observed in 1970 (Tumurbaatar, 2004), while this permafrost was at a high degradation stage close to 0°C in 2012. On the other hand, permafrost was in the stage of active degradation in the Khentii Mountain region.

Permafrost changes in Khuvsgul mountain. This mountainous region surrounded by the lake highlands of the Hangain Mountain in the south, the medium height mountains of the Selenge-Orkhon basin in the southeast, and the border of Russia in the north.

There are 33 permafrost monitoring sites in the Khuvsgul Mountain and 2 monitoring of temperature boreholes are presented. Permafrost temperature at depth of 10m was -3.91°C in 1989, -3.25°C in 2005, -3.3°C in 2014, and -2.95°C in 2019 at the Deed Tsagaannuur lake bank in center of Tsagaannuur soum of Khuvsgul province. At depth of 15 m, it was -1.22°C in 1987, -0.7°C in 2011, -0.26°C in 2016, and -0.199°C in 2019 (Figure 4.24). This means that over the past 30 years, the permafrost temperature in the Darkhad Basin of Khuvsgul Mountain has risen by 0.96°C. On the other hand, the permafrost temperature trend is 0.24°C - 0.32°C per 10 years in Darkhad Basin of Khuvsgul Mountain.

The permafrost warming trend (0.07°C/decade) was small in the Gobi-Altai mountain range and amounted to 0.14°C/decade in the Mongolian Altai, 0.22°C/decade in Hangai and 0.28°C/decade in Khuvsgul mountain. On the other hand, this means that in the warm permafrost regions of Mongolia, the permafrost warming trend is small and, nevertheless, permafrost is rapidly disappearing. While, in the cold permafrost regions of Mongolia, the permafrost warming trend is large and permafrost is currently degrading.

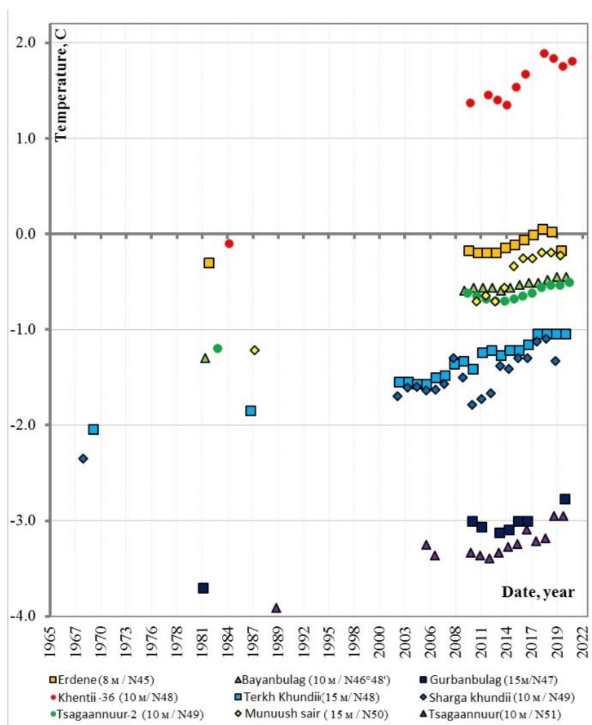


Figure 4.24 Permafrost temperature changes at 10-15 m depth over Mongolia

Future change of permafrost. Future changes of permafrost were estimated using the TTOP (Temperature on Top of Permafrost) model as a part of the Third National Climate Change Assessment report (TNC, 2018).

Using the inputs above, the output of model showed that permafrost zones cover approximately 28.01% of total territory of the country at the initial condition of future modeling. In terms of coverage of permafrost zones, the difference is 1.31% compared to permafrost map of Mongolia of 2016 (TNC, 2018). According to the model output, coverage of permafrost zones is expected to reduce by 16.46% - 18.31% in 2016-2035, 33% - 61.23% in 2046-2065, 74% - 94.7% in 2080-2099, respectively, and the model output for 2050 were used to assess impact, vulnerability and risk (Figure 4.25).

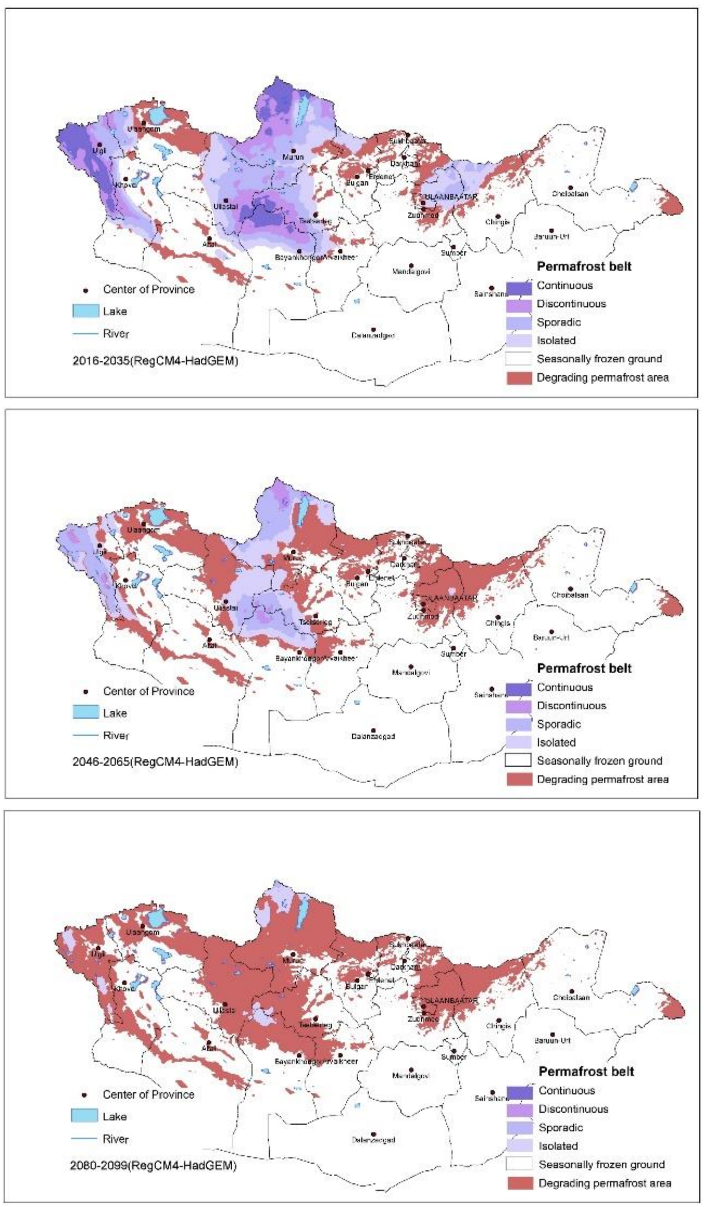


Figure 4.25 Future permafrost change in Mongolia, RegCM3-HadGEM2

Risk assessment for socio-economic, ecological consequences of permafrost degradation and coping methods. Changes in permafrost due to climate warming are manifested in the form of desertification, the disappearance of springs and streams, as well as changes in the water cycle in the ground within the mountain system, which will subsequently lead to ecological imbalance. In 2016, updated norm and rule of basis of buildings and facilities on permafrost was adopted. However, most of the buildings built on permafrost are damaged in some soum centers due to permafrost thawing, and in 2022, all provinces centers were connected by asphalt-concrete roads, and waves form on paved roads in permafrost areas, and therefore, safety of traffic on these roads is lost. This not only leads to significant economic losses, but also seriously violates the living and working conditions of people in comfortable conditions, comfortable movement on the roads.

In recent years, scientists from other countries in permafrost regions, as well as scientists from Mongolia, have conducted research on adaptive technology to stop the thawing of permafrost, adapted to the conditions of Mongolia, and this was laid under some engineering structures. Between 2017-2019, a scientific project "Permafrost study along some roads" was carried out to clarify the damage to roads on permafrost, and as part of this project, an adaptation technology was developed to stop the permafrost thawing under infrastructure (Jambaljav et al., 2019). In general, buildings and roads on permafrost become more dangerous with cracks on the wall and forming waves on the road surface within 1-10 years after construction and become more dangerous for operating in the future (Figure 4.26 and 4.27).

Figure 4.26 School building at Tsakhir soum, Arkhangai province, Crack on the wall due to permafrost thaw

Figure 4.27 Wave on road surface (settlement on surface) in Valley of Chuluut River

In 2021-2022, with the support of the Western Regional Road Corridor Development Project, implemented by the Ministry of Road and Transport Development and the Asian Development Bank, a road with an embankment of crushed stone and a thermosyphon was built at the Buraat pass and between Tsagaannuur-Ulaanbaishint, along the AH4 road. As a result of these adaptation technologies, the permafrost thawing under the roads should be stopped and there will be no waves on the road surfaces in the future (Figure 4.28).

Figure 4.28 Wave on road surface (settlement on surface) in Valley of Chuluut River

4.1.3 Pasture and Soil

Pasture state of Mongolia. A total of 1,519 national monitoring sites for pasture condition were conducted survey in the middle of August every year, and the "National report on the rangeland health of Mongolia" was published 3 times in 2015, 2018 and 2020.

According to the long-term study of the condition of pastures, indicators such as yield, cover, and greenness index are not enough to evaluate the pastures, so it is important to consider the current state of the main species of plants and their changes.

The National Agency of Meteorological and Environmental Monitoring (NAMEM) is experimenting and implementing with the methods and principles used in countries with dry grasslands in the study, monitoring and assessment of pasture in Mongolia, and it is based on the every site's ecological potential which is "State Transition Model".

In the framework of this new methodology, produced the definition of the ecological site description of each pasture monitoring sites, the pastures are classified into 25 ecological site groups, and reference level (plant species when the pastures are relatively better) is developed. Also based on this information relevant estimination is made on the level of pasture degradation, and then issued a "National report on the rangeland health of Mongolia".

Based on the assessment of the state of pastures in Mongolia as of 2020, the main plant species has changed from the reference level in almost 70% of the total areas (Figure 4.29).

From the maps of pasture state and degradation, the central and eastern regions have changed largely, indicating that these regions are more vulnerable to climate change and on the other hand, pasture lands are more affected due to high livestock density (Figures 4.29 and 4.30).

Considering the level of degradation, 31.1% of the total area of national pasture monitoring is not degraded (level I or normal), 17.7% is slightly degraded (II), 22.4% is moderately degraded (III), 17.9% is severely degraded (IV), while 11.0% was very severely degraded (V) or lost its pasture quality (Figure 4.30).

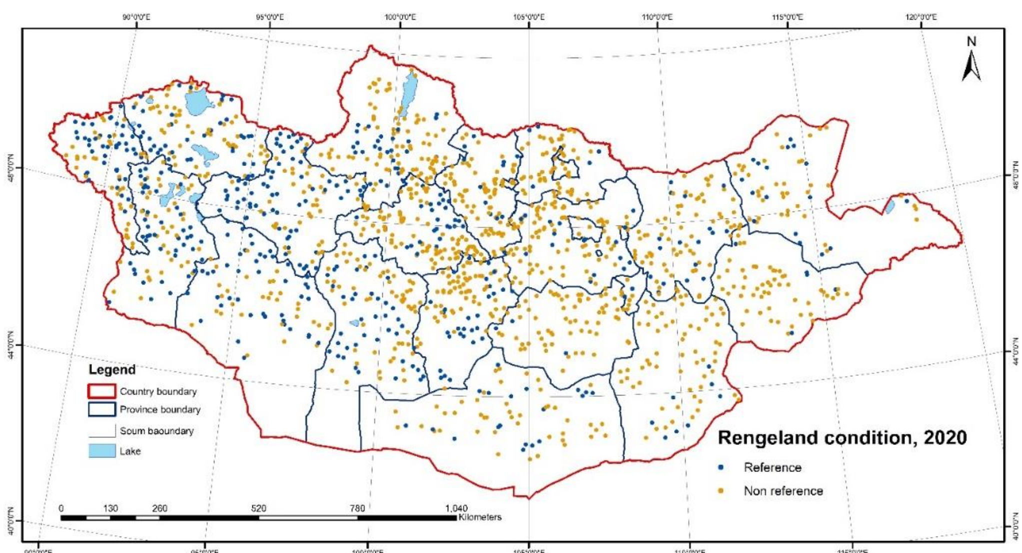


Figure 4.29 Pasture state of Mongolia, 2020

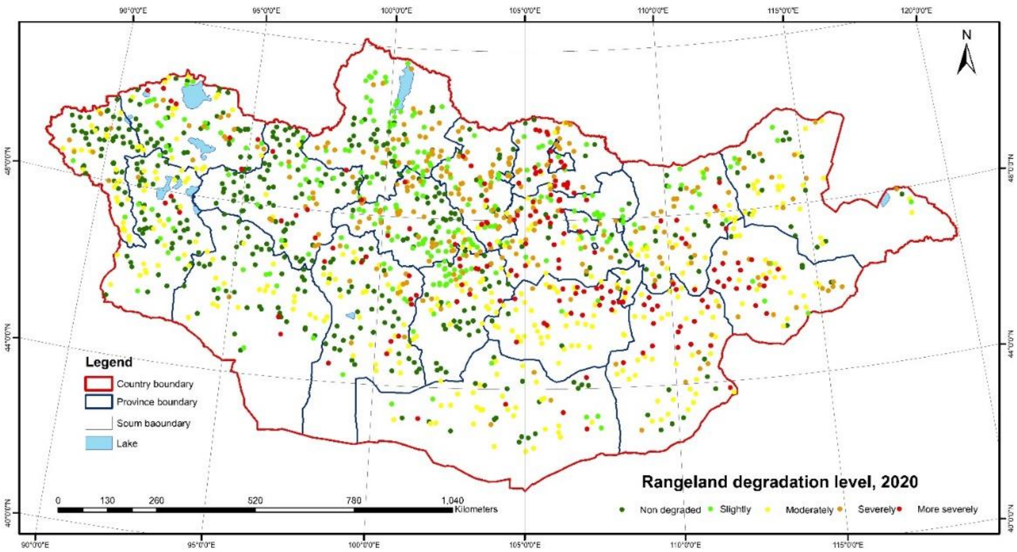


Figure 4.30 Pasture degradation, 2020

The Century4.0 model, that predicts soil oranic matter dynamic model that calculates soil-vegetation productivity, and the DayCent4.5 model, which is a day-step version of Century4.0 model, was used to assess the impact of climate change on pastures in Mongolia.

Daycent model were prepared by using more than 70 meteorological stations for the years 2000-2020, and then the model was run to determine the main parameters of soil-plant productivity, such as soil organic carbon (up to 20 cm), aboveg-round biomass (AGB), and below-ground biomass (BGB) were calculated in daily steps. The results from model-estimated current carbon content are show in Figure 4.31 as an average for July.

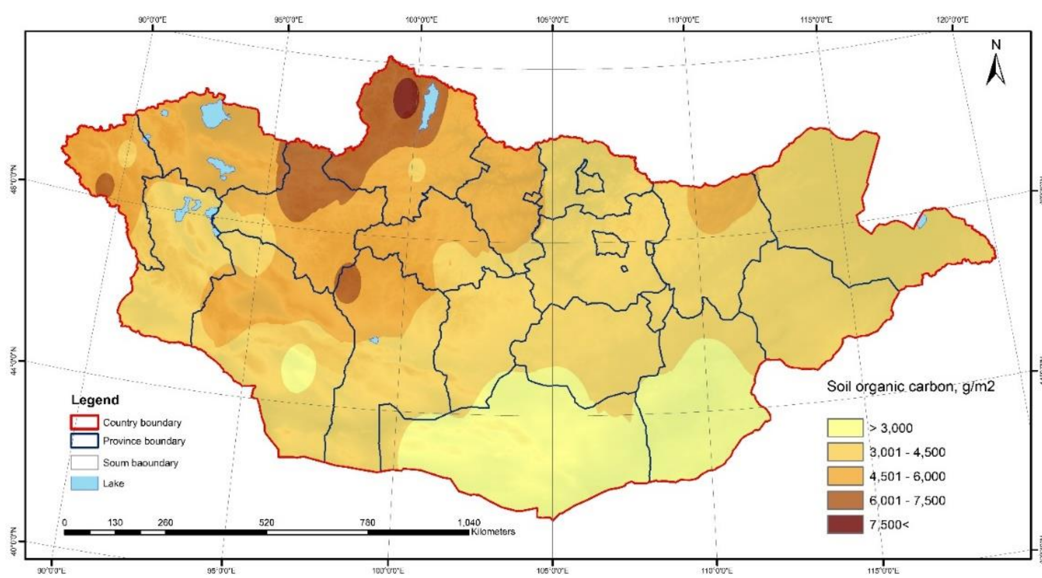


Figure 4.31 Soil organic carbon, g/m^2 (calculated DayCent model)

In order to calculate the future changes of soil organic matter, DayCent model used in accordance with the regional climate models (RegCM4-HadGEM2) scenarios with high (PRC8.5) and moderate (PCR4.5) emissions of greenhouse gases, and removing systematic errors at the meteorological stations, and prepared by maximum, minimum and average air temperature and precipitation (Gomboluudev, 2022), the future data for 2050 and 2080 were used.

The current soil organic carbon content calculated by the model is the highest in soums representing the high mountain region, 5,907 g/m^2, while the lowest is 2,824 g/m^2 in the desert region, and 4,165-4,746 g/m^2 in other natural regions. Under the impact of future climate change, the soil organic carbon content will decrease throughout the country. The calculation results show that the rate of reduction is greater in the case of high greenhouse gas emissions (PCR8.5), 18%-28% in the middle of this century and 27%-35% at the end of the century (Table 4.5).

Table 4.5 Current content of soil organic carbon, and it's changes

Natural zones	*Current content, g/m^2*	*Future changes,%*			
		Scenario RCP4.5		*Scenario, RCP8.5*	
		2046-2065	*2080-2099*	*2046-2065*	*2080-2099*
High mountain	5907.8	-4.2	-22.9	-22.8	-34.7
Forest steppe	4746.8	-2.3	-18.8	-18.8	-27.0
Steppe	4405.9	-6.6	-21.0	-21.9	-34.5
Desert steppe	4165.6	-8.9	-28.8	-28.8	-42.3
Desert	2824.4	-10.0	-24.3	-25.4	-34.5

Considering the distribution of soil carbon reduction in the area, the amount of land less than 3000 g/m^2 currently covers 15.2% of the total area, while it will be increased by 28.6% in 2050 (RCP4.5 version), and 41.6% in 2080. However, according to the RCP8.5 scenario, the area of low carbon content will increase rapidly, reaching 41.3% in 2050 and 73.9% in 2080 (Figures 4.32-4.33, Table 4.6).

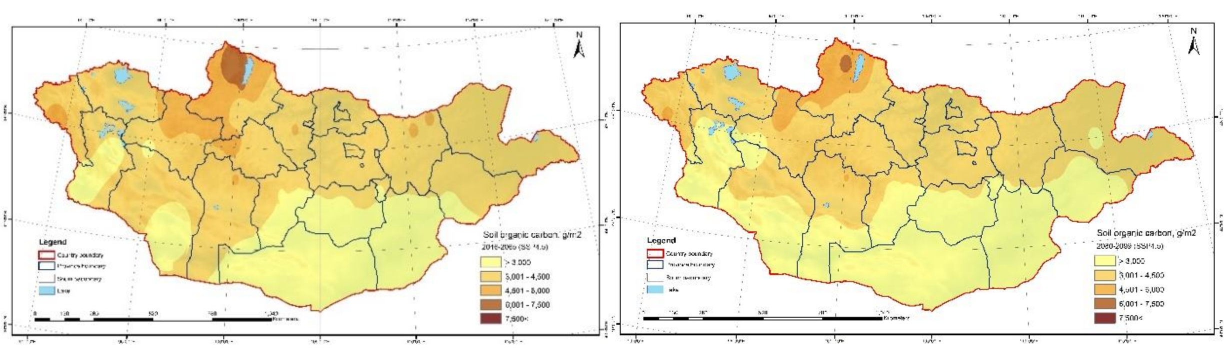


Figure 4.32 Soil organic carbon changes, g/m^2, a) 2046-2065, RCP4.5, b) 2080-2099, RCP4.5

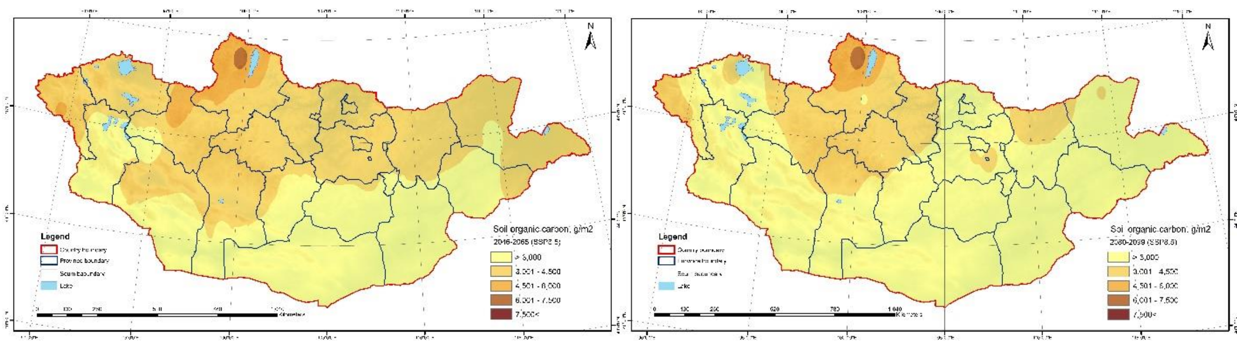


Figure 4.33 Soil organic carbon changes, g/m², a) 2046-2065, RCP4.5, b) 2080-2099, RCP8.5

Table 4.6 Soil organic carbon content, it's future changes (area, %)

Soil carbon, g/m²	*Current content*	*RCP4.5*		*RCP8.5*	
	2000-2020	*2046-2065*	*2080-2099*	*2046-2065*	*2080-2099*
< 3000	15.2	28.6	41.6	41.3	73.9
3001-4500	53.2	62.4	53.6	53.7	23.2
4501-6000	25.8	7.8	4.6	4.7	2.6
6001-7500	5.4	1.1	0.2	0.3	0.3
7501 <	0.4	0.1	0	0	0

The current content and future changes of the above-ground and below-ground biomass (AGB, BGB) of pasture plants by calculation using the DayCent model show that current area with a biomass of 3.0 g/m^2 -5.0 g/m^2 occupies about 25% of the total area (Figure 4.34), while it will decrease to about 20% in around 2050 and 2080 (RCP4 .5)

The biomass for content of 8.0 g/m^2 does not change much in the RCP4.5 scenario, but according to the amount calculated in the RCP8.5 scenario, the pasture area will decrease by about 10% from the current state (Figures 4.35-4.36).

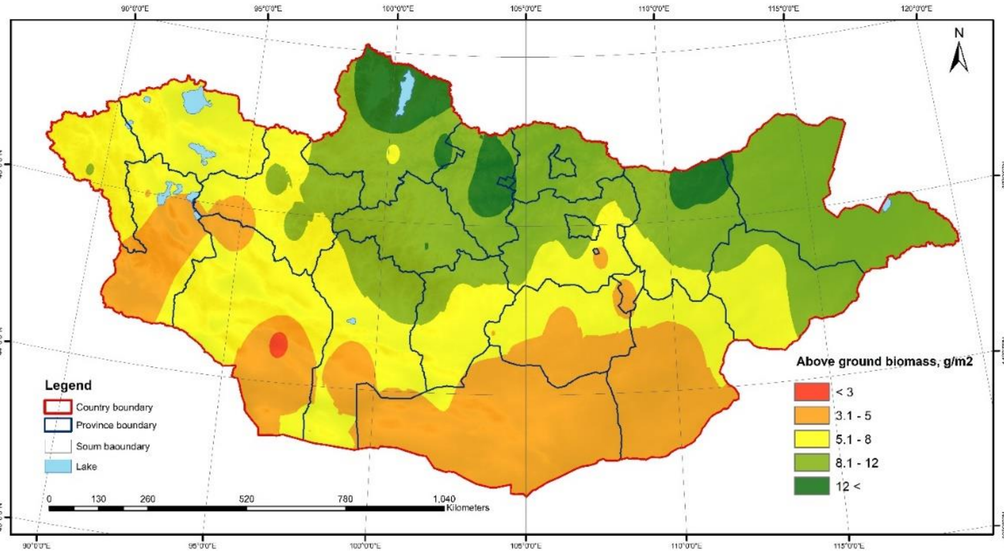


Figure 4.34 Above ground biomass, g/m² (estimated by DayCent model)

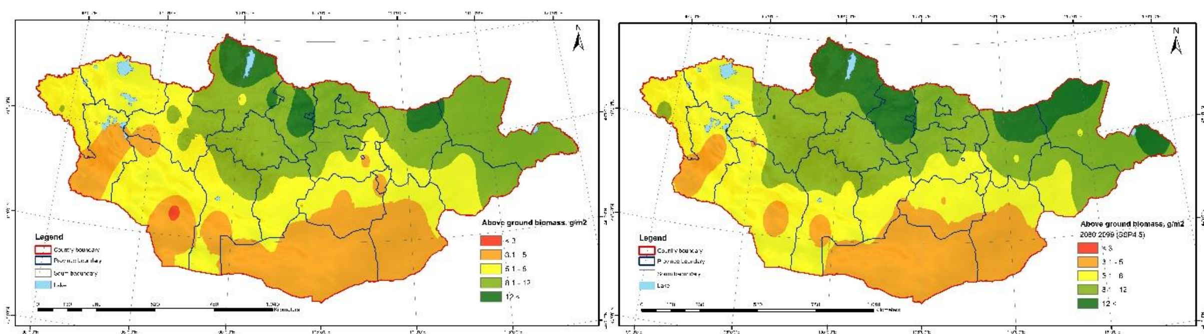


Figure 4.35 Above ground biomass changes, g/m², a) 2046-2065, RCP4.5, b) 2080-2099, RCP4.5

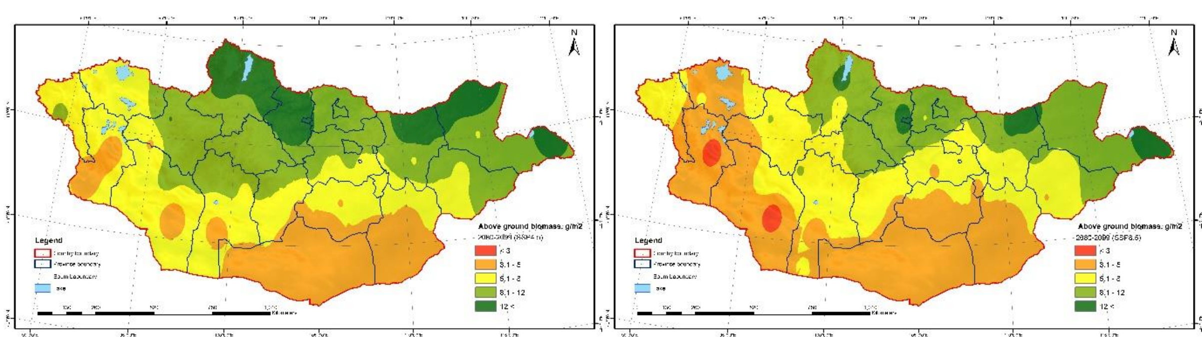


Figure 4.36 Above ground biomass changes, g/m², a) 2046-2065, RCP4.5, b) 2080-2099, RCP8.5

4.1.4 Land degradation, desertification

In "National Program for Combating Desertification" (2010) provides environmental balance by combating desertification, reducing desertification, and preventing land degradation, and improving the livelihood of local communities affected by desertification. Also in "Vision-2050" Mongolia's long-term development policy document (2020) "Protecting soil fertility and moisture, preventing land degradation and desertification, rehabilitating damaged and degraded land and putting it into agricultural circulation", "Identify and implement advanced methods for rehabilitating damaged and polluted land, preventing land degradation and desertification, and increasing soil fertility" and "Environmental monitoring network and data base will be expanded, technological development will be introduced, and an smart comprehensive information system will be formed". In "The Law on soil protection and preventing desertification" (2012) states that research and conclusions on the state of soil degradation and desertification shall be carried out by a professional organization.

The United Nations Convention to Combat Desertification (UNCCD) defines "desertification as the process of land degradation and land potential reduction in arid, semi-arid regions due to climate change and human factors" (UNCCD, 1994).

Land degradation is "the reduction and loss of the biological and economic productivity of the area as a result of land use forms such as arable farming, irrigation field, livestock grazing in the steppes, forest use and the complexity of their management practices" (UN, Sustainable Development Goals, 2015).

In 2020, the research team of the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE) completed the task of "Desertification atlas of Mongolia" in 2020 by order of the Ministry of Environment and Tourism (MET).

When updating the atlas, it was stated that land degradation and desertification are a long-term process and in respect of desertification it should be evaluated based on the long-term trends of the factors that determine it.

In developing the desertification atlas, it was used data and information from national databases: climate database, environmental database, remote sensing database, pasture and soil database, and socioeconomic database from National Statistic Office. Almost all database archieved in the IRIMHE and is constantly updated by expanding and enriching.

To assess desertification, more than 30 natural and social factors related to desertification and land degradation in this country were determined and 18 key indicators were selected from them (Table 4.7). These data were and processed accordanly and analyzed and then a comprehensive map of desertification in Mongolia was developed (Figure 4.37). The desertification atlas of Mongolia (2021) includes a total of 49 thematic images, and desertification images of each provinces.

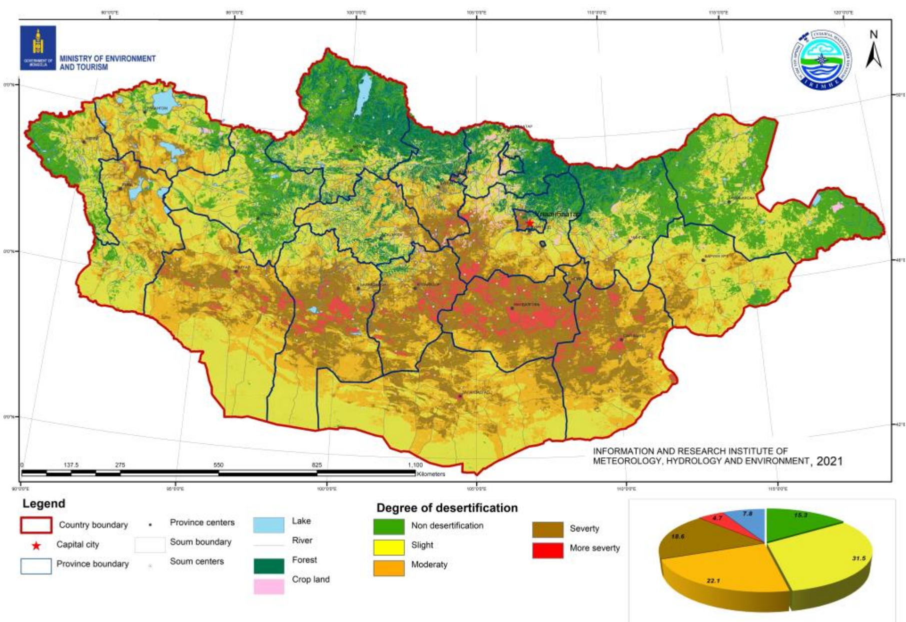
Table 4.7 Main parameters for assessing desertification

№	*Indicators*	*None/ Undetected*	*Weak/ Slight*	*Medium/ Moderately*	*Strong/ Severely*	*Very strong/ Heavily*
1	Change in the frequency of average hot days (TX90p) in June and July	<3.23	3.92	4.61	5.09	>5.2
2	Change in humidity coefficient (Shashko index)	<-1	-2.0	-3.0	-4.1	>-4.1
3	Drought frequency (VCI)	0-2	5	9	15	>16
4	Drought frequency during summer season	<10	29	59	79	>80

5	Standardized Precipitation-Evapotranspiration Index (SPEI)	<0	0.03	0.05	0.07	>0.07
6	Condition of the soil being eroded by water	<0.03	0.06	0.08	0.12	>0.12
7	Amount of soil eroded by wind	<10	60	100	150	>151
8	Changes in the concentration of PM2.5 dust in the air	<0	0.10	0.30	0.60	>0.60
9	Number of days for dust blowing	<0	0.20	0.40	0.60	>0.60
10	Trends in vegetation cover change (EVI)	>0.031	0.00	-0.01	-0.06	>-0.18
11	Trends in vegetation cover change (NDVI)	>0.041	0.03	-0.04	-0.12	>-0.29
12	Pasture biomass	>20.1	20.0	10.0	4.0	<2.0
13	Pasture carrying capacity	<50	100	300	500	>501
14	Soil degradation	<0.005	0.25	0.50	0.75	>0.75
15	Soil organic carbon content	500	60	32	14	<5
16	Land cover changes (LANDSAT)	Improved		No change		Degraded
17	Population density	<1	1	5	10	>10
18	Livestock density	<50	100	500	1000	>1000

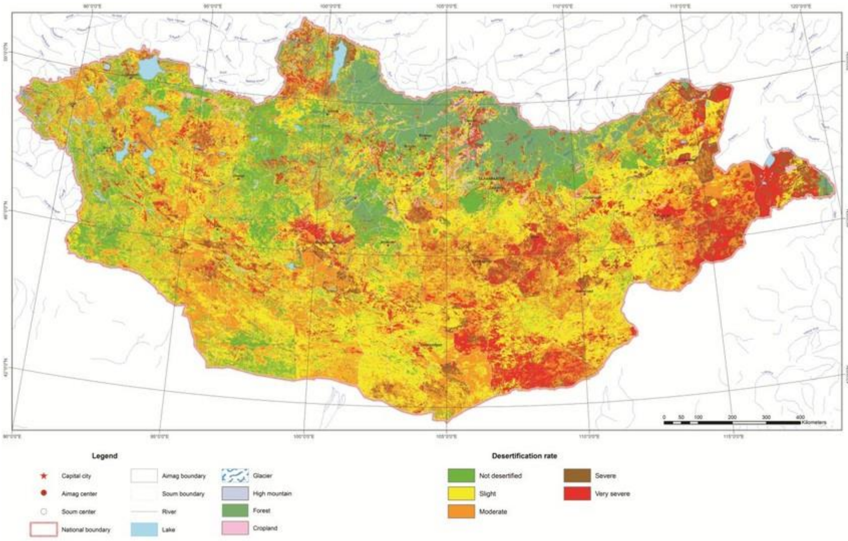
From the desertification map, as of 2020, 76.9% of the total territory of Mongolia has been affected by desertification, of which 31.5% is classified as slight, 22.1% as moderate, 18.6% as severe, and 4.7% as extremely severe (Figure 4.37).

If we compare this updated desertification map with the map of desertification released by the Institute of Geography and Geoecology (IGG) in 2010 (Figure 4.38), the areas with severe and extremely severe levels of desertification is depicted quite differently.



Source: IRIMHE, 2021

Figure 4.37 Desertification map of Mongolia, 2020



Source: IGG, 2010

Figure 4.38 Desertification map of Mongolia, 2010

There was a 3.2% increase in the area undetected desertification, and a 5.2% decrease in the area of extremely severe desertification.

In the previous map (2010), the steppes of Eastern Mongolia, especially, the Menen steppe as a whole, and some areas of the western taiga of Khuvsgul Lake were depicted as being in a very strong (extremely severe) level of desertification, while the new map (2020) developed by IRIMHE shows that desertification in these areas has a weak or moderate levels (Figure 4.38).

The area in the slight level of desertification decreased by 3.8% and the area in the moderate level also decreased by 3.8%, but the area affected by the severe level of desertification increased by 11.9%. This indicates the area that was in the slight or moderate level of desertification had converted to severe level (Figures 4.37 and 4.38).

By province, Dundgobi, Uvurkhangai, Gobisumber, Dornogobi, Bayankhongor, Tuv, Gobi-Altai, and Umnugobi provinces are more affected by desertification. The percentages of areas with desertification are seperated by each province (Table 4.8).

Table 4.8 Desertification areas (%) by provinces

№	Province name	None/ Undetected	Weak/ Slight	Medium/ Moderately	Strong/ Severely	Very strong/ Heavily	Others
1	Arkhangai	2.0	45.0	28.5	8.5	0.6	15.4
2	Bayan-Ulgii	41.1	39.4	13.2	3.9	0.1	2.3
3	Bayankhongor	1.2	24.3	30.4	33.6	9.8	0.7
4	Bulgan	10.2	19.4	20.1	16.9	4.2	29.2

5	Gobi-Altai	1.3	39.3	32.8	22.1	4.4	0.1
6	Gobisumber	0.1	0.2	25.6	60.5	13.5	0.1
7	Darkhan-Uul	16.9	36.6	10.4	4.9	0.5	30.7
8	Dornod	57.7	37.5	2.3	0.1	0.0	2.4
9	Dornogobi	0.3	13.9	32.2	43.4	10.2	0.0
10	Dundgobi	0.0	1.3	13.0	54.8	30.9	0.0
11	Zavkhan	33.9	48.6	9.6	1.1	0.0	6.8
12	Orkhon	0.0	4.7	27.3	26.1	17.8	24.1
13	Uvurkhangai	0.0	6.3	26.7	48.5	15.7	2.8
14	Umnugobi	0.5	37.8	37.2	22.9	1.6	0.0
15	Sukhbaatar	11.7	50.2	27.3	9.9	0.5	0.4
16	Selenge	28.6	24.8	4.5	0.5	0.0	41.6
17	Tuv	6.3	24.5	24.4	21.8	6.1	16.9
18	Uvs	13.9	41.0	23.8	9.2	0.7	11.4
19	Khovd	6.7	46.4	29.2	13.3	1.4	3.0
20	Khuvsgul	37.1	24.8	4.2	0.4	0.1	33.4
21	Khentii	34.4	32.8	13.6	4.1	0.4	14.7
22	Ulaanbaatar	1.9	26.5	20.5	25.2	7.6	18.3

Note: Others include lakes, forests, and farmland.

The natural factors leading to desertification are drought and dryness, which are intensifying under climate change, and one of the main causes of human factors is the excessive increase in the number of livestock and improper use of pastures.

In Mongolia, 62 sheeps unit per 100 hectares is the ecologically potential, but as of 2019, there are 105 sheep unit (147 if the number of livestock in each *bag* and *khoroo* is counted in the territory), which is one of the main reasons for the pasture degradation.

The issue of economic evaluation of pastures has not yet been resolved, and according to a study conducted by the scientists of the University of Agriculture and Life Sciences in 2013, the value of a unit area of pasture may vary between 849,879 - 2,044,505 MNT. The amount depends on the pasture biomass, nutrient quality and distance of the pasture, and average value of 1 hectare of pasture in the country is 1,487,931 MNT. (Nyambat et al., 2013). The basic value of pasture varies by location of regions, provinces and soums.

The change in number of dusty days is another reason for land degradation. The vegetation cover of the land affected by degradation will be thinned, and loosned soil particles will be released into the air and blown far away.

In Mongolia, based on meteorological station’s dust storm observation data for 1960-2000, the number of dust blowing days per year increased by 3-4 times. Also, including the data until 2020, there has been a sharp increase since the 2000s in the southern part of the central and the eastern region and the northern part of Gobi.

For example, if we consider the number of dust blowing days at the meteorological stations across foreland Altai and from the Southern Gobi to the Central region then the number of dust-blowing days in Bulgan soum of Khovd province, Zamyn-Uud soum of Dornogobi province, and Dalanzadgad soum of Umnugobi province has decreased in recent years, while the number of days of dust blowing has increased in Mandalgobi soum, Choir soum, and Bayan soum. Also, in northern part of eastern region while the dust blowing days has decreased and when in the southern part, specially, Sukhbaatar province it has increased significantly. In the western region, the number of days of dust blowing has been increasing in Gobi-Altai and Bayankhongor areas in the last ten years (Natsagdorj, 2017).

Recently, the visibility of distant objects is sometimes greatly reduced during dust storms, and the dark environment for a long time is also increasing, which indicates that dust storms are one of the consequences of land degradation and desertification.

Due to lack of forage in the pastures the livestock is gaining insufficient fat and due to lack of winter-spring pasture carriyng capacity livestock is loosing weight and it tends to increase year by year.

According to the national observation program from the mid-1970s the NAMEM has conducted observation and measurement on livestock in 15 soums representing different natural regions. But now, observing and measuring of the live weight and productivity are making on 75 selected livestock (newborn, young, mother) in only Orkhon soum of Bulgan province (forest steppe zone), in Bayan-Unjuul soum of Tuv province (steppe zone), and Altanshiree soum of Dornogobi province (Gobi zone).

According to data from 1980-2020, the autumn live weight of Orkhon soum ewes decreased by 1.8 kg, and the spring live weight decreased by 1.6 kg (Figure 4.39).

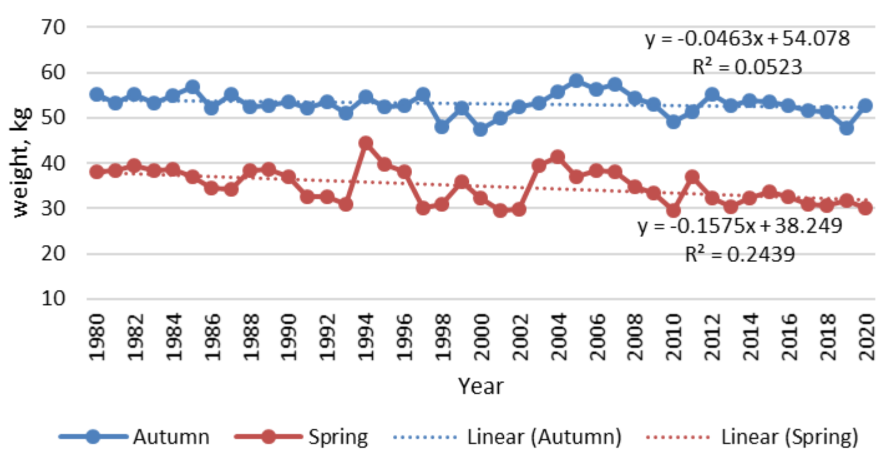


Figure 4.39 Long-term trend of live weight of ewe, 1980-2020 (Orkhon soum, Bulgan province)

Land cover change (by satellite). The map of Mongolia's land cover classification was mapped using the 300-meter resolution data of the Climate Change Initiative Land Cover (CCI-LC) of the European Space Agency (ESA) from 1992 to 2018 (Desertification atlas of Mongolia, 2021).

For land cover classification, by the guidance issued to assist Parties to the United Nations Convention to Combat Desertification (UNCCD) in preparation of their national reports (https://prais.unccd.int/sites/default/files/helper_documents/3-DD_guidance_EN.pdf), according to the instructions on how to make additions and improvements in the absence of data sources, land use is divided into the following 7 categories such as:

- Tree-covered areas
- Grassland
- Cropland
- Wetland
- Artificial surfaces
- Other land
- Water bodies

Based on these information, maps of land cover in 1992 and 2018 were developed (Figures 4.40 and 4.41).

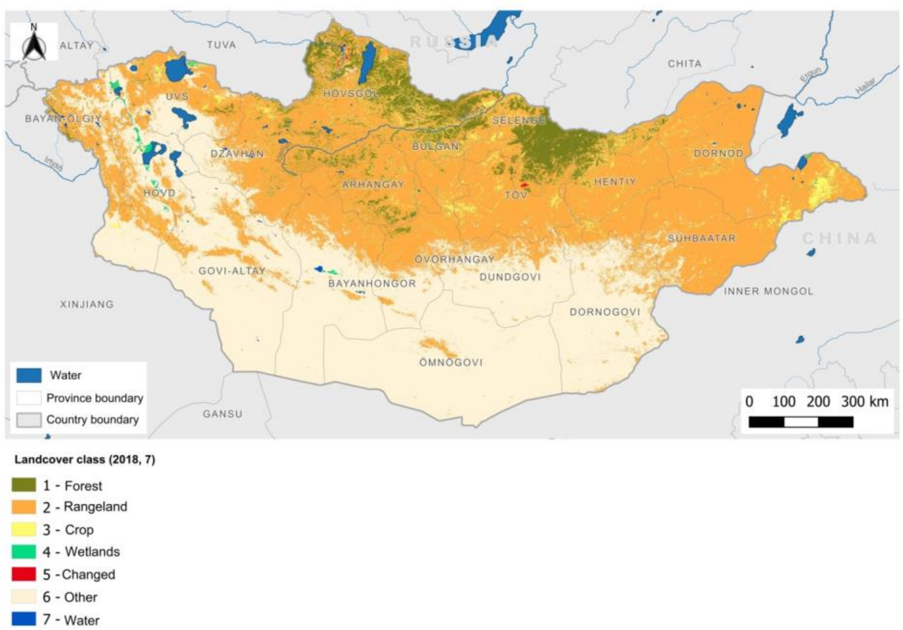


Figure 4.40 Land cover classification map, 1992

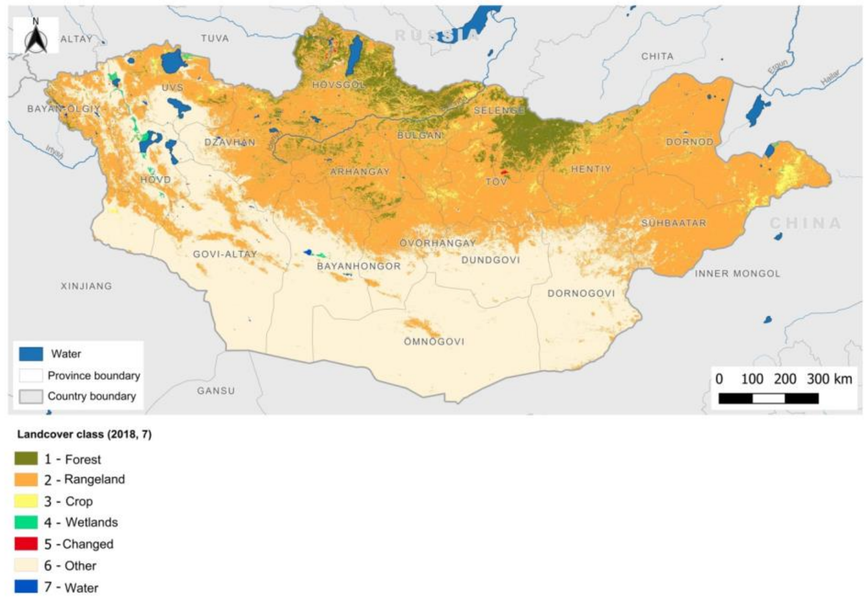


Figure 4.41 Land cover classification map, 2018

Land cover change is defined by change of land category in 1992 and 2018, respectively. Compare with 1992, category “Artificial surfaces” was increased by 67.08% as the highest change; cropland by 13.09%, grassland by 1.16%, and wetland by 0.12%, respectively. Conterary, in desert gobi it was decreased by 2.10%, water bodies by 0.93%, and forest by 0.41%, respectively (Table 4.9) (Desertification Atlas of Mongolia, 2021).

Table 4.9 Land cover change defined by area of classification change (Comparison 1992 and 2018)

Land cover classification	Area				Change	
	1992		2018			
	ha	%	ha	%	ha	%
Forest	8.736.169	6	8.700.556	6	-35.613	-0.41%
Rangeland	71.432.547	46	72.262.606	46	+830.05	+1.16%
Desert Gobi	69.418.855	44	67.960.242	43	-458.613	-2.10%
Wetland	374.859	0	375.321	0	+462	+0.12%
Cropland	4.971.663	3	5.622.257	4	+650.59	+13.09
Other	40.231	0	67.218	0	+26.987	+67.08
Water	1.491.711	1	1.477.836	1	-13.876	-0.93%
Total (km^2)	156.466.03	10	156.466.03	100		

Note: (+) is increasing and (-) is decreasing

Also, the land cover change map was produced by NDVI from MODIS satellite data based on 17 categories since 2000 every 5 years. If compare land cover map of 2020 to map of 2010, areas were in desert and gobi increased by 18%, steppe by 14% and dry steppe by 106%, respectively (Figure 4.42 and Table 4.10).

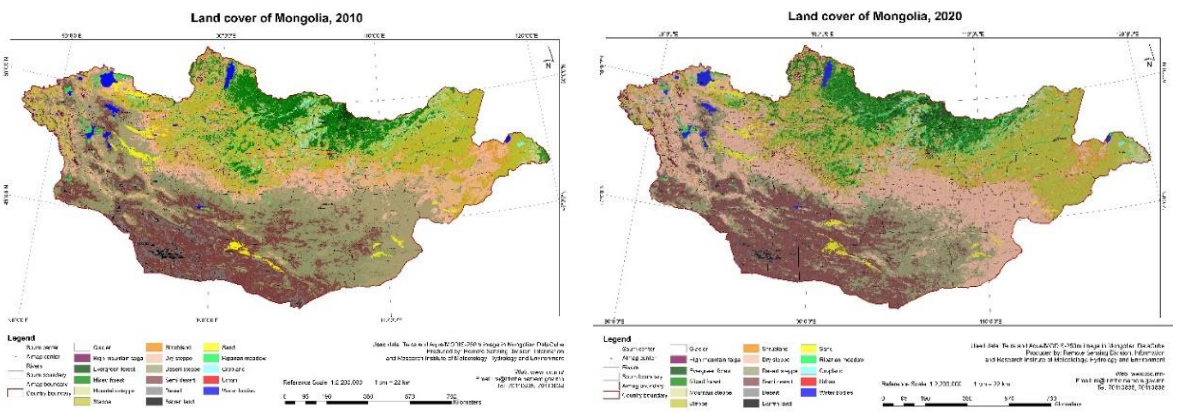


Figure 4.42 Land cover map a) 2010 b) 2020

Table 4.10 Area of land cover class and its change

№	Land cover clasess	Area in 2010 (km^2)	Area in 2010 (km^2)	Change (%)
1	Glaciers	945	733	-22
2	High mountain taiga, rocks	6,411	10,996	72
3	Evergreen forest	6,928	14,411	108
4	Mixid forest	126,084	122,692	-3
5	High mountain taiga	63,291	36,985	-42
6	Steppe	300,954	342,077	14
7	Shrub steppe	39,946	40,874	2
8	Dry steppe	206,222	425,506	106
9	Desert steppe	477,433	230,198	-52
10	Gobi and desert	218,834	257,207	18
11	Desert	55,432	6,025	-89
12	Bare land	7,962	4,642	-42
13	Sand	22,150	23,139	4
14	Medow	16,673	32,697	96
15	Arable farming	12,150	12,416	2
16	Urban area	382	612	60
17	Water bodies	13,350	13,932	4

4.1.5 Forest resources

Forest area and growing stock. In the Law on Land, the Unified Land Fund of Mongolia is classified into 6 groups as 1) agricultural land; 2) land of cities, villages and other settlements; 3) land under roads and networks; 4) land with forest resources; 5) land with water resources; 6) land for special needs. According to the information of the Forestry Research and Development Center in 2020, the total area of the forest land of Mongolia is 18,596.1 thousand. ha, of which the forest area is 18,075.7 thousand hectare and non-forest area (including 100 meters outside hayfield, pasture land of the forest edge, grassland on the southern slopes of Mountain sides within the forest land etc.) 520.4 thousand ha.

Forest area is classified in to closed forest (forest stock density>0.3) and open forest area (logged, burned, pest-infected, etc. forest area with stock density< 0.3). The closed forest area is 12,619.4 thousand ha, out of which natural forests area is 11,851.7 thousand ha, shrubs 759.7 thousand ha, planted forest 7.96 thousand ha and open forests 5,456.3 thousand ha (Figure 4.43). Coniferous and deciduous forests area in the Khangai zone are 10,530 thousand ha or 83.4% of Mongolia's natural forest, Saxaul forest area in Gobi and Desert zones are 2,089,000 ha or 16.6%, respectively.

In terms of species composition, Mongolian closed natural forest consists of 62.0%, of which Siberian larch, 10.06% birch, 5.17% Siberian pine, 4.26 % Scotch pine, 0.2% Siberian spruce, 0.01% Siberian fir, 1.29% willow, 0.29 poplar, 0.12 % aspen 0.02% Asiatic elm, 16.59 % Saxaul and 0.01 % *Populus diversifolia* (FRDC, 2021).

Mongolia’s forest growing stock is 1,248,642,118 m^3, of which larch contribute 79.2%, Siberian pine 8.9%, birch 5.9%, Scotch pine 4.9%, willow 0.28% (1.9 million m^3), Siberian spruce 0.23%, poplar 0.18%, Sibirian fir 0.01%, Asiatic elm 0.01%, aspen willow 0.05%, Saxaul 0.15% and *Populus diversifolia* 0.002%.

Forest cover change. In the practice of forest inventory and management in Mongolia, all forest stands with a relative stock density above 0.3 m^2 per ha are classified as closed forests. According to the definition issued by the Food and Agriculture Organization of the United Nations, forest is a minimum area of land of 0.05 – 1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10 – 30 per cent with trees with the potential to reach a minimum height of 2 – 5 meters at maturity in situ (IPCC, 2006). The area covered by closed forests in a given country or land area is called a forest cover. Forest cover rate is the ratio of the area covered by closed forests to the given area and is expressed as a percentage. The forest cover rate in Mongolia is 8.07%.

The main drivers of forest cover cange in Mongolia are unstable forest logging, fires caused by changing climate, and the spread of harmful insects. In the last 30 years, due to climate change and irresponsible human activities, there are increased negative effects of fires and harmful insects on the forest ecosystem in Mongolia and the forest cover has reduced significantly, and forest resources have descreased (Dorjsuren and Tungalag, 2017).

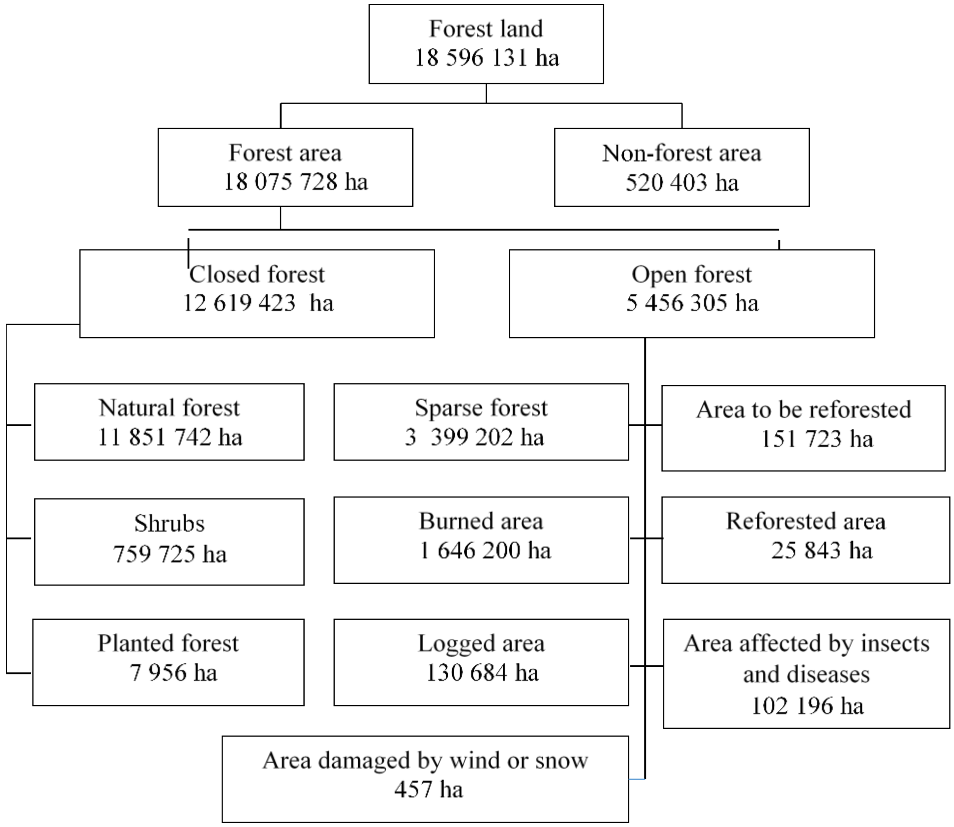
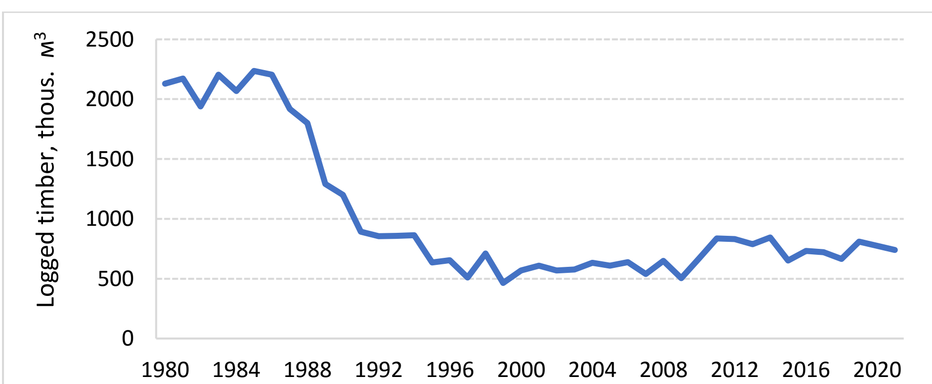


Figure 4.43 Forest land of Mongolia

Timber harvesting. In Mongolia, more than 2 million m^3 of timber were harvested annually in the 1980s, and more than 800,000 m^3 in between 1991-1994. However, the harvested timber volume was decreased up to 500 - 600 thousand m^3 since clear cutting of timber was prohibited by the Law on Forest approved in 1995, and after 2011, about 700-800 thousand (Figure 4.44). Therefore, in recent years, the extent of the negative impact of forest use on the forest ecosystem has been significantly reduced.



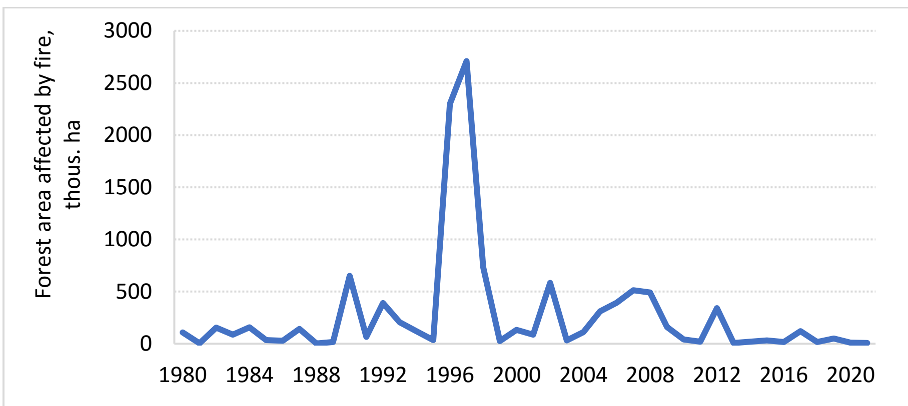
Source: FDRC, 2021

Figure 4.44 Volume official timber harvested in Mongolia, 1980-2020

Forest fire. Fire is one of the main external factors that have both negative and positive effects on forest ecosystem. Mongolia is located on the southern edge of the boreal coniferous forests of the northern hemisphere, with an extremely arid climate and high fire risk condition.

About 90% of forest fires in Mongolia are caused by carelessness of humans, of which 80% of fires occur during the in the dry period of spring and 5% - 8% occur in the autumn. The number of spring fires are less if there was more snowfall in winter-spring and fires are more if spring-summer was dry, and thus, the frequency of fires increases (Dorjsuren, 2014).

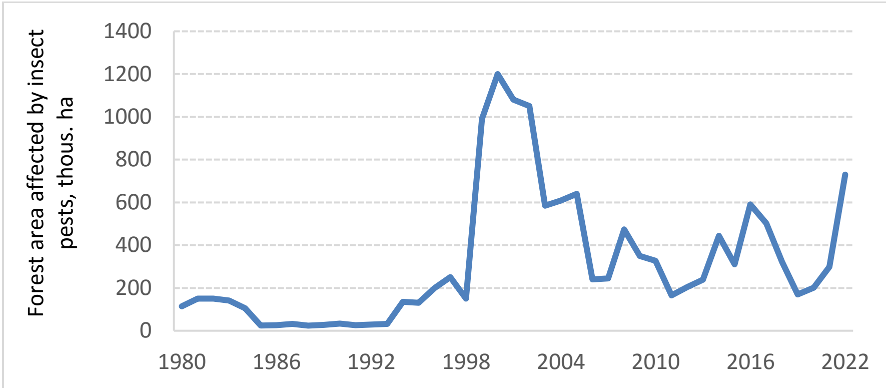
An analysis of forest fires in Mongolia since 1980 shows that fires occur in the forests of Mongolia every year, but large fires with an area of more than 500,000 ha occurred in 1990 (650 thousand ha), 1996 (2.3 million ha), 1997 (2.7 million ha), 1998 (732 thousand ha), 2002 (582 thousand ha), 2007 (512 thousand ha) mostly occurred when spring was more arid (Figure 4.45). Since 2010, the burned forest area has sharply decreased due to increased winter precipitation, reduced spring dryness, fire prevention measures, and awareness of the public about fire safety.



Source: FDRC, 2021

Figure 4.45 Forest area affected by fire of Mongolia, 1980-2020

Forest insect pests. At present, with global warming and drought, the frequency of forest fires and outbreaks of harmful insects has increased, which has become the main factor in the depletion of Mongolia's forests. In particular, outbreaks of harmful insects damaged forest area of 1.2-1.0 million hectares in 2000-2002, 584-640 thousand hectares in 2003-2006, and 591-602 thousand ha in 2016-2017 (Figure 4.46). Since 2021, the number area damaged by harmful insects has increased again, and in 2022 insect pests have infected 732,700 hectares of forest area. According to research conducted by the Forestry Research and Development Center, in 2022, 6 species of pest aphids spread to 75 soums of 11 provinces, in the green zone of the city of Ulaanbaatar, in the Bogd-Khan mountain park, and in the Gorkhi-Terelj national park (Table 4.11).



Source: FDRC, 2022

Figure 4.46 Area affected by insect pests of Mongolia, 1980-2020

Table 4.11 The species of forest insect pests outbeak distributed in Mongolia in 2022

№	Provinces (number of soums)	Species					Total area, ha
		Erannis jacobsoni Diak	*Zeiraphera diniana Gn.*	*Ocheria dispar L*	*Yponomeuta padella L*	*Leucoma salicis L*	
1	Arkhangai (15)	23,502	54,838	-	-	-	78,341
2	Bulgan (3)	14,671	34,232	-	-	-	48,903
3	Dornod (1)	-	-	-	1,150	-	1,150
4	Zavkhan (10)	27,368	20,579	-	-	74	48,020
5	Orkhon (2)	3,616	10,728	-	-	-	14,344
6	Uvurkhangai (6)	4,399	10,264	-	-	-	14,663
7	Selenge(4)	-	81,906	-	3,447	1,507	86,860
8	Tuv (4)	8,619	18,260	-	-	-	26,878
9	Uvs (10)	8,010	18,689	-	-	-	26,698
10	Khuvsgul (20)	22,838	269,651	35,000	-	-	327,489
11	Khentii (4)	12,220	12,646	-	-	-	24,865
12	Green zone of UB city	5,929	13,834	-	-	-	19,763
13	Bogdkhan Mountain SPA	2,257	5,267	-	-	-	7,524
14	Gorkhi Terelj National Park	4,328	-	-	-	-	4,328
	Total	137,755	550,893	35,000	4,597	1,581	729,826

Forest cover change. The total forest area in Mongolia between 2006-2020 and its change are shown in Table 4.12.

Table 4.12 Forest area of Mongolia, 2006-2020

Type of area	2006 *1000 ha*	2010 *1000 ha*	2015 *1000 ha*	2020 *1000 ha*
Forest area	17,557.2	17,590.1	17,911.1	18075.7
Closed forest	13,348.4	13,039.2	12,280.0	12619.4
Natural forest	12,740.4	12,331.1	11,500.4	11851.7

Shrubs	607.7	706.2	777.5	759.7
Planted forest	0.3	1.9	2.1	7.96
Open forest	4,208.8	4,550.9	5,631.1	5456.3
Sparce forest	2,892.7	2,987.2	3,495.3	3399.2
Burned area	707.1	1,057.5	1,708.3	1646,2
Logged area	202.5	240.2	106.1	130.7
Area to be reforested	405.9	197.0	174.0	151.7
Reforested area	0.6	8.3	10.7	25.8
Area affected by insects and diseases	-	59.8	135.8	102.2
Area damaged by wind or snow	-	0.9	0.9	0.5

The closed forests area of Mongolia has decreased by 806 thousand hectares. or 6.6% (50 thousand ha or 0.41% per year) between 1999 and 2015, and it reduced by 759 thousand ha or 6.2% from 2010 to 2015. i.e. 47.5 thousand ha or 0.39% per year (Dorjsuren and Tungalag, 2017).

Between 2006 and 2020, the forest cover of Mongolia was reduced by 729 thousand ha or 6.6% (52.1 thousand ha or 0.4% per year), but closed forest was increased by 339 thousand ha or 2.8% from 2015 to 2002, which was burned by the great fires of 1996-1997. This is related to the restoration of burnt forests, which effected by great fires of 1996-1997 through the natural regeneration and in 20-25 years regenerated forests are transferred to the closed forest category. Between 2006 and 2020, the burned forest area increased by 939 thousand ha or 133%, but the timber harvested area decreased by 72 thousand ha or 35.5%. Between 2010 and 2015, the burned forest area increased by 651 thousand ha or 62%, but between 2015 and 2020 it decreased by 62 thousand ha or 3.6%. The forest area destroyed by insect pests was increased by 76,000 ha or 127% between 2010 and 2015, but it decreased by 34,000 ha or 25% in the last 5 years from 2015 to 2020, and it again increased by 42,000 ha or 71% in the total period from 2006 to 2020 (Table 4.13).

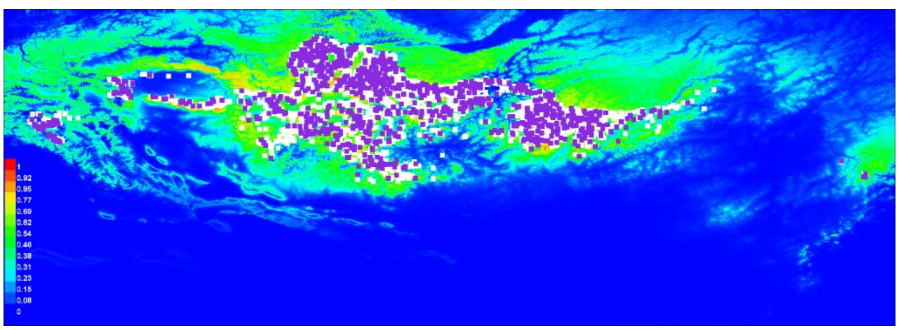
Table 4.13 Change of forest area in Mongolia (2006-2020)

Type of area	2006-2010		2010-2015		2015-2020		2006-2020	
	Change 1000 ha	*%*	*Change 1000 ha*	*%*	*Change 1000 ha*	*%*	*Change 1000 ha*	*%*
Forest area	-309.2	-2.3	-759.2	-5.8	339.4	2.8	-729.0	-5.5
Closed forest	-409.3	-3.2	-830.7	-6.7	351.3	3.1	-888.7	-7.0
Natural forest	98.5	16.2	71.3	10.1	-17.8	-2.3	152.0	25.0
Shrubs	1.6	533.3	0.2	10.5	5.9	279.0	7.7	2553
Planted forest	342.1	8.1	1,080.2	23.7	-174.8	-3.1	1,247.5	29.6
Open forest	94.5	3.3	508.1	17.0	-96.1	-2.7	506.5	17.5
Sparce forest	350.4	49.6	650.8	61.5	-62.1	-3.6	939.1	132.8
Burned area	37.7	18.6	-134.1	-55.8	24.6	23.2	-71.8	-35.5
Logged area	-208.9	-51.5	-23.0	-11.7	-22.3	-12.8	-254.2	-62.6
Area to be reforested	7.7	1283.3	2.4	28.9	15.1	141.1	25.2	4200
Reforested area			76.0	127.1	-33.6	-24.7	42.4*	70.9*

Area affected by insects and diseases	9.0	-0.4	-44.4	-0.4*	-44.4*

Impact, vulnerability and risk of forest. The assessment of the impact of forest area resources was carried out using the MaxEnt (Maximum Entrophy) model based on machine learning methods; data from the Multi-Purpose Forest Inventory in Mongolia (NFI GIZ, 2016); using the multi-model ensemble results (CMIP6) of the Assessment report; and the Intergovernmental Panel on Climate Change (AR6, IPCC) with high greenhouse gas emissions (ssp8.5).

The MaxEnt model was used to calculate the probability of the geographical distribution of the dominant tree species in Mongolia. In this calculation, 3,324 points of multi-purpose forest inventory in Mongolia were selected and 75% of them were machine learning data (training samples) and 25% were used for testing and verification data (training samples) to guide the model. The locations of these data points are shown in Figure 4.47. Statistical analysis of geographic distribution points of the dominant tree shows that the probability of AUC (Area under curve) for all types of tree modeling is 0.839, and that of the test is 0.836, and the points agreed and overlapped. Therefore, this model can be used for the assessment of future changes in forest distribution area.



Note: training points are marked in white and test points in pink

Figure 4.47 Location of forest distribution model training and testing points

Figure 4.48-4.49 show the distribution of the current and future state of forest distribution in Mongolia. Here, the current and future values of bio-climate indicators (Bio1-year the average air temperature, Bio12-year the total precipitation) were calculated and input into the model to calculate the probability of changes in forest area. Area change is expected to decreased by 0.92% (2,115.6 km^2) for the period of 2021-2040, and by 0.32% (723.1 km^2) for the period of 2041-2060, while in the distant future, on the contrary, it is likely to increase by 0.70% (1,592.5 km^2) for the period of 2081-2100 (Table 4.14).

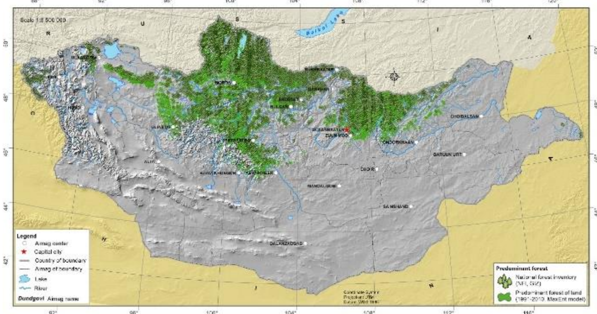


Figure 4.48 Overlapping the current distribution of forests in Mongolia with forest inventory points

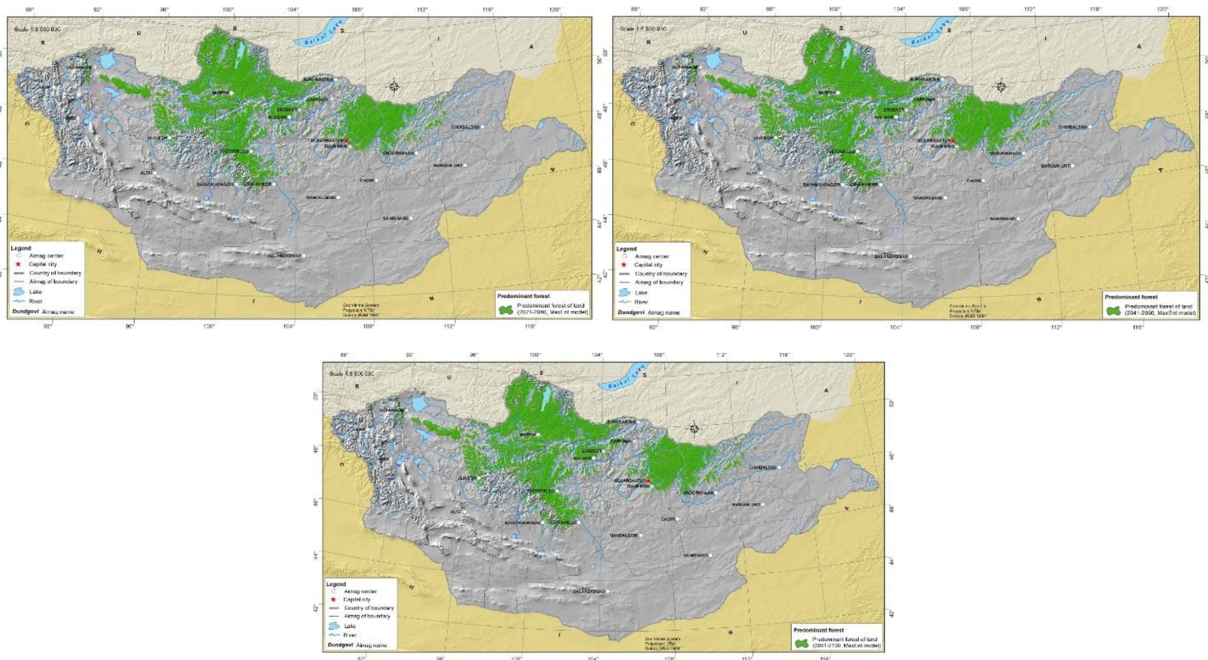


Figure 4.49 Future distribution of forests in Mongolia under ssp8.5 GHG scenarois: a) 2021-2040, b) 2041-2060 c) 2081-2100

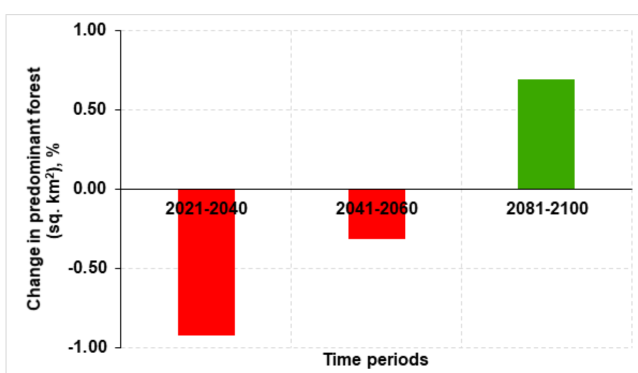


Figure 4.50 Future change of forest area in Mongolia (baseline 1991-2010)

Table 4.14 Future change of forest area in Mongolia (ssp8.5, AR6 IPCC)

Dominant forest area change	*2021-2040*	*2041-2060*	*2081-2100*
Percent, %	-0.92 (↓)	-0.32 (↓)	+0.60 (↑)
Area, km^2	-2115.6 (↓)	-723.1 (↓)	+1592.5 (↑)

Figure 4.51 shows that the forest area of Mongolia will decrease or increase by no more than 1% in the future due to climate change, but this change will occur differently depending on location. Due to the current warming of climate in the territory of Mongolia, the upper border of the forest in the high mountains may rise and the forest belt may shrink. In the future, due to the melting of frost in the high mountain belt, wetting of the surface soil, and the increase of heat accumulation during the growing season, the upper border of the forest will rise. Thus, the intensity of photosynthesis will likely increase, while the conditions for forest growth in the lowlands between the mountains and the mountains will likely shrink even more. Based on the spatial distribution of this change, it is desirable to optimize the management of forest resources and introduce adaptive technologies.

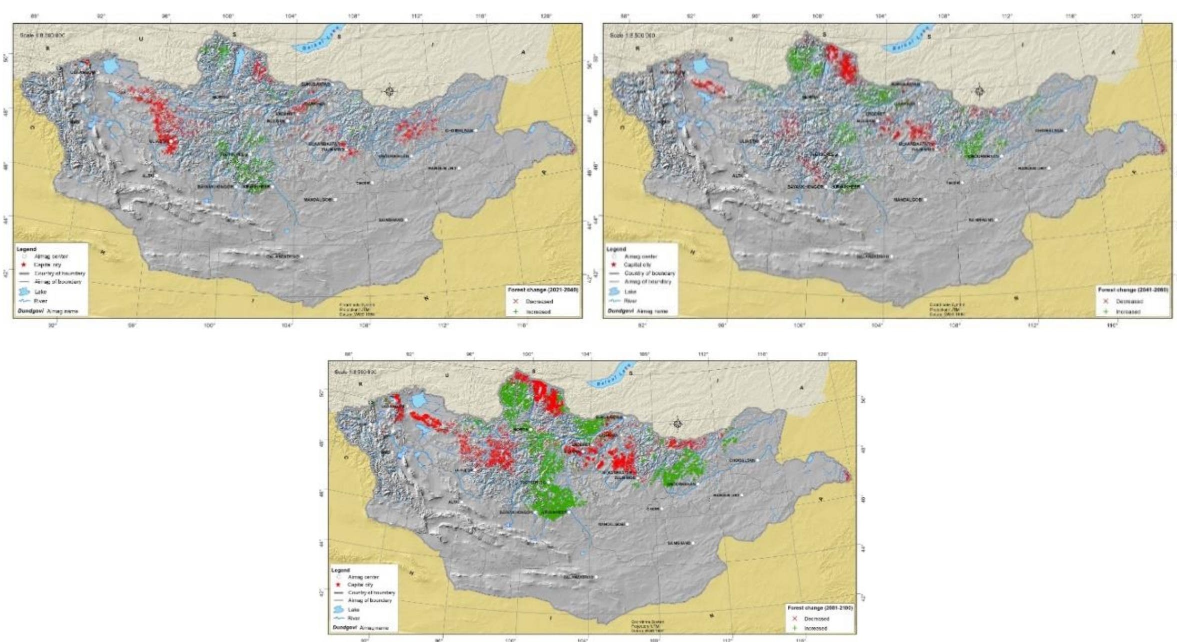


Figure 4.51 Future change of forest area in different period: a) 2021-2040, b) 2041-2060 c) 2081-2100

Vulnerabilty and risk assessment of forest and measures. Until recently, considerably more attention was paid to using forests to mitigate climate change, through the absorption of carbon dioxide (CO_2) from the atmosphere, than there was on considering the need to adapt forests to avoid the worst effects that climate change could have on them. The switch from a mitigation-oriented approach to the one that considers adaptation in a more balanced manner underscores the need to have approaches to assess the vulnerability of forests to climate change (FAO, 2018).

In Mongolia, the growth and productivity of trees and stands of subalpine, taiga and subtaiga forests would be increased as global climate warming progresses. In the future, as global warming increases, forests will grow in the upper parts of high mountains, the upper boundary forest distribution may be rise higher, however, the area of boreal taiga forests on permafrost will be decreased, their distribution boundary may move to the north latitude (Tsedendash, 2011, Dorjsuren, 2018).

Extreme weather conditions have a direct negative impact on forest ecosystems and woody plants. There are cases that when young and middle-aged forest trees freezes and dies, or the freezing of flowers and young buds of conifers and the loss of seeds and wood mass in depressions and river valleys where frost occurs which leading to temperature invasion in early spring when the tree sap begins to move.

It is observed that the forest and trees growing on the southern slopes of the mountain, as well as, the planted seedlings and saplings on the reforestation areas are dried and died to drought; trees dropped by strong winds; and young and thin trees bended or falled under the weight of wet snow that falls in early autumn or late spring.

In the last 100 years, global warming and desertification have been occurring intensively in Mongolia, but during this period, a humid and cooler climatic cycle lasting several years took place. The expansion process of forest areas to the meadow steppes is observed in the Central, southeastern and northeastern provinces of the Khangai Region, also in the eastern and western provinces of the Khentii Region (Dorjsuren, 2018).

Within the framework of preperation the Third Climate Change Report, a specific index was developed to assess the current and future vulnerability of Mongolia's main nature and socio-economic sectors, such as water resources, forest resources, permafrost, biodiversity, arable farming culture, animal husbandry and public health. The forest ecosystem of Mongolia was assessed as a very vulnerable by above mentioned index.

Forest fires and the spread of harmful insects caused by side effects of climate change are causing significant damage to the forests of Mongolia. According to 2020 data from the Forestry Research and Development Center, the burned forest area was 1 million 646.2 thousand ha, and the forest area destroyed by harmful insects was 102.2 thousand ha.

Forest fire is one of the external factors that influencing the regeneration of trees, growth and development of trees and forests, and the plant community changes The occurrence and spread of forest and steppe fires is possible only in prolonged dry weather, but more than 90% of fires are caused by human incompetence. The increase of air temperature leads to increase in the number of forest and steppe fires. When the temperature increases by 1°C in the fire-hazard period, the area of forests effected by fire increases by 15%-17% (Roshydromet, 2014; Shunkina, 2015).

The extent of the damage caused by the forest fire and the degree of burning of the trees depends on the type and intensity of the forest fire. Forest fires are divided into 3 types depend on the main burning material and the nature of spreading fire:

a) Surface fire - caused by the burning of the lower tiers of the forest, such as shrubs, grasses, lichens and mosses;
b) Crown fire - all tiers of the plant community of the forest are burned, and the fire spreads through the crown of trees;
c) Ground fire - occurs when the organic part of the forest soil burns. These fires occur in forests with dense moss and peat soils and cause great damage to the forest. About 90%-95% of forest fires in Mongolia are surface fires, and the rest are crown and ground fires.

Surface fires are classified as a low, medium, and high-intensity fires depending on high-intensity fires. The low-intensity fires burn dead plants, fallen leaves, needles, and fallen dry branches, grass and moss cover, shrubs, seedlings and young trees. The grass covers generally restored within 2-3 years. The medium-intensity fires burn the part of the forest canopy, grass and moss cover, shrubs, seedlings, young trees and fallen trees, in some places the soil surface will be mineralized and charred black spots will to be affected. The 10%-20% of the trees dry up, and on stem of most trees there will be small burns up to 1-1.5 m height. After the fires, the forest natural regeneration occurs, the grass cover is restored after 7-10 years, and the ecological balance is generally maintained. The high-intensity fires burn the grass cover, shrubs, saplings, trees, forest floor and upper organic part of the soil to a depth of 5-7 cm. During a high-intensity surface fires, the root neck of tree and lower part of the tree stem are burned, most of the tree trunks have burn scars more than 1.5 m, and lots trees to be died (Dorjsuren, 2009).

According to a study conducted in 1996, in the larch forest of Mongolia damaged by surface forest fires, 75% of the area was affected by the low-intensity forest fires, about 15% by medium-intensity fires, and about 10% by the high-intensity fires (Dorjsuren, Mijid, 2019). In mountain areas of Khuvsgul, Khangai and Khentii regions, 75% of the burned forests are regenerated and covered with conifers and deciduous trees, 70% of the Central Khangai Pseudoforests are covered with larch and 15% are replaced by shrub and grassland communities and have been converted into bare rocks (Dorjsuren, 2009; Dorjsuren, Michid, 2019; Dorjsuren and Tungalag, 2017).

Climate change cuases an increase of the reproduction and spread of harmful insects, which creates opportunities for large dispersal in places where they were not previously distributed, and causes damage to forests. Warming will change the geographical location of insect pests, make them easier to overwinter and accelerate their life cycle, which will lead to increase in the number of dead tress and an increase in frequency of forest fires, and burnt trees will become more vulnerable to insect attacks (FAO and CIFOR, 2019).

If primary harmful insects eat the leaves and needles of forest trees in period of 2-3 years, the tree's vitality weakens, carnivorous insects settle on tree trunks and feed wood and conditions are created for the spread of infectious diseases, and as a result, most of the trees wither and die. In forest effected by insects, grasses and shrubs are growing intensivly, which delaying the natural regeneration of the trees, therefore, the forest can be restored by planting trees only.

In order to overcome the risks and damage caused to the forest sector and the forest ecosystem due to climate change, it is necessary to develop a new policy and strategy for adapting the forest sector of Mongolia to climate change impacts, as well as an action plans until 2030 in connection with the "One Billion Trees" national tree planting campaign.

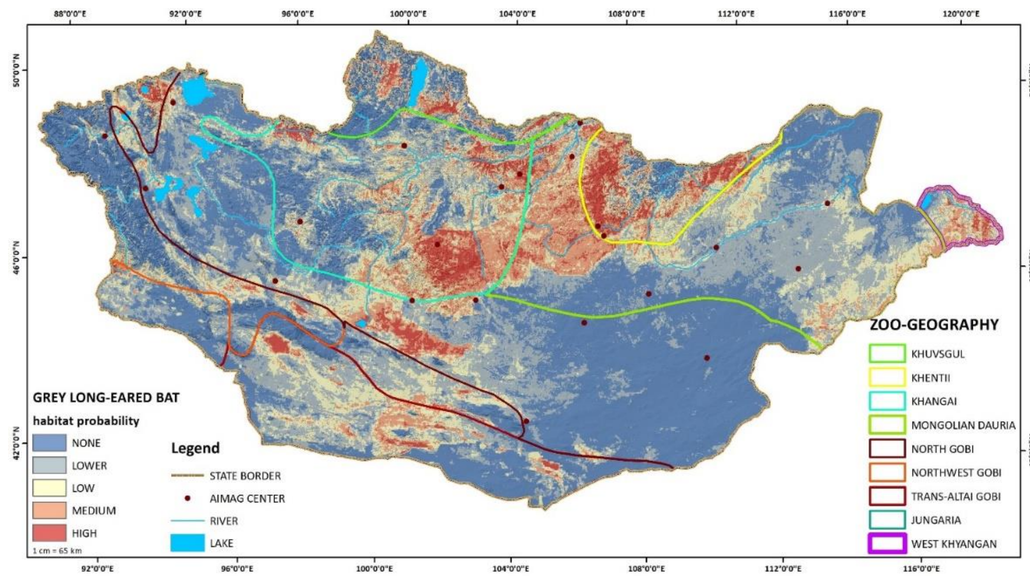
4.1.6 Biodiversity

Habitat and distribution of selected wildlife species in our country were identified by the MaxEnt (Maximum Entropy) model to estimate how climate change will affect them. The impact was modeled for the representative animals in fauna that were not included in the 3rd National Communication Report. In this way, selected mammal and avian species are widely distributed in Mongolia through its natural zones, and environmental variable ecosystems are probably unique and vulnerable to climate change, such as birds (for example, Mongolian Ground jay-*Podoces hendersoni,* Demoiselle Cranes-*Grus virgo*) and mammals (for example, Grey long-eared bat-*Plecotus austriacus*).

The Grey long-eared bat is not only the species widely distributed across the country's various natural zones, but also, they are bats, considered to be the most indicator and sensitive mammals to climate and weather changes, while the Henderson's ground jay is the representative of endangered species bird distributes in the Gobi across desert regions. Another bird the Demoiselle crane is not only wetland and migratory species, but also it is a representative of a steppe bird, that is sensitive to such types of environmental changes of their habitat.

The HadGEM3 model results on low, medium, and high greenhouse gas emissions (ssp1-2.6, ssp2-4.5, ssp5-8.5) from the Intergovernmental Panel on Climate Change 6th Report (AR6, IPCC) were used. The baseline period (1970-2000) and future periods 2021-2040, 2041-2060, 2061-2080, and 2081-2100 were used in this assessment.

Mammals. The Grey long-eared bat (*Plecotus austriacus*). Based on the bio-index or basic climate data from 1970-2000, the habitat range of the Grey long-eared bats in Mongolia is identified as 505,953.8 km^2, while the core habitat is 78,773.7 km^2 (Figure 4.52, Table 4.15). However, according to the future climate model, the average change in the core habitat of bats in the period of 2021-2040 will be 86,872.3 km^2 by 10.3%; in 2041-2060 it will be 90,373.2 km^2 by 14.7%; and in 2061-2080 it will be 94,441.4 km^2 by 19.9%, and it is expected to increase by 13.5% to 89,391.7 km^2 in 2081-2100. The distribution area is expected to increase by 3.5% to 523,598.4 km^2, by 2.6% to 538,667.8 km^2 by 1.3% to 542,443.8 km^2, and however, a 4% decrease to 521,050.9 km^2 in 2081-2100.



Source: www.worldclim.org

Figure 4.52 Habitat modeling of Grey long-eared bat, 1970-2000

Table 4.15 Habitat changes of Grey long-eared bat

Year & scenario	*Core habitat by sq, km*				*Habitat distribution sq, km*			
	ssp1-2.6	ssp2-4.5	ssp5-8.5	average	ssp1-2.6	ssp2-4.5	ssp5-8.5	average
1970-2000	78,773.7				505,983.8			
2021-2040	89,896.9	81,663.3	89,056.5	*86,872.3*	524,867.2	508,091.8	537,836.2	*523,598.4*
2041-2060	91,529.0	92,797.1	86,793.5	*90,373.2*	535,663.8	542,200.8	538,138.8	*538,667.8*
2061-2080	97,026.8	95,382.8	90,914.8	*94,441.4*	542,595.6	547,120.6	537,615.2	*542,443.8*
2081-2100	86,839.7	94,513.3	86,822.1	*89,391.7*	504,186.3	532,965.4	526,001.0	*521,050.9*

Spatial expected changes in the core habitat and distribution areas are shown in Figure 4.53 for HadGEM3 scenarios over 4 periods. There is a relatively small change in the habitat of the Grey long-eared bats, but the trend is increasing by the way, which shows a negative outlook for the bat families of mammals. While 18.8% (14,813.4 km^2) of its total core habitat and 17.4% (89,234 km^2) of the distribution area is currently included in the State Protected Area Network (SPAN). In the future, the distribution area of this species trend is favorably increasing 4-14% within the SPAN (Figure 4.54). However, a slight decrease is expected for the core habitat.

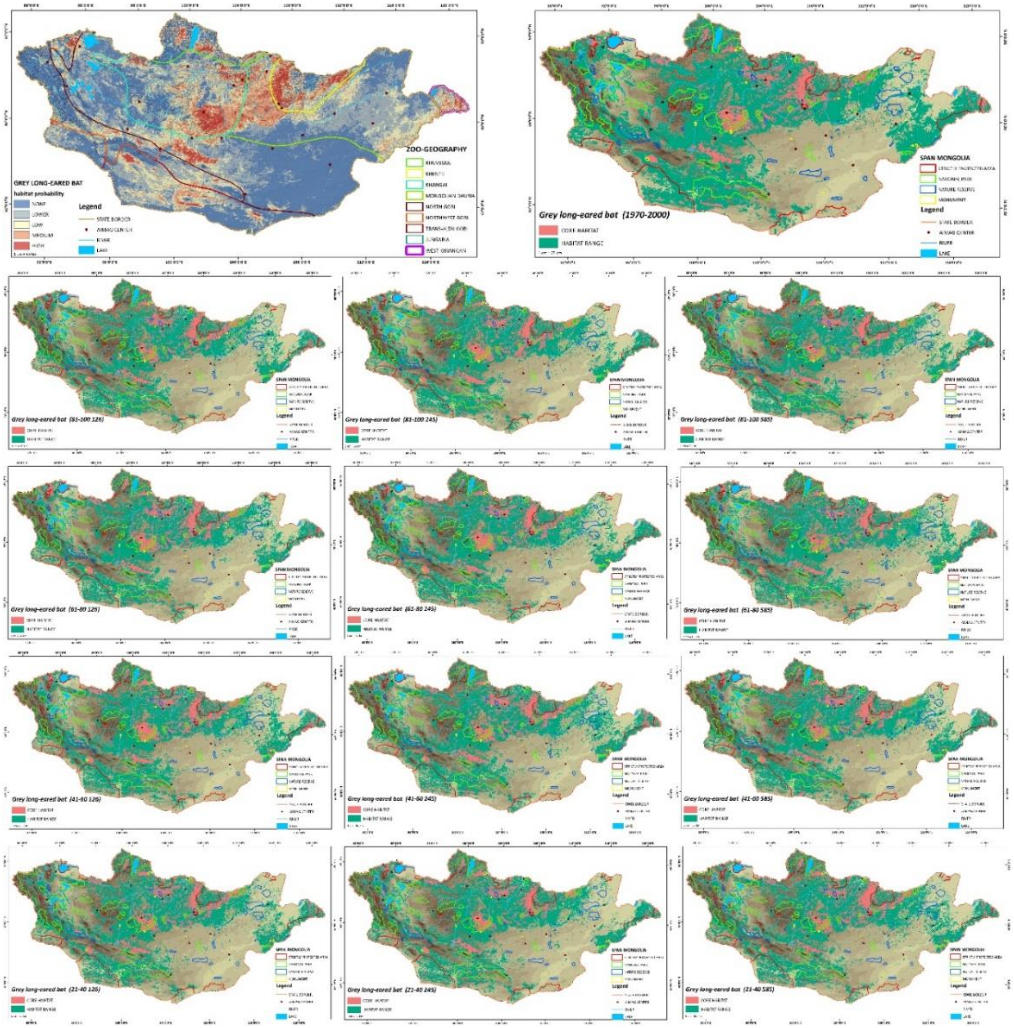


Figure 4.53 Future habitat changes of Grey long-eared bat

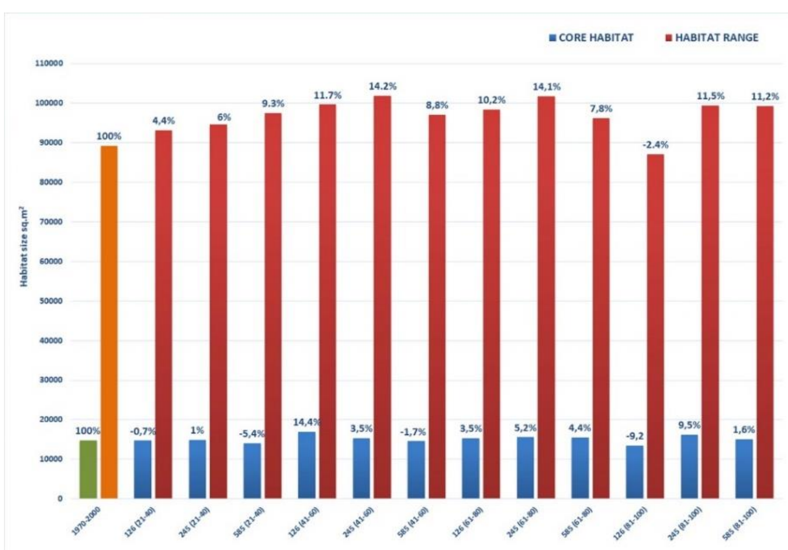
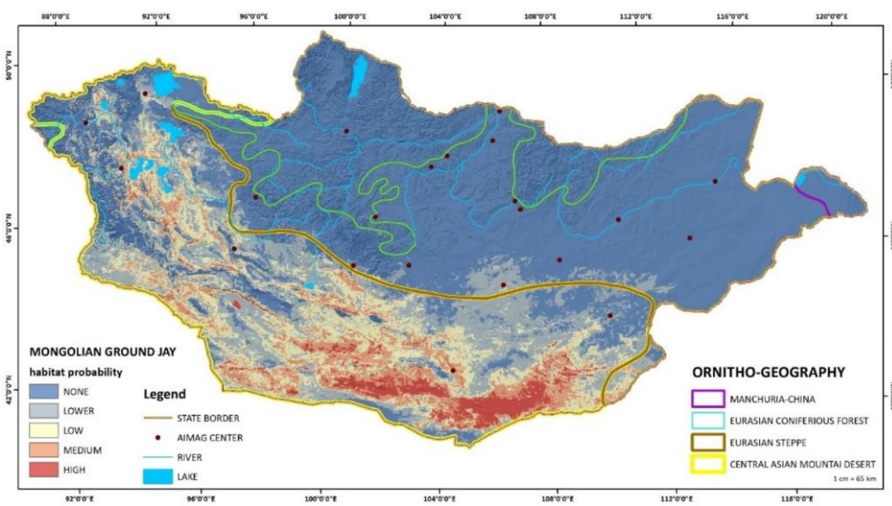


Figure 4.54 Future habitat changes of Grey long-eared bats in the SPAN

Bird. Mongolian Ground Jay (*Podoces hendersoni).* The Mongolian Ground Jay distributes across the major Gobi Desert regions in the country, which are the unique terrains with weather conditions through the Lakes valley, Great Lakes Basin, Trans Altai Gobi, and Southern Gobi. It is the species that might be interesting among the bird to demonstrate effects of future climate changes. The MaxEnt modeling result shows that the current or basic core habitat is 42,974.2 km^2 and the distribution area is 327,512.8 km^2 (Figure 4.55). While, according to the future climate change models, the Mongolian ground jay core habitat reduced from 40,222.1 km^2 by 6.4% in 2041-2060 to 40,032.2 km^2 by 6.8%, 38,821.4 km^2 in 2061-2080 by 9.78% and however increase by 4.5% to 44,918.1 km^2 in 2081-2100, respectively, average greenhouse gas emissions options (ssp1-2.6, ssp2-4.5, ssp5-8.5). As regarding as, the species, an expected to be impacted is generally negative (Table 4.16). Figure 4.55 shows that the potential habitat losses and decreases are observed in the core habitat of Mongolian ground jay in the country, but significant changes are relatively small.

According to the average greenhouse gas scenarios, the distribution area of the Mongolian ground Jay is expected to increase by 1.9% to 333,854.1 km^2, 4.6% to 342,424.2 km^2, 2% to 333,948.1 km^2, and 6.8% to 349,894.2 km^2respectively. Compared to the core habitat, a distribution area is to remain stable and also, may increase slightly.



Source: www.worldclim.org

Figure 4.55 Habitat modeling of Mongolian Ground Jay, 1970-2000

Table 4.16 Habitat changes of Mongolian Ground Jay

Year & Scenario	*Core habitat by km^2*				*Habitat distribution by km^2*			
	ssp1-2.6	ssp2-4.5	ssp5-8.5	average	ssp1-2.6	ssp2-4.5	ssp5-8.5	average
1970-2000	42,974.1				327,512.1			
2021-2040	40,933.3	38,546.9	41,186.1	40,222.1	332,007.3	327,537.6	342,017.3	333,854.1
2041-2060	39,417.3	40,051.9	40,627.4	40,032.2	339,014.8	350,385.3	337,872.6	342,424.2
2061-2080	41,234.8	36,160.8	39,068.7	38,821.4	324,163.3	350,121.9	327,559.0	333,948.1
2081-2100	46,923.9	42,686.7	45,143.6	44,918.1	364,622.3	344,250.2	340,810.1	349,894.2

According to the SPAN of Mongolia, 23.1% (9,915.65 km^2) of the core habitat and 24.9% (81,662.74 km^2) of the distribution area of Mongolian ground Jay are determined (Figure 4.56). An expected habitat dynamics in the future shows that despite of distribution area slightly decreases, the general prediction is increased from 2.4% to 27.5%, while the core habitat will be declining by 13.3% (Figure 4.57).

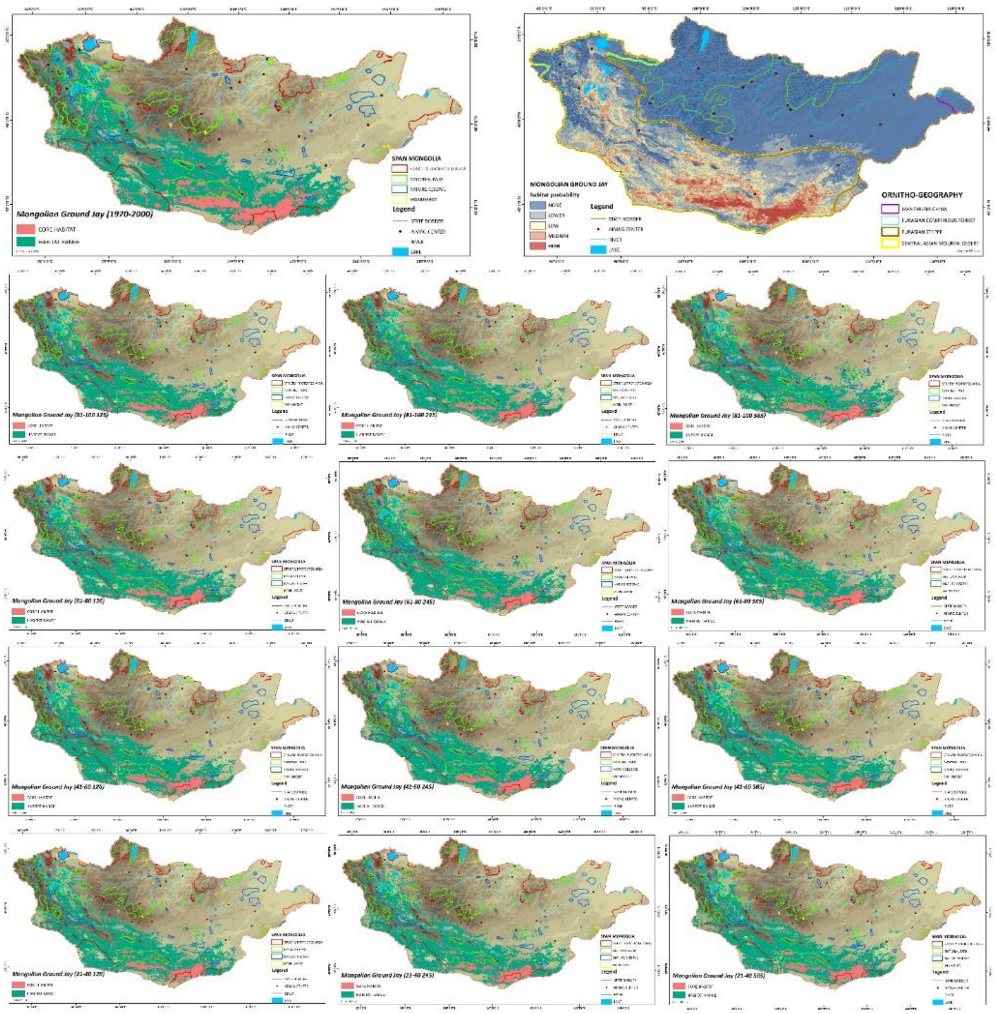


Figure 4.56 Future habitat changes of Mongolian Ground Jay

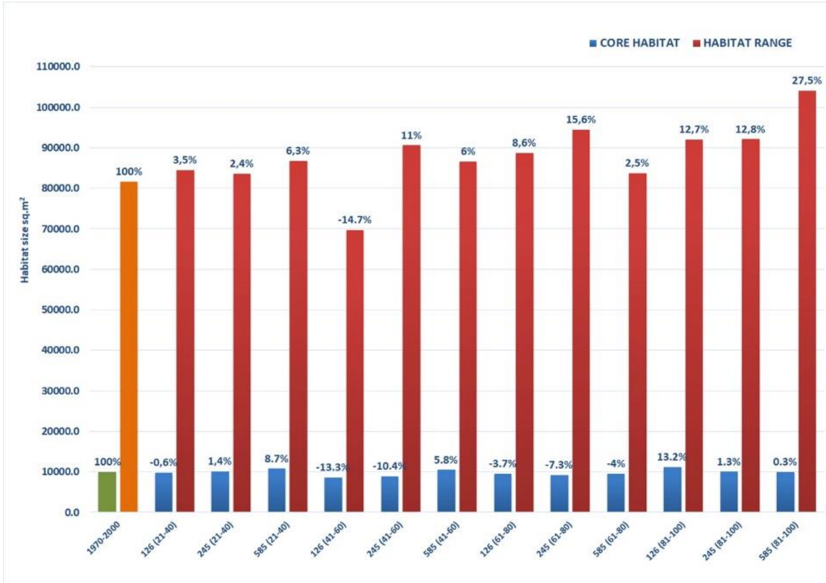
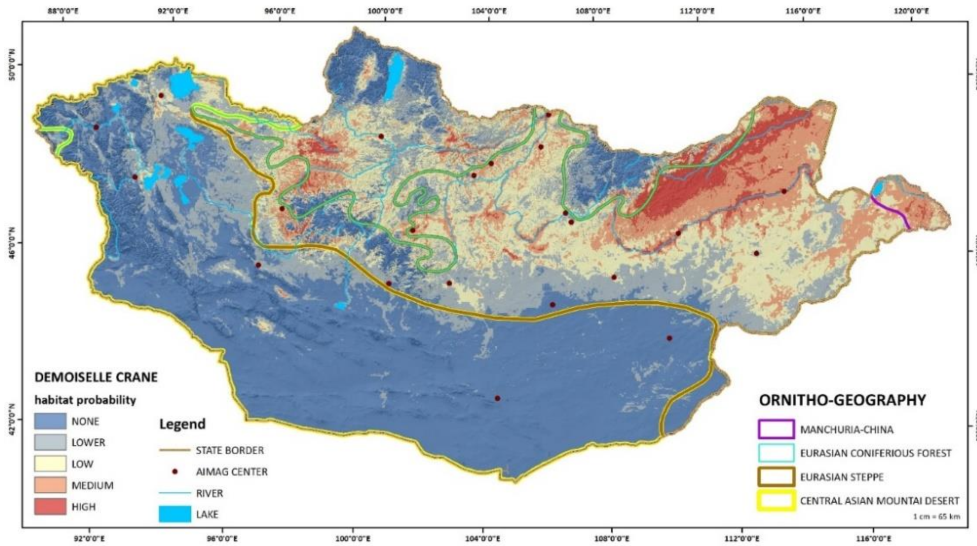


Figure 4.57 Future habitat changes of Mongolian Ground Jay in the SPAN

Demoiselle Crane (*Grus virgo*). The area where the Demoiselle Cranes distributes in Mongolia includes the northeastern such as the Mongol Daurian Steppe and headwaters of Onon, Kherlen, Ulz, and Tuul rivers those are the wetlands. In terms of environment, geography, and landscape, this species seems to appear in wetlands, and however, it is considered as a steppe bird in Mongolia, this means that the bird can be considered fully to be indicator of the changes in the marginal ecosystem between the steppe and wetland areas. Therefore, the Demoiselle Crane is one of the birds that can describe the future climate change in its distribution area.

An estimated core habitat of the Demoiselle Crane is 57,952.88 km^2, and the distribution area is 508,553.39 km^2 (Figure 4.58). As a result of the HadGEM3 low, medium, and high-resolution gases (ssp1-2.6, ssp2-4.5, ssp5-8.5) by the Intergovernmental Panel on Climate Change (AR6, IPCC) model for the future changes used for identification of habitat the Demoiselle Crane. The MaxEnt results show that expected changes of the average core habitat is 61,915 km^2 increased by 6.8% in 2021- 2040, 62,059.9 km^2 by 7.1% in 2041-2060, 58,534 km^2 by 1% in 2061-2080, and 60,779.8 km^2 by 4.9% in 2081-2100, respectively. Climate change-affected habitat distribution is relatively stable across the Mongolia-Daurian and Central Khalkh Steppe and forest zones. (Table 4.17). Habitat distribution changes based on climate change are described similarly for core habitat, such as an average is 530,645.7 km^2 by 4.3%, by 3.3% to 525,578 km^2, by 2.2% to 522,184.2 km^2 and by 3%, 523,600 km^2, respectively. Modeling result data shows that the habitat distribution of the Demoiselle Crane of Mongolia is projected relatively stable which means cannot be denied an expected climate change affection in the region is less impacted (Figure 4.59).



Source: www.worldclim.org

Figure 4.58 Habitat modeling of Demoiselle Crane, 1970-2000

Table 4.17 Habitat changes of Demoiselle Crane

Year & scenario	*Core habitat by km²*				*Habitat distribution km²*			
	ssp1-2.6	ssp2-4.5	ssp5-8.5	ssp1-2.6	ssp2-4.5	ssp2-4.5	ssp1-2.6	ssp2-4.5
1970-2000		57,952.9				508,553.4		
2021-2040	69,663.7	56,880.3	59,201.0	*61,915.0*	557,460.8	511,076.9	523,399.4	*530,645.7*
2041-2060	62,356.4	64,829.0	59,102.2	*62,095.9*	537,040.2	532,643.8	507,051.9	*525,578.6*
2061-2080	50,872.6	58,003.4	66,725.9	*58,534.0*	516,286.0	527,363.6	522,903.1	*522,184.2*
2081-2100	58,719.8	62,529.3	61,090.2	*60,779.8*	509,324.3	539,582.9	521,892.9	*523,600.0*

Although the habitat is relatively stable for the Demoiselle Crane within its distribution, only 7.8% (7,722.71 km^2) of the core habitat and 8.4% (42,915,04 km^2) of the habitat range covered by the SPAN that the bird species playing an important role on the ecosystem and environment where they habitat. (Figure 4.60). Future trends of habitat distribution changes rarely remained stable across all scenarios and generations. But core habitat is going to be enhanced by 50%-71% compared with other selected species of this study.

The impact of climate change effect on this region, especially, for the wetlands and steppes is expected to be minimal. There is a need to focus on the core habitat reduction might be a potential during the peiod of 2061-2080 that develop the mitigation plan and take conservation measures effort to reduce negative impacts.

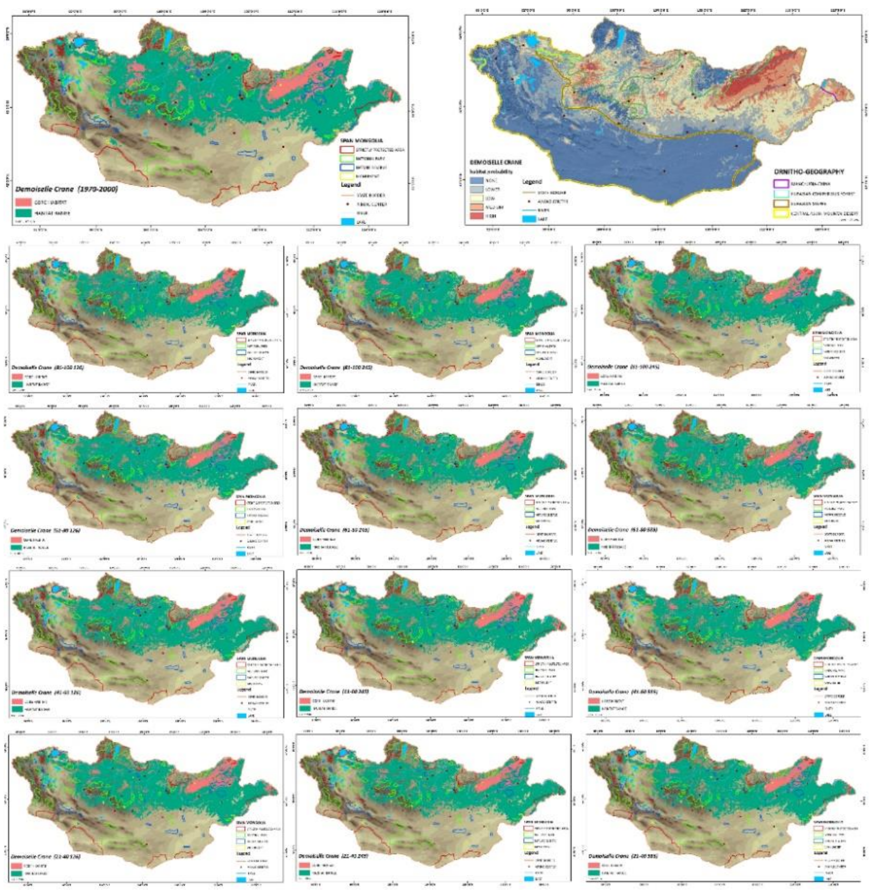


Figure 4.59 Future habitat changes of Demoiselle Crane

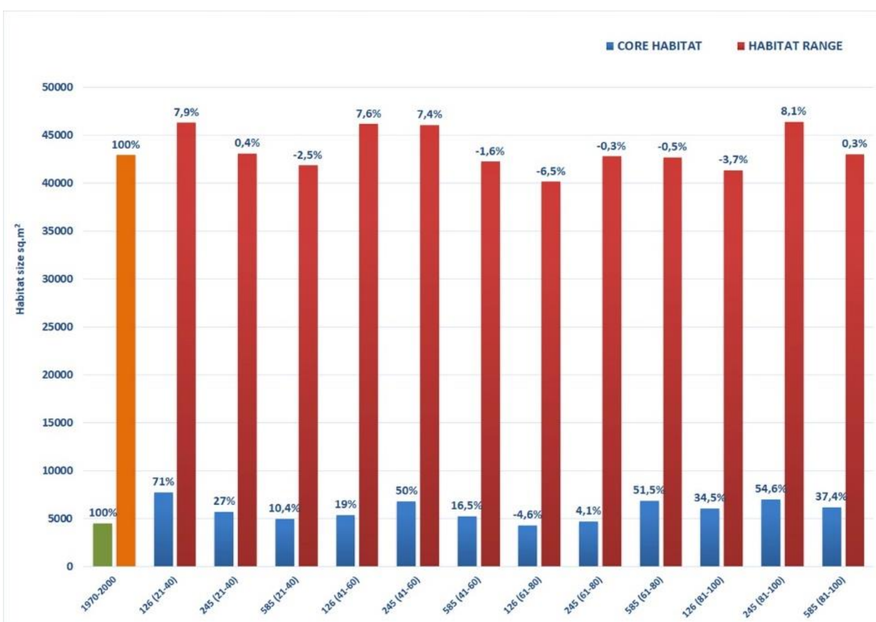


Figure 4.60 Future habitat changes of Demoiselle Crane in the SPAN

Finally, an ecosystem-based adaptation policy was determined for the conservation measures and management on a scientific basis based on the impact assessments on birds (*Podoces hendersoni, Grus virgo*) and mammals (*Plecotus austriacus*), which are widely distributed in the territory of Mongolia, might be vulnerable to the climate change.

4.2 Impact on socio-economic sectors

4.2.1 Animal husbandry

Present state of livestock. Livestock sector continues to occupy an important place in Mongolia's economy, employment, and export earnings. By 2019, the export of agricultural products accounted for 10.9% of Mongolia's gross domestic product (GDP), 8.2% of export earnings, and 25.3% of the total labor/workforce is employed in this sector. Although the share of the livestock sector in GDP and export income continues to decrease, traditional livestock farming employs 29.8% of the total labor and is still the main source of livelihood for over 30% of all households. In 2019, the livestock sector produced 545.0 thousand tons of meat, 1,074.2 million liters of milk, 33.7 thousand tons of sheep wool, 10.9 thousand tons of cashmere, 2.2 thousand tons of camel wool, and 17.6 million pieces of animal skin were produced by slaughtering.

In recent years, the frequency of drought has increased and number of livestock has been fluctuating depending on it. For example, consecutive drought years in 2017-2020 were the main reason for the increased loss of livestock in the Gobi region, such as soums of Bayankhongor, Gobi-Altai, Umnugobi, and Dundgobi provinces.

Changes in livestock population and herd structure. Analyzing the inventory data, the number of livestock, which was stable at 22-25 million during 1970-1990, since it further increased continuously reaching 71.0 million in 2019, except for dzud occurred years in 2000-2003 and 2009-2010. However, more than 9 million livestock were lost in 2009-2010, while in 2020, the number decreased by 4 million and reached to 67.1 million livestock (Figure 4.61).

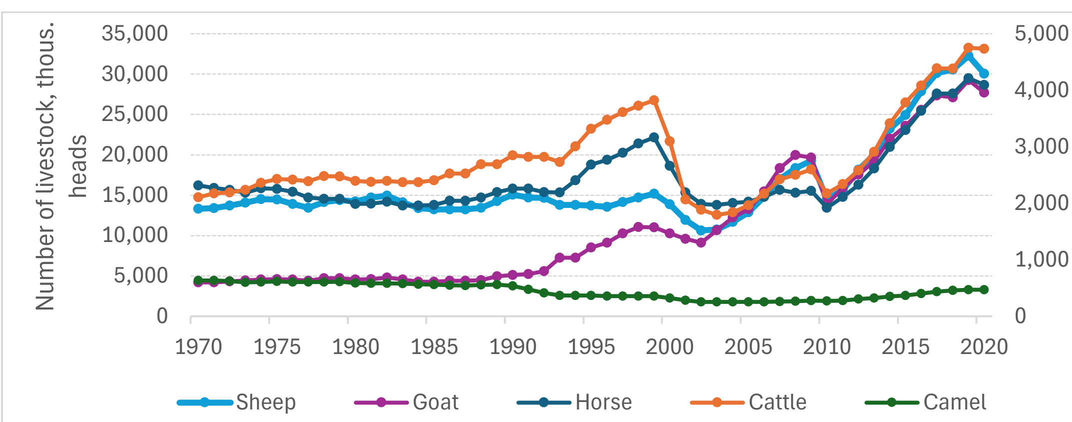


Figure 4.61 Trends in number of each livestock type

As shown in Figure 4.62, the number of camel herds has been almost constantly decreasing since the 1960s of the last century. The number of cattle, which is the most common herd among five types livestock has been increasing since the 1950s, however it has tendency to decrease in the drought and dzud since 2000s, while the number of goat herds has increased constantly year-by-year, and it accounted for 41% of the total herd by 2020.

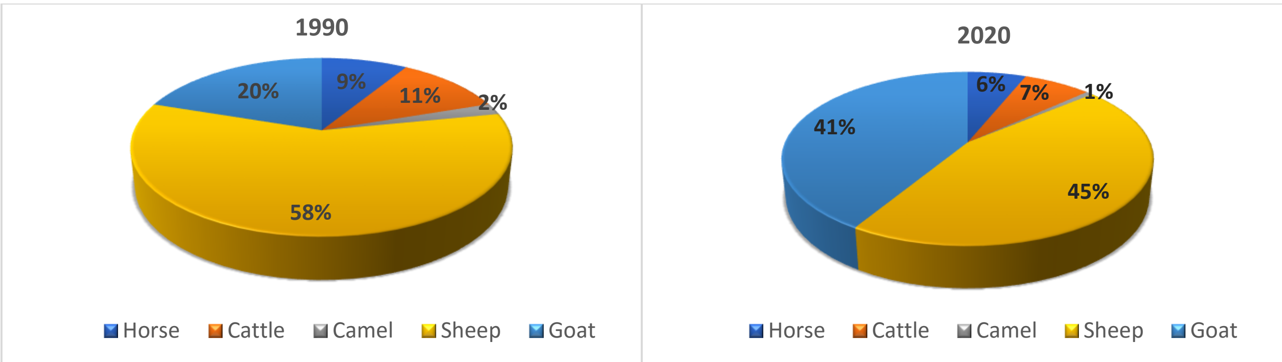


Figure 4.62 Percentages of each livestock herd in 1990 and 2020

In the last 30 years, the traditional herd structure of five types of livestock has been significantly disrupted. In 1990, cattle accounted for 11% of the total herd, while it dropped to 7% in 2020. This is due to the increase in the total number of livestock, changes in the structure of the herd, i.e. doubling the size of goat herd, and changes in the rangeland health condition. However, the share of goat herd that do not much underrate the pasture has increased from 20% in 1961-1990 to 40% of the herd since 2008. This increase in the goat population is also due to the increase in cashmere market demand.

Comparing the distribution of cattle herds in 1990 and 2020, depending on the characteristics of cattle grazing, the migration of herdsmen increased to the regions where grass and plants grow relatively high, thus, the number of cattle herds increased. By 1990, the number of cattle was 15-20 thousand in the entire area of Khuvsgul, Arkhangai, most of Bulgan, Khentii, and in soum of Uvurkhangai, Sukhbaatar; while by 2020, the largest increase was in most soums of Arkhangai province, which is an average of 40-50 thousand, and Khuvsgul, Khentii, Dornod and Sukhbaatar provinces have 20-30 thousand heads (Figure 4.63-4.64). The distribution picture shows that the herds of biologically characterized cattle that use pastures with relatively tall plants will continue to move from the western to the eastern regions, and thus increase in numbers.

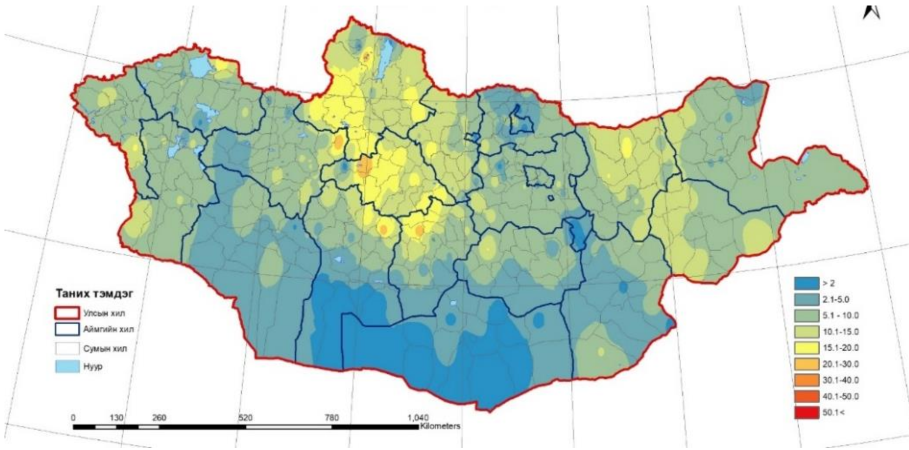


Figure 4.63 Cattle herd distribution (thousand head), 1990

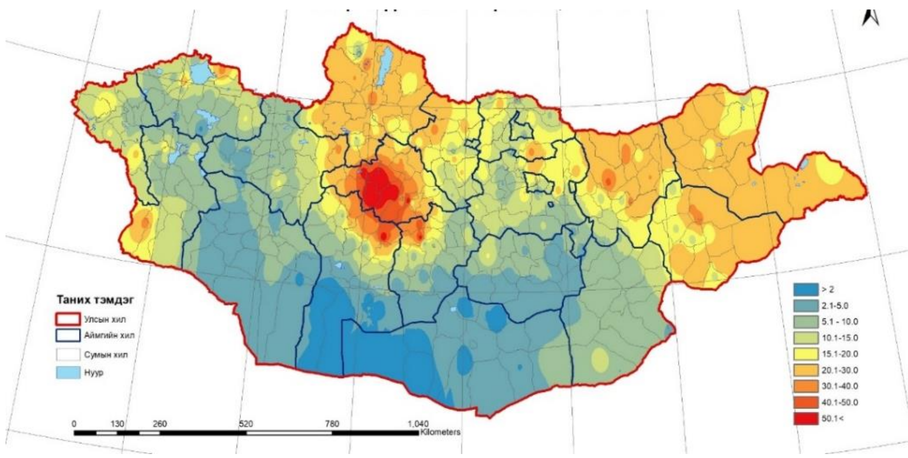
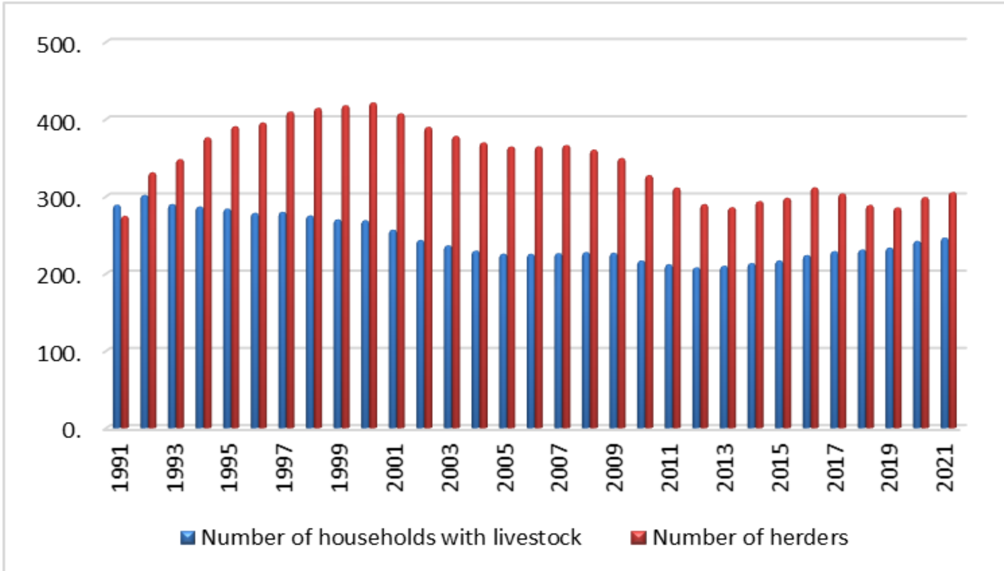


Figure 4.64 Cattle herd distribution (thousand head), 2020

Number of herder households. During socialist period, almost 250,000 herders from more than 100,000 herder families had 23-25 million livestock, and the number of herder families increased rapidly from the beginning of 1990s caused by livestock privatization and shortage of jobs in urban areas. After the 3-consecutive-year drought and dzud during 1999-2000 and 2001-2002, and the great dzud in 2009-2010, in countryside, the number of households with fewer livestock has increased, and accordingly the number of livestock decreased again, however as of 2021, there are about 246,000 households with livestock and 305,000 herders (Figure 4.65). In recent years, the number of herders, especially young herders, has been decreasing.



Source: NSO

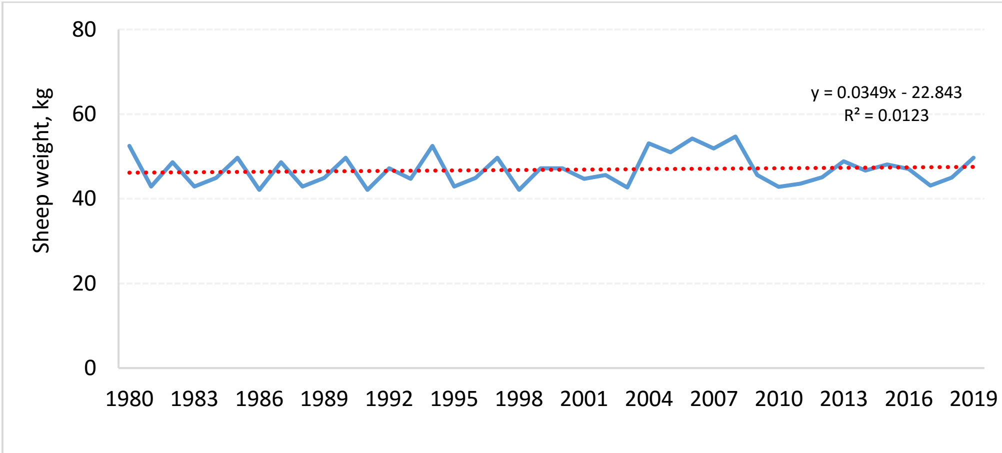
Figure 4.65 Trend of herder households and herders

Due to the increase in frequencies of drought and dzud, the productivity of livestock has decreased, especially, for lives of herders who live in remote areas far from the market will be adversely affected, as a result increased herder's migration to urban areas, and urban concentration are expected to continue.

Changes in livestock productivity and live weight. According to the rangeland health monitoring, 69% of the 1,550 monitoring sites were altered with respect to the plant species composition in comparison with the reference state.

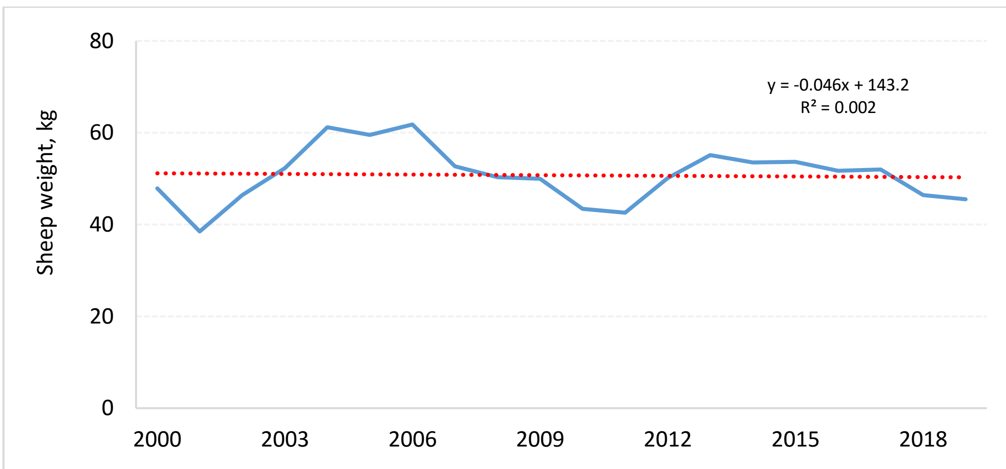
According to the zoo-meteorological monitoring information conducted since 1980 in forest steppe and since 2000 in steppe region, livestocks are unable to fully fattened up and livestock size becoming smaller because of the increased drought frequency, the delayed summer season, and the decline of pasture biomass.

The long-term zoo-meteorological monitoring data in the Bayan-Unjuul soum of Tuv province that represents steppe region and Orkhon soum of Bulgan province that represents forest steppe region demostrated that the live weight of mature mongolian female sheep (ewe) has decreased (Figure 4.66-4.67). Moreover, according to the research conducted on cattles and goats, the decreasing trends of live weight can be observed.



Source: IRIMHE

Figure 4.66 Weight of ewe, Orkhon soum of Bulgan province



Source: IRIMHE

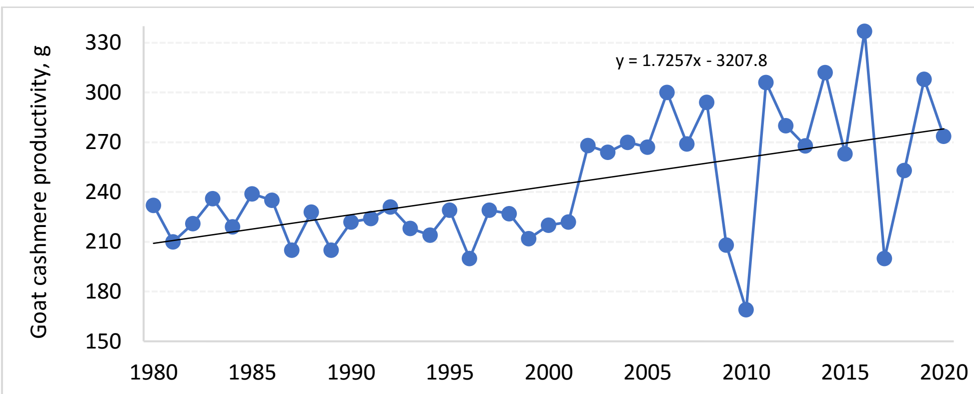
Figure 4.67 Weight of ewe, Bayan-Unjuul soum, Tuv province

The ewe weight decreased depending on an adverse environmental conditions of winter and spring seasons, and a physiological state of ewes during pregnancy, which is greatly influenced by the environmental conditions. Therefore, the changes in the winter- and spring-weight of the sheep were calculated using a dynamic statistical model which calculates the change in the live weight of the livestock. According to the model results, the amount of winter weight loss of grazing sheep is 0.31 kg - 3.25 kg in 2020, and 0.35 kg - 4.47 kg in 2050. In 2080, it is expected to decrease by 0.34 kg - 5.18 kg for all regions in comparison with the current weight. The decrease in livestock weight is greater in Bayan-Ovoo soum of Khentii province and Bayan-Unjuul soum of Tuv province, those represents the steppe region (Table 4.18).

Table 4.18 Future changes in winter-spring weight of ewes, kg

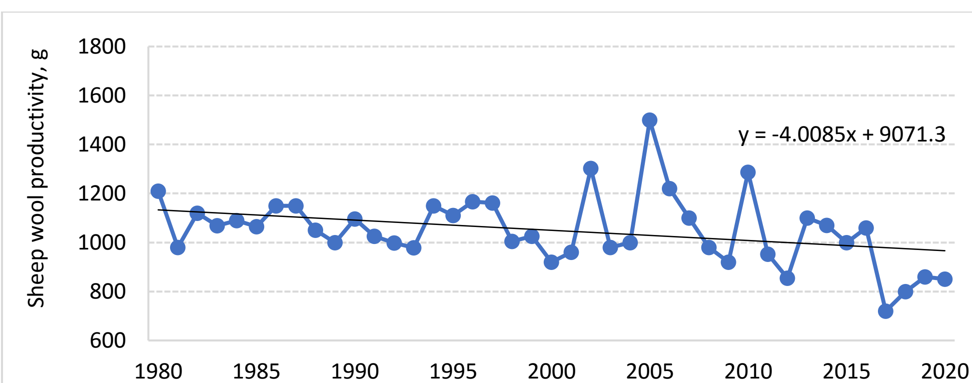
Province/Station name	Present (2020)	2050	2080
Khentii-Bayan-Ovoo	-1.39	-2.22	-4.00
Zavkhan-Bayantes	-1.23	-1.92	-2.61
Bulgan-Bulgan	-0.11	-0.93	-1.75
Bayankhongor-Galuut	-1.80	-2.55	-3.30
Umnugobi-Dalanzadgad	-1.22	-1.85	-2.48
Tuv-Bayan-Unjuul	-3.25	-4.47	-5.18
Dornogobi-Sainshand	1.05	0.35	-0.34
Arkhangai-Tariat	0.31	-0.51	-133

From 1980s to 2000, productivity of goat cashmere has been relatively flat, with a significant upward trend over the last ten years, except for the dzud year occuring of 2009-2010 (Figure 4.68). This is because the herdsmen pay great attention to the improvement of the breed of goat herds that are valuable for the market. However, output of sheep wool has a high fluctuation; however, it has a general tendency to decrease (Figure 4.69).



Source: IRIMHE

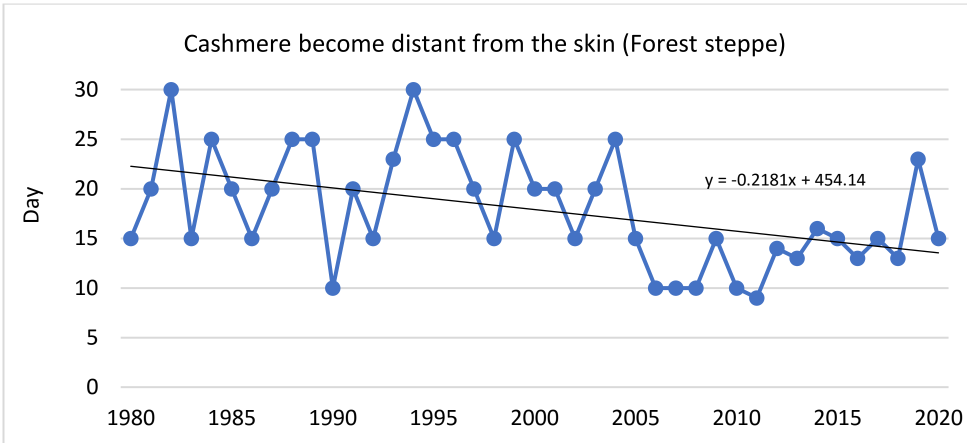
Figure 4.68 The average productivity of goat cashmere measured at zoo meteorological post in Bulgan province



Source: IRIMHE

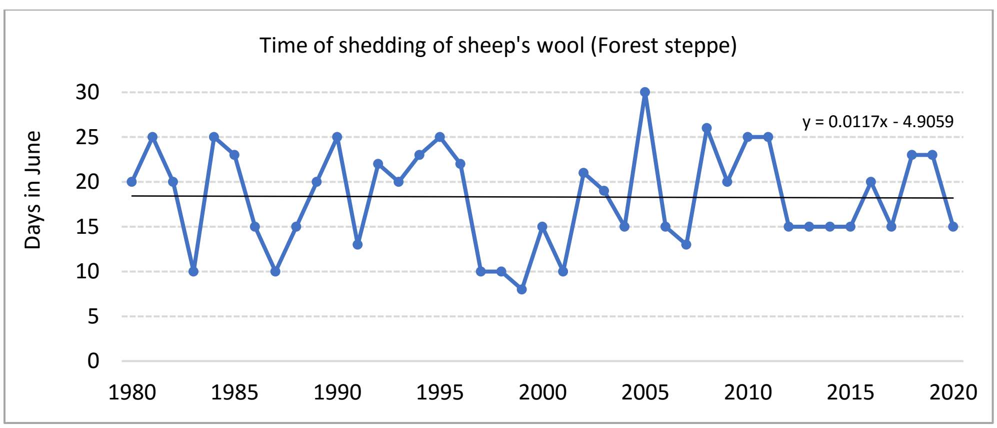
Figure 4.69 The average productivity of sheep wool, measured at zoo meteorological post in Bulgan province

Due to climate warming, the timing of 'goat cashmere loosens from the skin' has been delayed by 5-10 days in springs (Figure 4.70). However, the timing of sheep's wool shedding is almost unchanged (Figure 4.71).



Source: IRIMHE

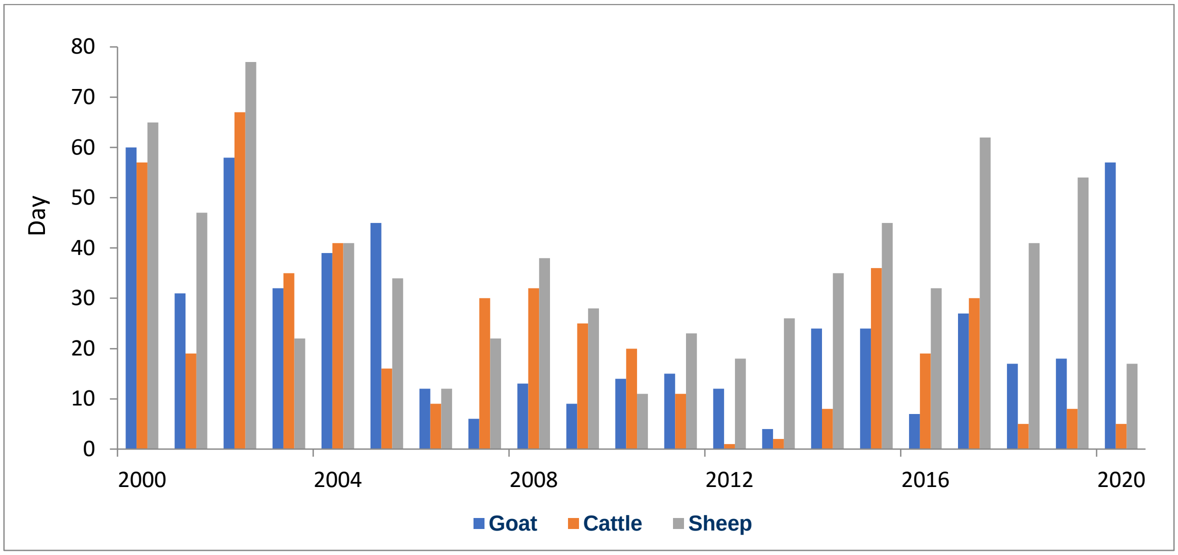
Figure 4.70 Goat cashmere shedding time



Source: IRIMHE

Figure 4.71 Sheep wool shedding time

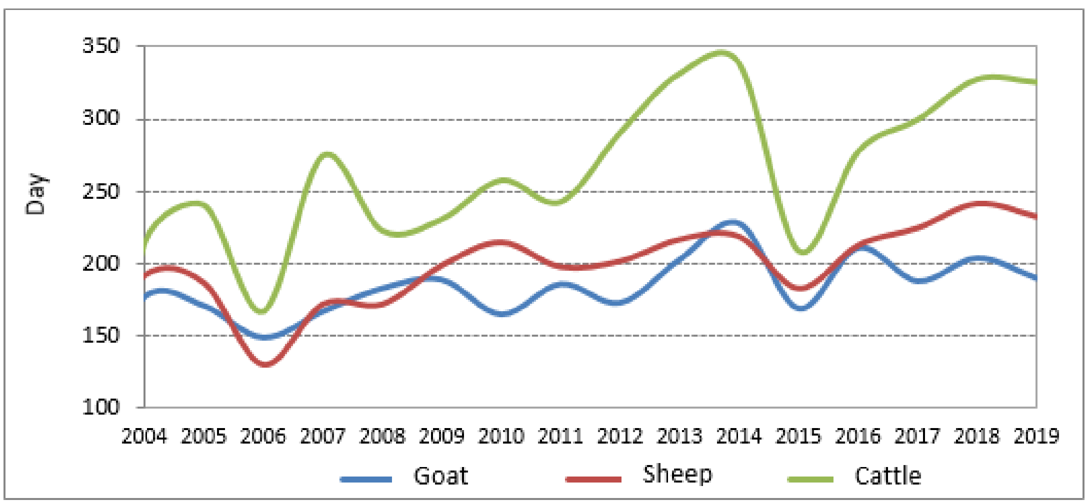
Livestock adaptation to climate change. According to research results, the number of extremely hot days unsuitable for livestock grazing in summer is increasing along with decrease in the pasture yield. Hot weather conditions disturb the heat balance of the animal's body, and have a negative effect of reducing grazing time, weakening the body, and reducing fatness. On a clear day without wind, sheep starts grazing at 22°C and Mongolian cattle at 28°C in forest and steppe areas. According to observational data, the number of hot days unfavorable for livestock grazing in forest-steppe areas is expected to increase in the future (Figure 4.72).



Source: IRIMHE

Figure 4.72 Number of hot days unfavorable for livestock grazing, 2000-2019

Also, according to observation data, due to the warming of the last 20 years there is a tendency to increase the number of days that animals are showered (Figure 4.73).



Source: IRIMHE

Figure 4.73 Number of days the livestock watered, 2004-2019

According to the future climate projections, it is clear that the intensity of drought and dzud will increase significantly in Mongolia in the future. Therefore, it is necessary to control the number of livestock to their grazing capacity in an early adaptation manner, to reserve nearby pastures for use when there is a risk of drought, to protect grazing pastures for herd migration during drought, and to restore degraded pastures.

In recent years, in order to adapt to climate change, farmers have neglected the benefits they get from animals, and have taken measures to prevent calving in some drought years, only in order to get good fattening and keep the animals healthy. When showing the distribution of non-pregnant animals (maiden) in the total of ten years, there was a little change in 1991-2000 and 2001-2010, however, in 2011-2020, even though there no drought years were observed, the summer was started late, especially in the Gobi region, there were many consecutive drought years, so it was common for herders act breeding animals as bare (Figure 4.74 and 4.75).

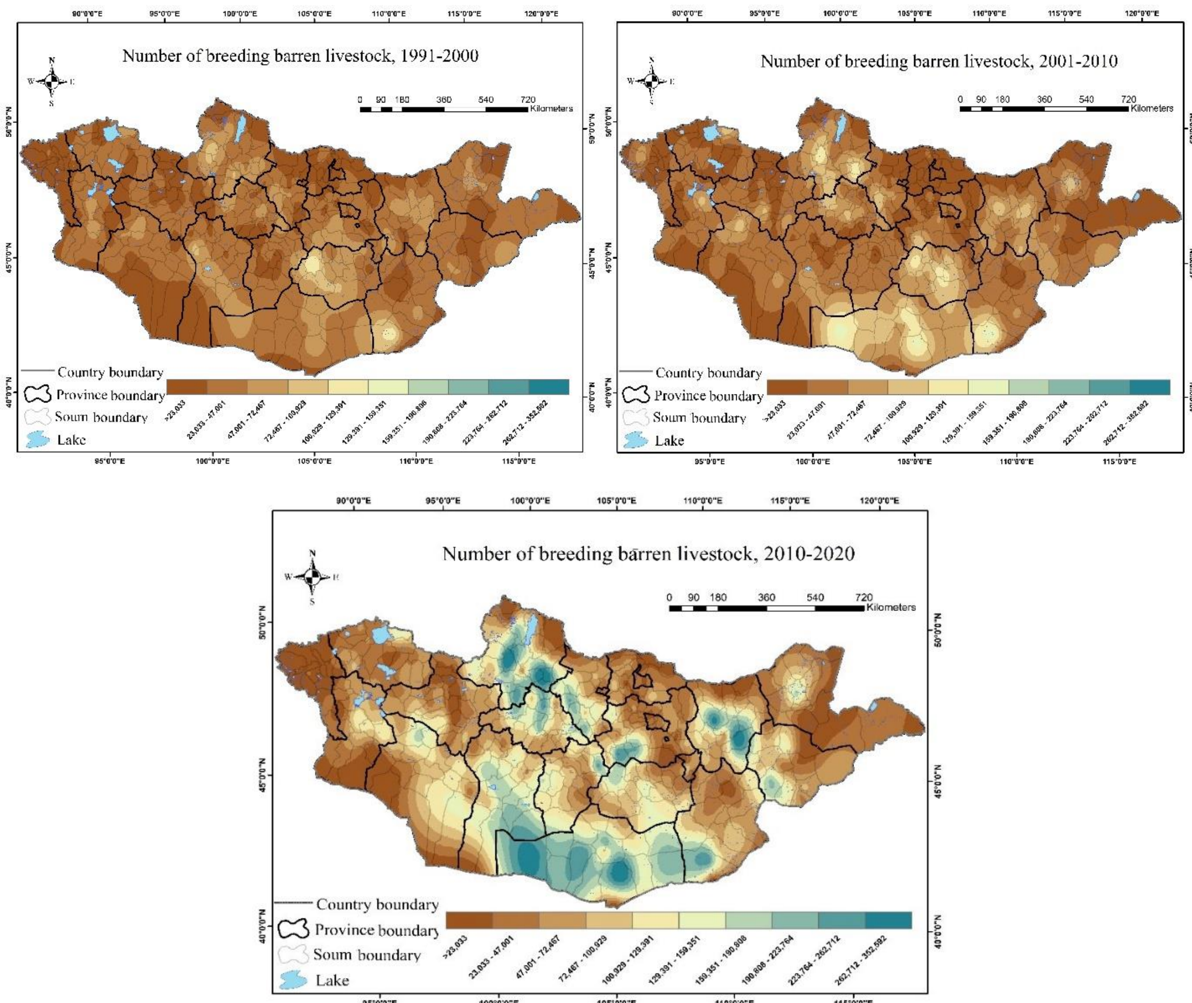


Figure 4.74 Distribution of bare breeding animals. a) 1991-2000 b) 2001-2010 c) 2011-2020

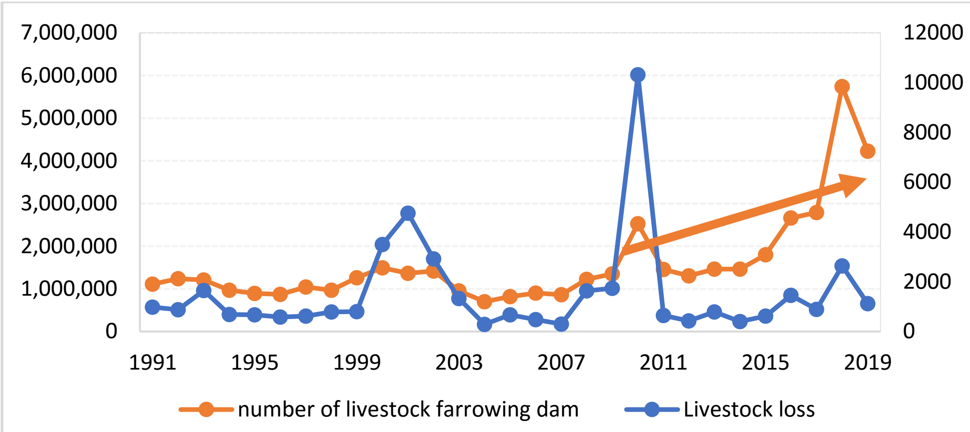


Figure 4.75 The number of bare breeding and lost animals (thousand head), 1971-2019

Hot weather conditions in summer and autumn greatly affect sheep grazing, and reproduction, fattening, and productivity depend on it. In hot conditions, animals graze less, thus reduced the grazing activity and shortened the day's grazing time.

When Mongolian sheep are hotter than the regional average of 20˚C -22˚C, their grazing stops and the amount of grass they eat decreases. According to the future trend of climate change, for example, the regional changes that will hinder the grazing of Mongolian sheep at the level of 2050 and 2100 were calculated based on the results of the climate change calculation model.

In recent years, the amount of weight loss due to insufficient fattening of livestock in summer and autumn, insufficient grazing capacity in winter and spring, tends to increase significantly in recent years. On the other hand, researchers and herdsmen alike criticize the fact that the traditional way of herding animals has changed, and there is an increase in the speedy herding of animals by cars and motorcycles. Thus, the decrease in the weight of animals and the decrease in meat yield will create certain biological and economic consequences. The ability of exhausted animals to replenish their fat in summer and autumn is weakened, which is the main condition for animals to become weight growdown

4.2.2 Arable farming

Food security. For Mongolia, as a country, which imports 70% of its food products, ensuring food supply and safety has becoming one of the challenging topics. As of today, Mongolia imports the majority of its strategic food products (except meat products), which shows that the security of food supply has some concern since it has become dependent on foreign countries. The international organizations include the 3 indicators when making an assessment of food consumption and population health in a country or region.

Food security is an important component of national security related to the population policy and lineage of any country, and each country takes appropriate measures to ensure its food security based on a realistic assessment of its own (Figure 4.76).

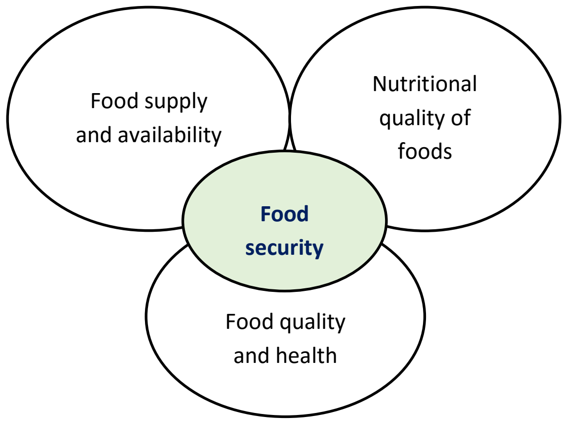


Figure 4.76 Basic concepts of food security

Food supply means whether the country is able to provide its population with the main strategic food products, such as meat, milk, vegetables, and fruits, and whether this supply is carried out independently by its own internal capacity, or in larger or smaller quantities from foreign countries, depending on the problem, whether it is performed by importing.

The availability of meat and meat products, milk and milk products, flour, sweets and sugar is sufficient for needs of the popultions, and the availability of other food products is insufficient or lacking (Statistical indicators of food security-2014, 2015).

Until 1990, there were self-sufficient in domestic demand for wheat, but afterward the cultivation of wheat decreased significantly (Figure 4.77). In 1990, the largest amount of wheat was cultivated (532.9 thousand ha), while in 2007, the lowest amount was cultivated (116.7 thousand ha). As part of the Atar II (2008) and Atar III (2019) campaigns implemented by the government, wheat cultivation has increased and reached 377.0 thousand ha in 2020.

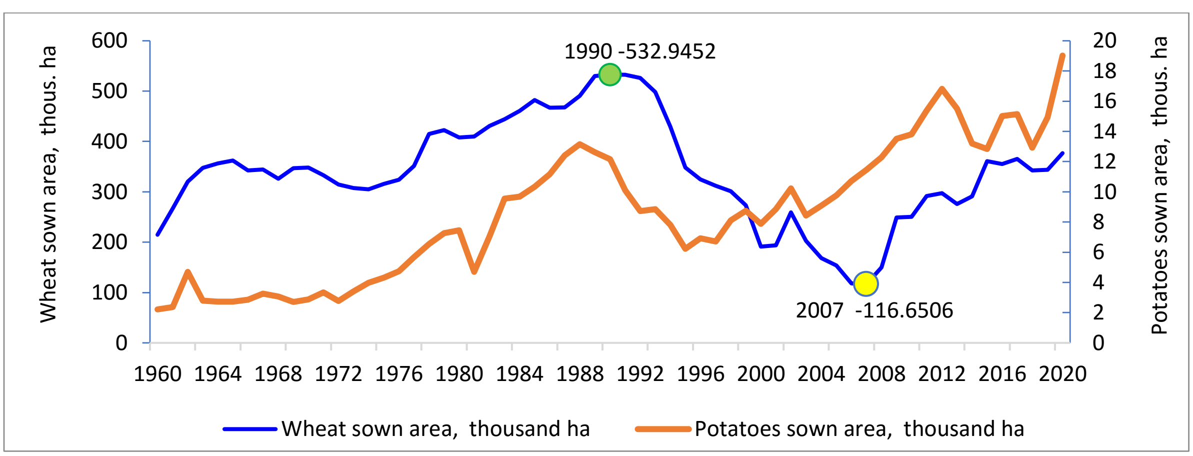


Figure 4.77 Long-term time series on wheat and potato fields

According to the long-term progress of wheat and potato harvest per hectare, there is a large variation depending on weather conditions of the year, but it increased until 1990, then decreased dramatically, and gradually increased from 2003 (Figure 4.78).

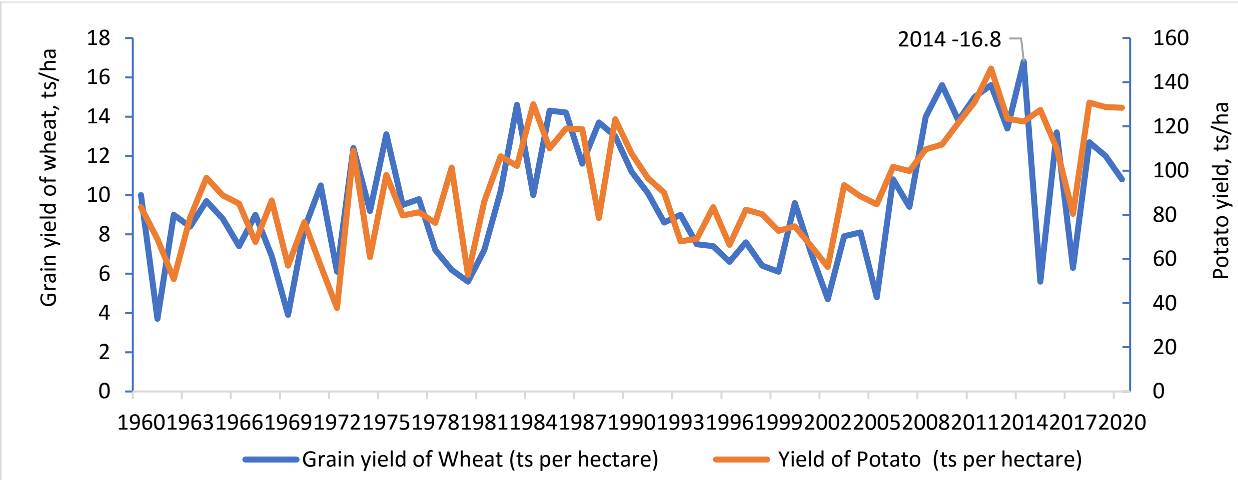


Figure 4.78 Trends in yield per hectare

Crop model. The process of crop formation of cultivated plants is somehow governed by certain biological, physiological and biophysical laws that occur in plants under the direct influence of many factors of the external environment. Theoretically, the physical basis of these processes can be explained mathematically and it is possible to model all the processes of plant growth. Currently, dynamic modeling methods based on complex differential equation systems are used to model the phenomena occurring in the agroecosystem.

The Decision Support System for Agrotechnology Transfer (DSSAT) is cropping-system model (DSSAT 4.7.5) for 42 crop types. The DSSAT model is a system that calculates the growth and development of cultivated plants over time in certain soil moisture, soil organic matter, nitrogen, carbon, and weather conditions, and during agrotechnical works.

As part of this research, we selected 16 meteorological stations located in the main agricultural regions to evaluate the impact of climate change on the growth and yield of wheat and potato, the main cultivated crops of Mongolia (Table 4.19).

Table 4.19 Location and information of selected stations

№	*Meteorological Station*	*Latitude*	*Longitude*	*Meters Above Sea Level, m*	*Type and mechanical composition of soil*	*Data length*
1	Darkhan	105.98	49.47	706	Dark brown, light loamy	1984-2020
2	Eruu	49.75	106.67	676	Dark brown, light loamy	1964-2020
3	Tarialan	49.6	102.00	1236	Dark brown, loam	1969-2020
4	Ugtaal	48.27	105.42	1160	Dark brown, light loamy	1980-2020
5	Khalkhgol	47.62	118.52	688	Brown, loam	1980-2020
6	Baruunkharaa	48.92	106.07	811	Dark brown, light loamy	1961-2020

7	Baruunturuun	49.40	94.60	1232	Brown, sandy loam	1969-2020
8	Erdenesant	47.20	104.25	1356	Brown,light loam	1975-2020
9	Orkhon	49.15	105.4	748	Dark brown, light loamy	1979-2020
10	Khutag	49.37	102.7	933	Dark brown, loam	1979-2020
11	Jargalant	48.52	105.9	1200	Dark brown, light loamy	1992-2020
12	Ingettolgoi	49.45	103.95	800	Dark brown, loam	1992-2020
13	Tsagaannuur	50.1	105.43	800	Dark brown, light loamy	1992-2020
14	Kharkhorin	47.2	102.77	1430	Dark brown, light loamy	1993-2020
15	Orkhontuul	48,835	104,806	800	Dark brown, light loamy	1993-2020
16	Undurkhaan	47.320	110.670	1033	Brown, sandy loam	1964-2020

The input data required for the DSSAT 4.7.5 model for the selected stations are defined as follows:

Weather data: Daily solar radiation (mJ/m^2 day), maximum air temperature (°C), minimum air temperature (°C), and precipitation (mm).

The baseline mean was taken as a 30-year based on an average from 1991-2020. When inputting multi-year climate data for a given station, the model's weather subroutine can generate daily data based on parameters such as climate averages. Missing data from some observations have been replaced by it.

Cultivar data: Specifies the parameters that define the cultivar (Table 4.20). There are several types of varieties specified in the template, so we can choose from those varieties. From these varieties, wheat and potato varieties were selected and the most similar varieties were selected in terms of yield and growing period in Mongolia (Tables 4.31 and 4.32). If we can determine the coefficients on the basis of the variety test, we can accurately identify the variety.

Table 4.20 Cultivar specific parameters for modeling

Coefficients	*Definition*
VAR#	Identification code or number for the specific cultivar
VAR-NAME	Name of cultivar
ECO#	Days at optimum vernalizing temperature required to complete vernalization
P1V	Days at optimum vernalizing temperature required to complete vernalization.
P1D	Percentage reduction in development rate in a photoperiod 10 hour shorter than the threshold relative to that at the threshold
P5	Grain filling (excluding lag) phase duration (°C.d)
G1	Kernel number per unit canopy weight at anthesis (#/g)
G2	Standard kernel size under optimum conditions (mg)
G3	Standard, non-stressed dry weight (total, including grain) of a single tiller at maturity (g)
PHINT	Interval between successive leaf tip appearances, °C.day

Table 4.21 Input data wheat cultivar parameters for DSSAT model

@VAR#	*VAR-NAME*	*ECO#*	*P1V*	*P1D*	*P5*	*G1*	*G2*	*G3*	*PHINT*
990099	SPRING-MONG	DSWH04	5	55	500	30	45	1.5	60

Table 4.22 Input data potato cultivar parameters for DSSAT model

@VAR#	VAR-NAME	ECO#	G2	G3	G4	PD	P2	TC
IB0004	POT_MONG	IB0001	2000	25	0.2	0.7	0.6	19

Soil data: Mechanical composition structure of soil, soil organic carbon, nitrogen content (%), pH, bulk density (g/cm^3) were newly determined for each soil layer of Darkhan, Kharkhorin, Baruunturuun, Jargalant, Khutag-Undur, and Undurkhaan stations (Table 4.23).

Table 4.23 Soil data of Tarialan meteorological station

*MNTA020001 Agrowater SIL 100 Clay, Tarialan																
@SITE COUNTRY LAT LONG SCS FAMILY																
Tarialan Mongolia 49.612 101.990 Chernozem																
@ SLB	SLMH	SLLL	SDUL	SSAT	SRGF	SSKS	SBDM	SLOC	SLCL	SLSI	SLCF	SLNI	SLHW	SLHB	SCEC	SADC
5	A	0.1	0.272	0.506	1	0.68	1.23	-99	15.2	55.7	-99	-99	8.3	-99	-99	-99
10	A	0.1	0.265	0.514	1	0.68	1.21	-99	8.2	59	-99	-99	8.3	-99	-99	-99
20	A	0.1	0.262	0.506	1	0.68	1.23	-99	14.3	51.6	-99	-99	8.4	-99	-99	-99
30	B	0.1	0.256	0.524	0.607	0.68	1.18	-99	13.2	50	-99	-99	8.5	-99	-99	-99
40	B	0.1	0.226	0.503	0.497	2.59	1.24	-99	13	35	-99	-99	8.6	-99	-99	-99
50	B	0.1	0.264	0.528	0.407	0.68	1.17	-99	14.7	51.8	-99	-99	8.6	-99	-99	-99
60	B	0.1	0.295	0.521	0.333	0.68	1.19	-99	19.3	61.7	-99	-99	8.7	-99	-99	-99
70	B	0.1	0.275	0.517	0.273	0.68	1.2	-99	12.8	61	-99	-99	8.7	-99	-99	-99
80	B2	0.1	0.23	0.456	0.223	1.32	1.37	-99	9.6	42.2	-99	-99	8.7	-99	-99	-99
90	B2	0.1	0.208	0.351	0.183	2.59	1.66	-99	8.2	34.1	-99	-99	8.8	-99	-99	-99
100	B2	0.1	0.213	0.286	0.15	2.59	1.84	-99	8.4	36.3	-99	-99	8.8	-99	-99	-99

Agro-technical activities: Information such as planting time, sowing rate, and harvesting time are prepared and defined by the above meteorological stations.

Defining the correct planting rate is one of the most important problems in growing wheat. Not only the yield depends on the planting rate, but the protein and gluten, which are the main indicators of wheat quality, will change a lot (N.Byambajav, S.Ganbaatar, 2000).

The seed quality, field emergence, biological resistance, and plant life of grain plants are calculated, and the seed rate is calculated in order to maintain the required number of plants per unit area to form the estimated yield in accordance with the state of soil moisture and weed distribution (S.Ganbaatar,1999). It is recommended to plant winter wheat with 2-5 million germinated seeds per hectare.There is a small difference in yield of wheat between 2.5 and 4.5 million norms in the Orkhon-Selenge basin (L.Tovuu, 1986).

The growth and development of plant in a semi-arid region like Mongolia depends mainly on the distribution and amount of rainfall. In Mongolia, which has dominated by non-irrigated agriculture, the main factor that determines the fluctuation of wheat yield is the weather conditions of the year.

Therefore, the long-term trend of wheat yield and the correlation between the rainfall and actual yield of wheat at some stations are shown in Figures 4.79-4.80. As can be seen from the figure, the trend of wheat yield in the most areas increased until the 1990s, then decreased sharply until 2004, and increased in the last 5 years years in until 2020.

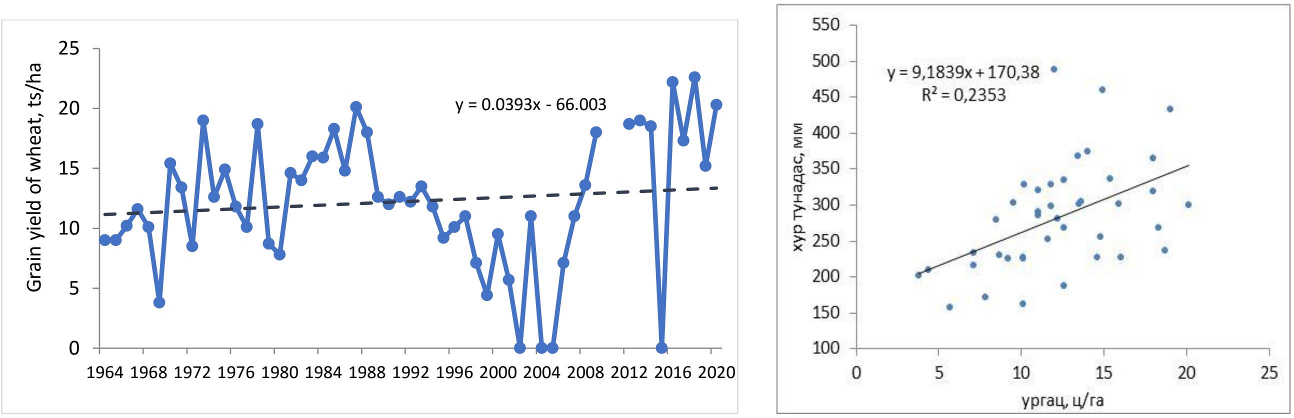


Figure 4.79 Trend in actual wheat yield and correlation between the precipitation and the actual yield in Eruu meteorological station

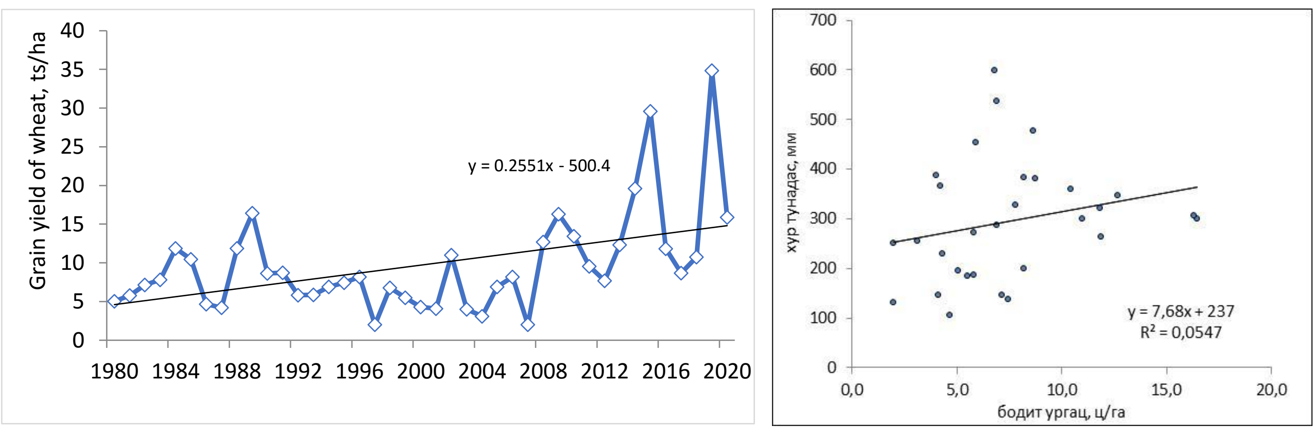


Figure 4.80 Trend in actual wheat yield and correlation between the precipitation and the actual yield in Halhgol meteorological station

As part of the research work, we derived the results using the DSSAT model based on the actual data of 16 stations, and results of the Darkhan meteorological station as a representation are shown in Figures 4.81 and 4.82.

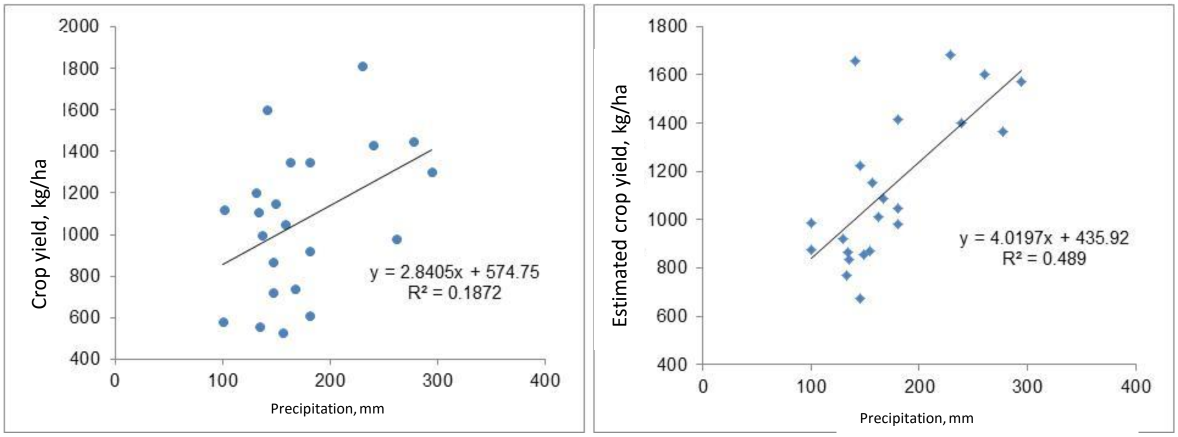


Figure 4.81 Correlation between the precipitation and the actual yield (Darhan station)

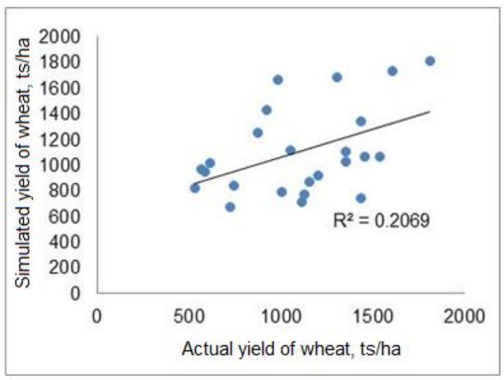


Figure 4.82 Correlation between the simulated and the actual yield (Darhan station)

The simulated wheat yield in the Darkhan station is 1,104 kg ha^{-1} and the actual wheat yield is 1,099 kg ha^{-1} with the mean square error of 330 kg ha^{-1} (Figure 4.83). Also, the dynamics of the growth of the crops, and the weight of plant organs (leaf, stem, crown) the aboveground were calculated (Figure 4.84 and 4.85). The root weight of wheat in shown Figure 4.84 reaches its maximum value around 50-55 days after sowing and gradually decreases afterward.

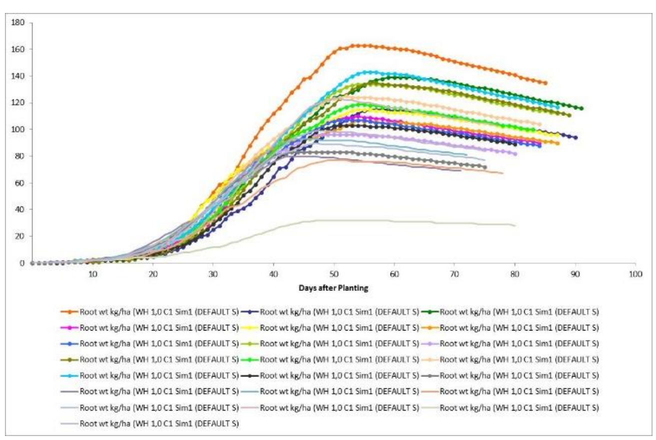


Figure 4.83 Trend of root weight of wheat (Darhan station) during 1984 to 2020

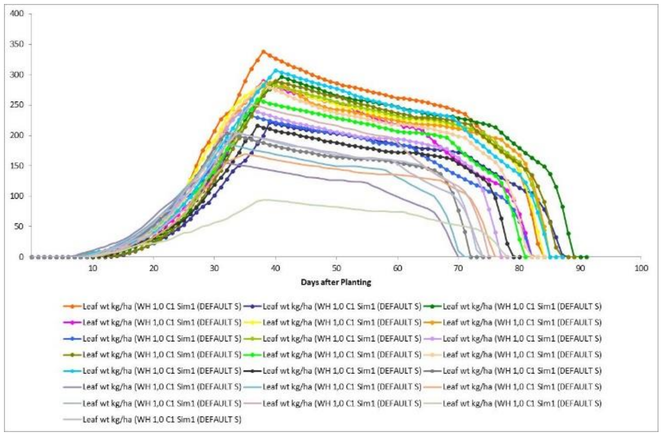


Figure 4.84 Trend of leaf weight of wheat (Darhan station) during the 1984 to 2020

Effects of changes in air temperature and precipitation on cultivated plants. In Mongolia, as of 2020, 80% of agricultural land is in the central region, 11% in the eastern, and 9% in the western region (Figure 4.85). Also, the largest crop is harvested from the Central region.

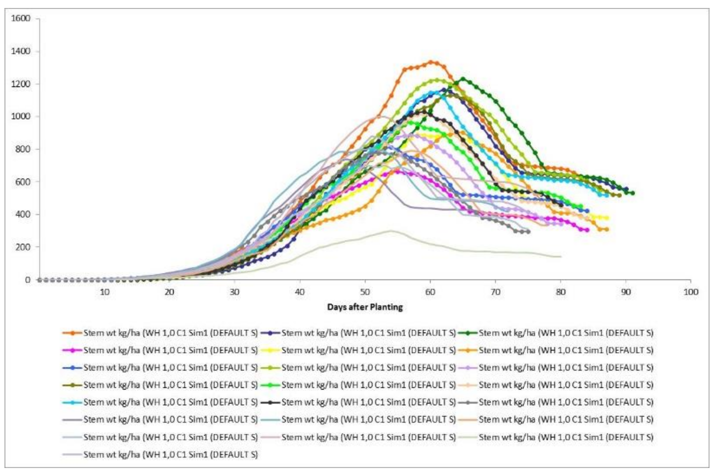


Figure 4.85 Trend of stem weight of wheat (Darhan station) during the 1984 to 2020

Effects of changes in air temperature and precipitation on cultivated plants. In Mongolia, as of 2020, 80% of agricultural land is in the central region, 11% in the eastern region, and 9% in the western region (Figure 4.86). Also, the largest crop is harvested from the Central region. These crops are cultivated mainly non-irrigated in Mongolia and are directly dependent on the agro-climate and agro-weather conditions.

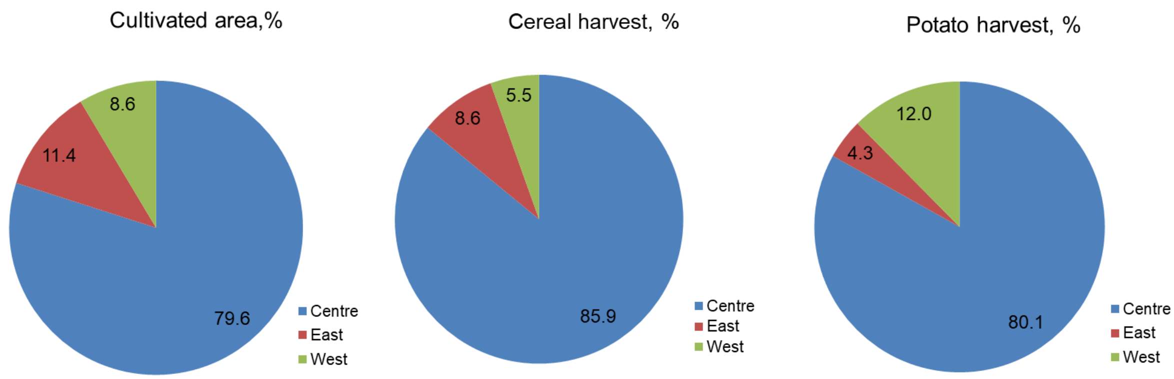


Figure 4.86 Cultivated area and the cereal and potato production in Mongolia,%

We calculated how the length of the growing season and yield of crops will be affected when the average air temperature increases by 1 and 2 degrees, precipitation decreases by 20% and 10%, and increases by 10% and 20% at 16 weather stations using the DSSAT 4.7.5.0 model (Table 4.24). At 16 selected stations were calculated the percentage of changes in wheat yield in the western, eastern and central regions. This simulation was made considering the atmospheric CO_2 concentration as 380 ppm.

Table 4.24 Changes in wheat yield,% (compared to the present)

Atmospheric CO_2 concentration (380ppm)									
Changes in precipitation,%	Changes in air temperature, °C								
	t+0	t+1	t+2	t+0	t+1	t+2	t+0	t+1	t+2
Centre region				East region			West region		
0		-11.7	-21.9		-12.6	**-25.4**		-8.6	**-17.0**
10	6.6	-5.9	-17.3	8	-5.1	**-16.9**	9.8	-1.0	**-10.0**
20	12.7	-1.1	-12.3	15.9	2.6	**-12.0**	18.0	6.5	-3.2
-10	-6.7	**-16.9**	**-27.0**	-8.4	-	-	-7.2	-	-
-20	-13.4	**-23.5**	**-32.7**	-16.9	-	-	-16.3	-	-

As can be seen from the table above, assuming that there is no change in air temperature and rainfall increases by 10 or 20% in cultivated areas, the wheat yield tends to increase by 6.6-18.0%. However, if the air temperature increases by 1 or 2 degrees than the current one, the harvest is expected to decrease by 8.0-25.4%, and the largest decrease in the yield (25.4%) is expected to be in the cultivated areas of the western region. Also, if the air temperature increases by 2 degrees, even if the amount of precipitation increases by 20%, the yield is expected to decrease. This indicates that even with increased rainfall, heat stress will adversely affect wheat growth.

Effects of the wheat growth period and planting date on wheat production. In the central agricultural zone, it is suitable that the planting date of wheat is between 5th-15th May for seeding (L. Tovuu, 1972, M. Olziy. 1974, N. Nyamjav. 1976, G. Davaadorj, 1985, S. Ganbaatar, J. Ganbold, 1997). Ganbaatar (1999) concluded that the main factor determining the planting date of crops is soil temperature. It was concluded that it is beneficial to plant when the temperature of the soil at the depth of planting is stable at 10°C and the sum of the daily average temperature from planting to germination is below 100°C. Figure 4.87 is shown how the growing season of wheat will change if the air temperature increases by 1 or 2 degrees warmer than the present. When the air temperature warms up by 1 or 2 degrees, the growth period is expected to be shortened by 6-14 days.

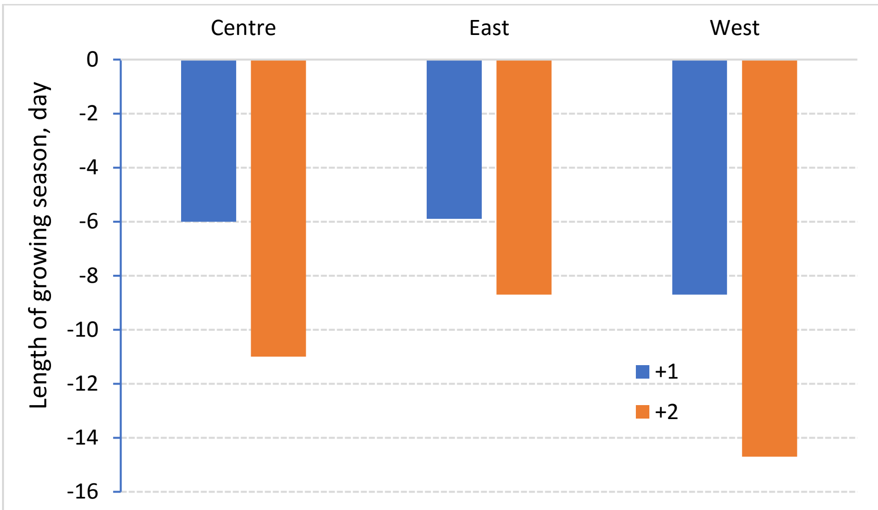


Figure 4.87 Changes in growing season of wheat

Future trend of crop growth. Future climate change may affect crop yields, and assessing future impacts is important for regional water and food security (Jia, D., et al., 2022). A number of experimental studies describing the effects of increased CO_2 on various plants have indicated positive effects on plant biomass (Thurig, B., et al., 2003). Average growth rate of 156 plant species increased by 37% when CO_2 concentration in the air increased from 300 ppm to 600 ppm. Average growth rate of C3 plants increased by 41% and C4 plants by 22% (Allen, L.H.JR., 1996).

It affects photosynthesis and reduces plant transpiration. This is because as pore conductance decreases, transpiration per unit leaf area decreases. An increase in photosynthesis and a decrease in transpiration means an increase in the plant's water use coefficient, or a decrease in the amount of water needed to produce a unit of biomass. Therefore, we estimated how the wheat yield will change in the near (2016-2035), mid-future (2046-2065), and far future (2080-2099) from (RCP4.5) and (RCP8.5) emission scenarios, relative to 1986-2005. It was calculated using the DSSAT v4.7.5 (Figure 4.88).

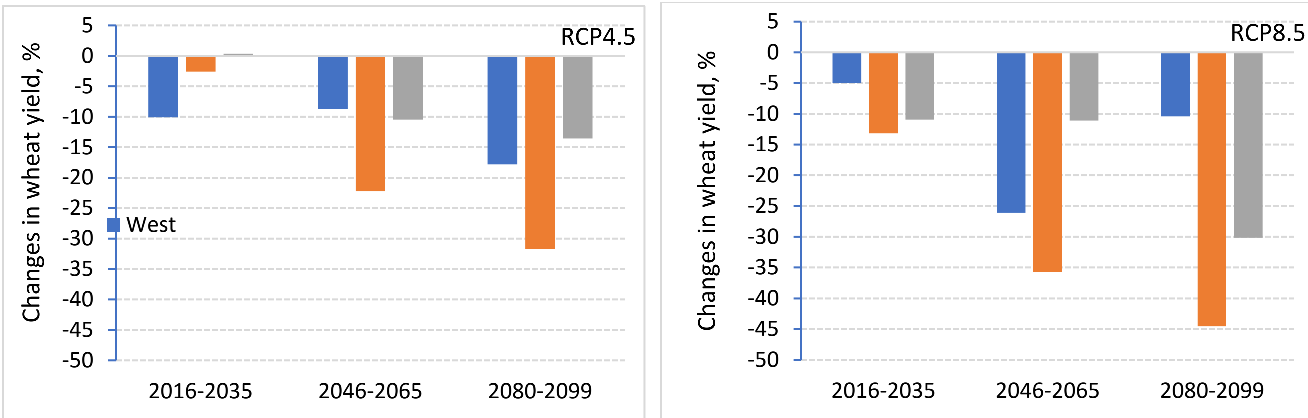


Figure 4.88 Changes in wheat production under future climate change,%

As shown in Figure 4.88, future changes in wheat yield are projected to decrease by an average of 4%, 14%, and 21% in relation to the baseline mean (1986-2005) under the RCP4.5 scenario in 2020, 2050, and 2080, respectively. However, according to the scenario with the highest emission of greenhouse gases (RCP8.5), it is expected to decrease by an average of 10%, 24%, and 28% relative to the baseline mean (1986-2005) in 2020, 2050, and 2080, respectively. In this calculation, the sowing period is considered to be sown in the current period between 10th – 15th of May. Also, it is assumed that there will be no change in crop varieties and soil fertility conditions.

4.2.3 Tourism

Tourism is a vital sector that significantly impacts the country's economy. It directly accounts for 3.6% of the world's gross domestic product (GDP) and indirectly accounts for 10.3% (WTO, 2020). Moreover, it accounts for 7% (1.6 trillion US dollars) of global exports and 30% of services. Furthermore, regarding employment, 1 out of 10 employed people work in this sector, and 1 out of 5 newly created jobs are in tourism (UNWTO, 2019, Figure 4.89).

Source: UNWTO, 2019

Figure 4.89 The main status of world`s tourism sector

The global tourism sector has increased productivity over the last 60 years. However, at the end of 2019, the COVID-19 pandemic caused a 73% decrease in tourists in 2020, reaching the historical minimum level (Figure 4.90).

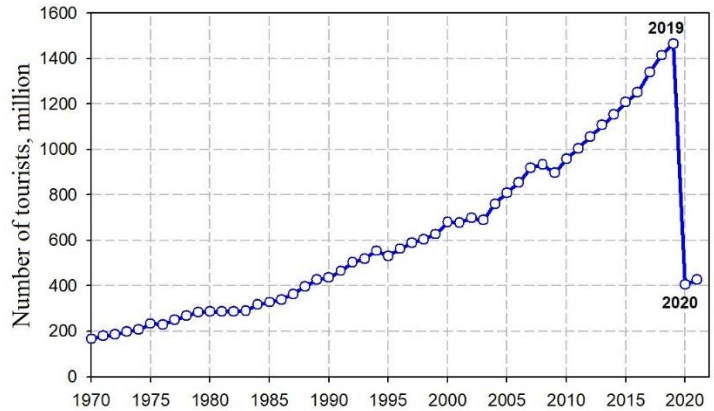


Figure 4.90 The inter-annual variation of number of tourists

The World Economic Forum (WEF) has updated the tourism sector competitiveness index every two years for the last 15 years. This updated index provides a unique and essential insight into each country's economic development to maximize the tourism sector's potential growth and a strategic benchmarking tool for policymakers and other sectors to advance future development.

The index is calculated within the framework of five leading indicators: environment, tourism policy, infrastructure, tourism demand indicators, and tourism sustainability (Figure 4.91). Based on these five indicators, Mongolia was ranked 93rd among 140 countries in 2019 and 84th among 117 countries in 2021 (Table 4.25).

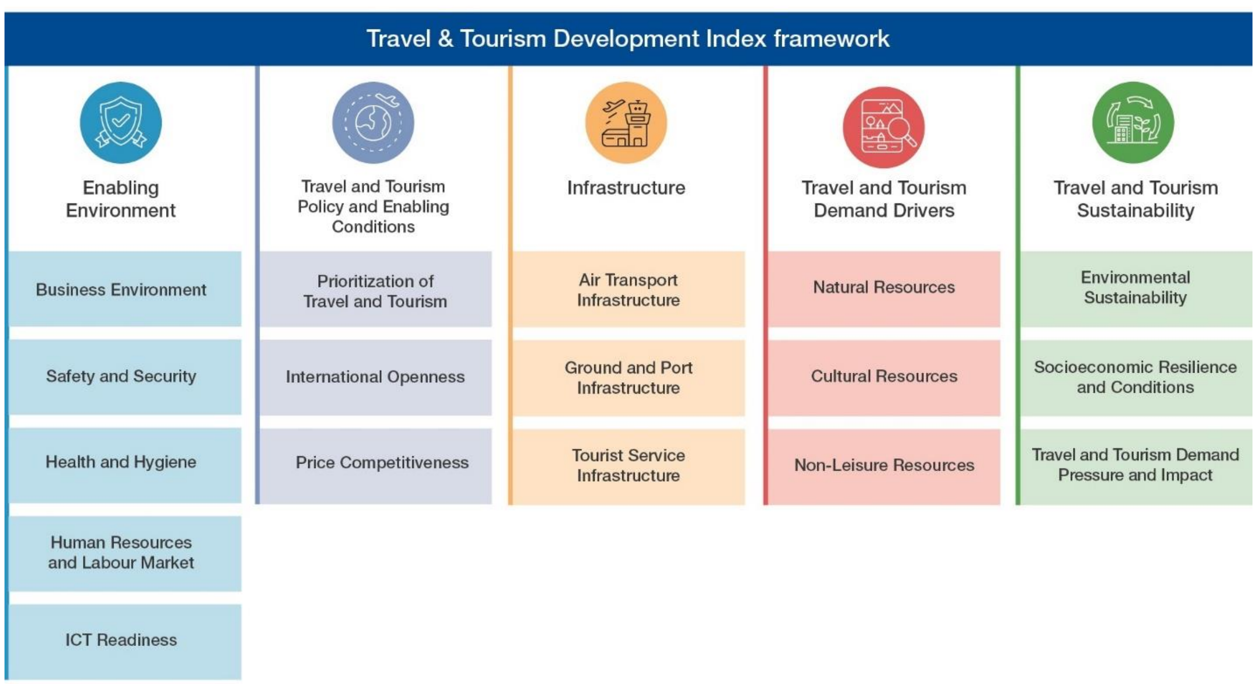


Figure 4.91 The tourism development index

Table 4.25 General evaluation of tourism development index 2021

Rank	*Country name*	*Assessment /score/*
1	Japan	5.2
2	United States of America (USA)	5.2
3	Spain	5.2
4	France	5.1
5	Germany	5.1
...	...	...
84	Mongolia	4.1

Source WEF, 2022

The Government of Mongolia approved the National Tourism Development Program for 2016-2025. The Ministry of Environment and Tourism is being developed and implementing many subprograms such as the "Sustainable Tourism Development Plan," "Special Interest Tourism Development Sub-Program" and “Government Policy Resolution on Tourism Development".

These programs take step-by-step measures, including intensifying tourism development, improving the tourism law and legal environment, increasing capacity, and reducing seasonality. Moreover, implementing the issue of improving the global tourism competitiveness index based on joining the international tourism network.

The development of tourism sector in Mongolia has started to grow more rapidly due to the transition from a planned economy to a market economy. It is possible to earn significant income using inexhaustible resources (wild nature, traditional animal husbandry, etc.).

The number of tourists coming to Mongolia has continuously increased in the last twenty years. In 2019, it received a maximum of 577.3 thousand tourists, meanwhile earned a net income of 607 million US dollars (Ministry of environment and tourism, 2020), and accounted for 6.48% of GDP (Figure 4.92). However, in 2020 and 2021, the number of tourists dropped sharply due to the coronavirus (COVID-19) epidemic, which decreased by 95% compared to 2019. Meanwhile, domestic tourism is rising due to the expanding paved road network and the growing interest in the country's historical places.

Figure 4.92 The inter-annual variation of number of tourists, Mongolia

The most important factor influencing the development of tourism is the regional climate condition, a natural resource that influences the choice and decision of tourists to travel.

Regarding the satisfaction of tourists, the climate condition has been identified as an essential natural resource for tourism (Hu & Ritchie, 1993; Gomez-Martin, 2005; Scott et al., 2012). On the other hand, the regional climate resources are the most critical indicators for the development of the tourism sector (Bigano et al., 2007; De Freitas et al., 2008; Mohammadi et al., 2009; Cetin, 2015) and also highly influenced on the choice of tourist destinations (Dogru et al., 2016).

Climate condition comfort index is a bioclimatic indicator that assesses the physical discomfort of people in different weather environments.

Several indices of climate comfort have been developed to express the diversity of tourism climate resources.The tourism climate index TCI (Tourism Climate Index) developed by Canadian researcher Mieszkowski (Mieczkowski, 1985) is the most widely used.

The Tourism Climate Index (TCI) is divided into five sub-indices (Table 4.26), including the most active duration time of the tourists, which is calculated with the highest weight of 40%.

Next, sunshine and precipitation variables are given the second highest weighting of 20% each and followed by daytime comfort index with 10% and wind speed with 10%, respectively.

Table 4.26 Sub-Indices of Tourism climate index

Sub index	*Used climate variables*	*TCI impact*	*Weight of TCI*
Confort index in day time (CID)	Maximum and minimum (°C) realtive humidity (%)	It represents heat confort during tourist main activities (from 12 am to 16 pm)	40%
Confort index during day (CIA)	Mean temperature (°C) and realtive humidity (%) in day time	Represents heat comfort during 24 hours.	10%
Precpitation	Total precpitation	It shows negative impact outdoor activties	20%
Sunshine	Day sunshine, hour	Positive impact	20%
Wind	Wind speed, m/s	Impact depends on temperature extreme change	10%

The following equation calculates the tourism climate condition comports index (TCI) using the above five criteria and shown values description (Table 4.27).

$$TCI = 2 \times (4(CID) + CIA + 2(precipitation) + 2(sunshine) + wind))$$

Table 4.27 The description of TCI indexes

TCI value	*Explaining of TCI*
90–100	Ideal
80–89	Excellent
70–79	Very good
60–69	Good
50–59	Acceptable
40–49	Marginal
10–39	Unfavorable
20-29	Very unfavorable
10-19	Extremely
-30-9	Impossible

Source: Mieczkowski, 1985

Here selected, the five most visited provinces by tourists coming to Mongolia (Umnugobi, Ulaanbaatar, Bayan-Ulgii, Uvs, and Khuvsgul), and the tourism climate condition comport index was calculated monthly (Table 4.28). Indeed, the duration of pleasant weather for tourism varies, caused by different climates zone. Domestic and foreign tourists usually travel in the summer because Mongolia has a "very pleasant" climate for tourism between June and August.

Four provinces are rated as "good" for the climate condition except for Khuvsgul, where the tourism can continue until September.

Table 4.28 TCI indexes calculated for five regions in Mongolia

Soum name	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Unmugobi	42	53	65	69	94	96	91	95	92	69	57	48
Ulaanbaatar	26	40	54	68	80	87	87	84	77	63	46	26
Bayan-Ulgii	24	37	53	68	82	93	91	91	73	60	41	31
Uvs	22	26	38	65	86	97	94	94	83	61	42	20
Khuvsgul	26	29	51	65	71	80	83	75	65	61	37	25

The TCI index decreased from pleasant to good in July at Dalanzadgad and Ulaangom cities related to the increase in hot days due to climate change. In contrast, the TCI index increased in the Gobi region during winter. In the future, it should be considered as a resource that the climatic conditions of the winter tourism season are entering suitable criteria (Figure 4.93).

The results of this study are the first impact assessment of climate change in Mongolia's travel and tourism and will be a basis for tourism policy documentation and adaptation.

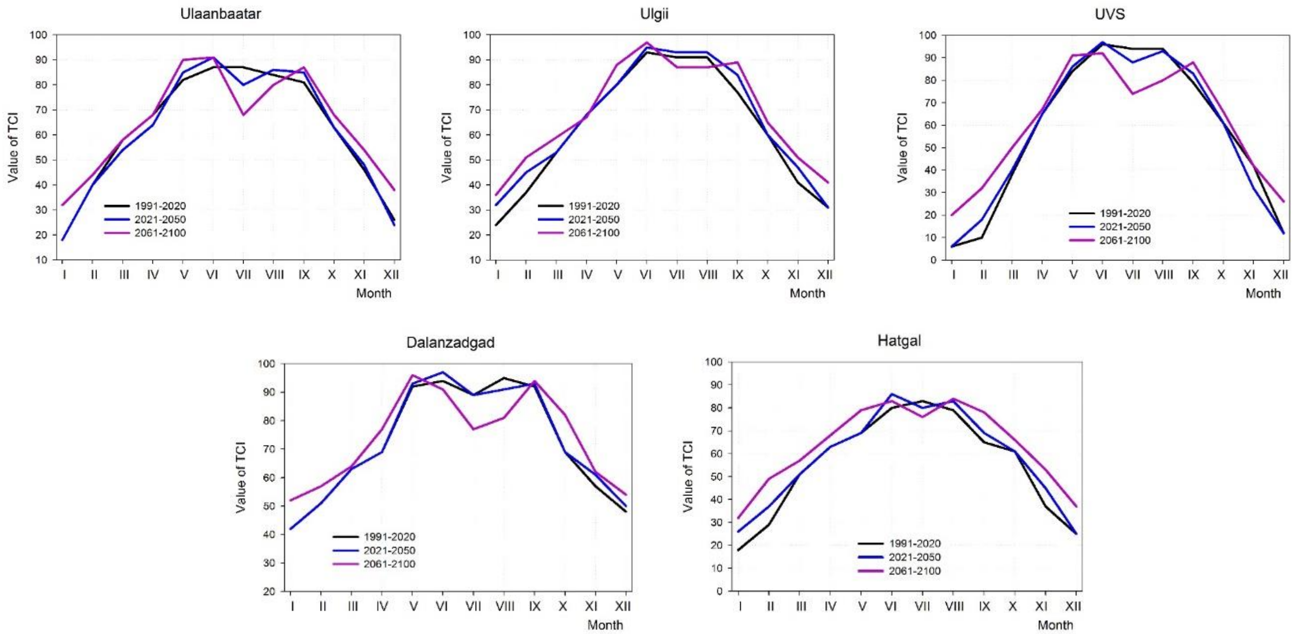


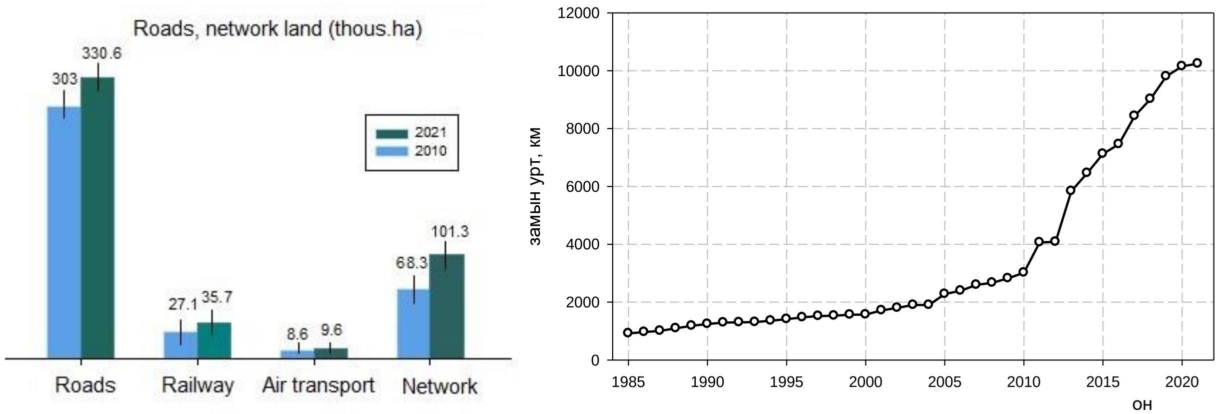
Figure 4.93 The inter-annual variation of TCI indexes

4.2.4 Infrastructure

Mongolian governments aimed to build roads and engineering infrastructure, create a healthy, safe, and comfortable environment for citizens to live in, and meet global standards within Mongolia's Sustainable Development Concept 2030 and Vision 2050 long-term development policy documents. The amount of road and network land is constantly increasing within this objective's framework due to the growing development of the infrastructure sector.

Our country's land of roads and its network line are increased from 407 hectares in 2010 to 477.2 thousand hectares in 2021. Here include 330.6 thousand ha (69.2%)of road land, 35.7 thousand ha (7.5%) of railway land, 9.6 thousand ha (2.0%) of air transport land, and 101.3 thousand ha (21.0%) of network land, respectively (Figure 4.94).

Moreover, Mongolia built 2.5 thousand km of paved roads between 1985 and 2010, and additionally, 10.3 thousand km of roads (four times more) between 2011 and 2020.



Source: NSO

Figure 4.94 Land areas (thous.ha) of roads, lines, networks and the inter-annual variation of road length, km

The expansion of roads and networks has contributed to the livelihood of citizens and the local economy. Meanwhile, many years of hard work and money have become worthless due to the frequency and intensity of disasters.

Climate change has the most significant impact on Mongolia's infrastructure sector, such as increased frequency of floods due to increased intensity of summer precipitation and mountains and valleys covered in snow due to increased snowfall days in winter, and also power, high voltage lines, and other buildings covered by wet snow during spring and autumn (MARCC, 2014).

In the last 20 years (2000-2020), the frequency of disasters has doubled In Mongolia. In addition, floods rapidly damage roads and networks due to heavy precipitation. After 1950, 54% of the observed daily intensive precipitations were accounted for after 2000 (Figure 4.95). In other words, these increasing trends of intense precipitations will highly affect the infrastructure sector's development.

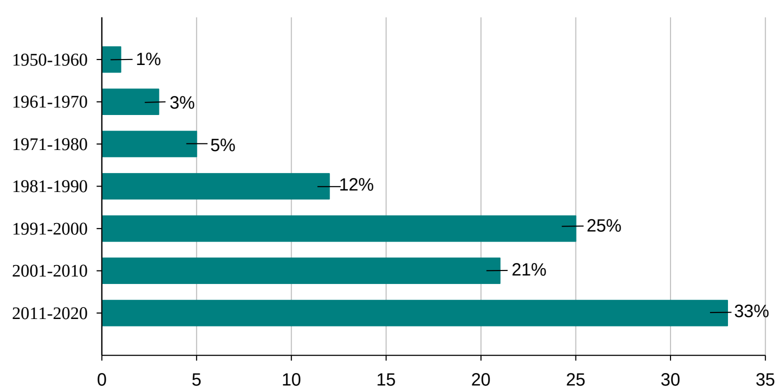


Figure 4.95 Comparison of a 10-year interval of maximum daily precipitation

Heavy rains have severely damaged many road bridges since 2000, which cannot be calculated by money. For example, on July 18, 2003, heavy rain and hail were observed during 20-22 minutes, and 28-

54 mm of precipitation fell in Ulaanbaatar. As a result, ten people died, 130 km of flood dam damaged, 300 houses and 93 ger flooded. The total damage was 300 million MNT (Figure 4.96). Also, on June 28, 2017, due to strong winds and heavy rains, two iron anchor poles, and a total of 44 poles of the 110 kW overhead power line in the Bulgan-Erdenet direction were broken and fell. As a result, 70,198 customers of 159 soums lost power (Figure 4.97).

Figure 4.96 Flood situation, 18 Jun 2003

Highway around Lun

August 22, 2021

Bulgan - Erdenet

power line in 2017

June 28

Bridge of Tes sum, Uvs province

April 23, 2016

Heavy rain, strong wind and flood cause not only damage and loss in infrastructure such as power outage, raod and bridge damage but also significant damage to country society and economy.

Figure 4.97 Examples of damages of infrastructure caused by heavy precipitation, strong wind and flood situation

One of the positive indicators of the impact of climate change on infrastructure and socioeconomics is the shortening of the firing times in household.

The thermal capacity of the building significantly depends on the outside air temperature. Therefore, the researcher G. Namkhaizhantsan determined the firing starting and ending date in Mongolia estimated based on the Russian methodology, which is still used as a technical indicator. Due to climate warming, the heating season for buildings and apartments decreased by 12 days between 1975 and 2018.

Within the framework of the sixth report, beginning, middle, and end of this century, the heating days will be reduced by 2, 8, and 20 days, respectively, based on the results of the scenario of the period with the highest emission of greenhouse gases (ssp585, AR6 IPCC) (Figure 4.98). Therefore, the reducing trends are one of the advantages of climate change for saving energy for heating.

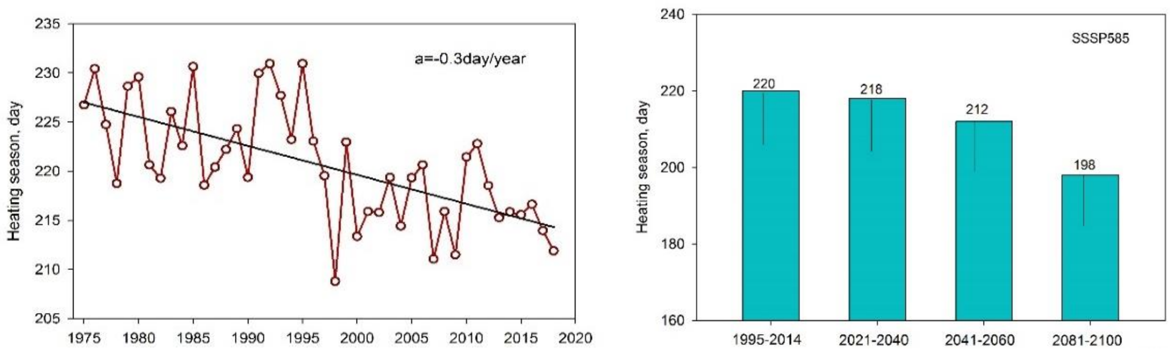


Figure 4.98 The interannaul variation average heating duration in Mongolia

In the future, it is necessary to take early warning measures to make the infrastructure sector resistant and adapt to climate change, mainly to estimate the risk of flooding roads and bridges and improve management.

4.2.5 Natural disaster

Hydrometeorological disaster and hazard. Resolution No. 286, approved by the government in 2015, included 13 types of hydrometeorological disasters based on their intensity and duration time. Due to the rapid changes in global climate change, the frequency and intensity of disasters and their damages have increased yearly. If ranked all disasters according to the damage to society and the economy, drought, forest fires, snow and dust storms, flush floods, and extreme cold events are among the main hazard pheninomena. Figure 4.99 shows a long-term variation of hazards between 1989 and 2020.

In Mongolia, in average disaster events occur 55 times a year. Here we considered the frequency of annual disasters throughout the last three decades. The disaster frequency was 29 times in 1989-1998, 53 times in 1999-2008, and 80 times in the last ten years. Additionally, windstorms, flush floods, lightning, gusts of wind, and hail are the most frequent, accounting for 21%, 21%, 14%, 12%, and 7% of the total disasters, respectively, and the rest takes less than 6%.

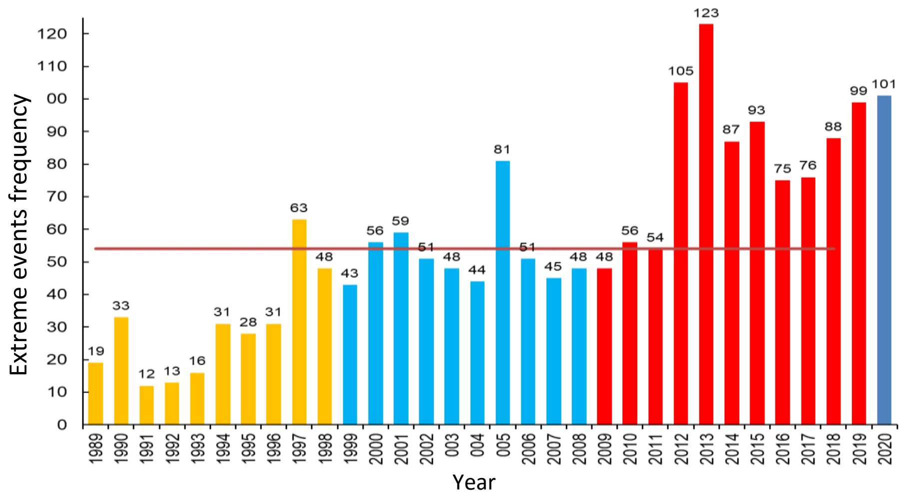


Figure 4.99 The frequency of weather-related extreme and disastrous events in Mongolia

Table 4.29 The frequency of weather-related extreme and disastrous events in Mongolia, 2000-2020

Extreme event	*Wind and storm*	*Heavy snow*	*Heavy rain*	*Squall wind*	*Shower rain and flood*	*Hail*	*Thunderstorm*	*Heat wave*	*Cold wave*	*Freeze*	*Cold rain*	*Wet snow*	*Flush flood*	*Avalanche*	*Ice clashing*
Mean occurrence /annual /	16	3	5	9	16	5	11	2	1	4	1	2	2	1	2

According to the records of the last 20 years, 54% of atmospheric-related disasters and 41% are convection-related disasters. In Mongolia, 539 people died, 29.773 million animals were killed, and 681.8 billion MNT were lost due to extreme and disastrous events from 2001-2021.

In 2010, frequent heavy snowfalls and previous summer drought conditions and severe cold weather observed during winter in Mongolia. As resulted in large numbers of livestock killed and more than 526 billion MNT of damage to the country and society, which takes 86% of the total damage.

Drought and Dzud. Drought and dzud are long lasting climate events that cause the high damage to the socio-economics of the country. There is many research on drought and dzud, and each researcher has put forward criteria for drought and dzud in their study framework. For example, L. Natsagdorj and G. Sarantuya have determined the dzud index considering the weather conditions of the summer and winter seasons. This study used dzud index to assess the long-term changes.

Figure 4.101 shows the long-term changes in the drought-summer index and wheat yield based on 48 stations distributed throughout Mongolia.The figure shows that the frequency of droughts has increased since 1995, and drought conditions have intensified. Nevertheless, most of the agricultural land in our country is unirrigated land. In other words, the annual yield depends entirely on the weather conditions.

The historically largest wheat harvested between 1981 and 1993 was associated with suitable summer conditions. However, the amount of wheat harvest has decreased since 1995 caused of the increased frequency of drought, and the lowest harvest was 75,000 tons in 2005 (Figure 4.101).

Generally, this decreasing trend depends on the weather conditions. However, on the other hand, the agricultural sector is temporarily fallen related to the social-economic status of Mongolia, which moved to a market system and privatized state-owned enterprises. As a result, the government's support for this sector has weakened.

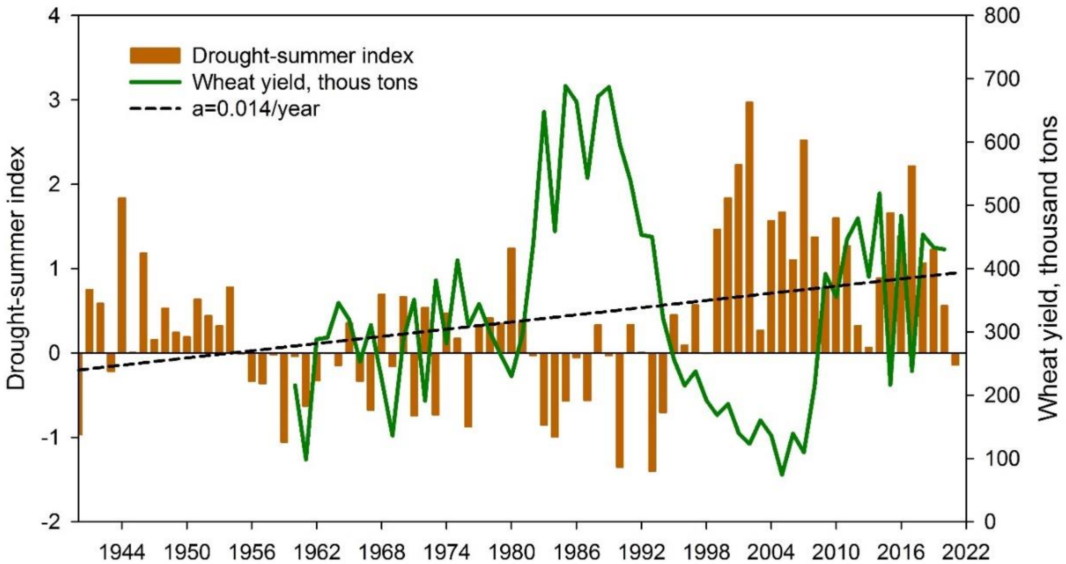


Figure 4.100 The interannual variations of drought-summer index and wheat yield

The averaged dzud index and the long-term changes in the number of livestock lost in Mongolia shown in Figure 4.102. As the figure shows, since 2000, the frequently observed dzud conditions have been highly associated with drought conditions. Additonnally, livestock mortality is one of the primary indicators of dzud conditions. About 30% of all livestock were lost during the most intensive dzud of 1943-1944. Moreover, 10% (15%) and 23% of total livestock were lost during dzud conditions (2000-2003 and 2009-2010).

In the future, it is clear that the frequency of dzud and droughts will likely increase, negatively affecting Mongolia's national security and pastoralism.

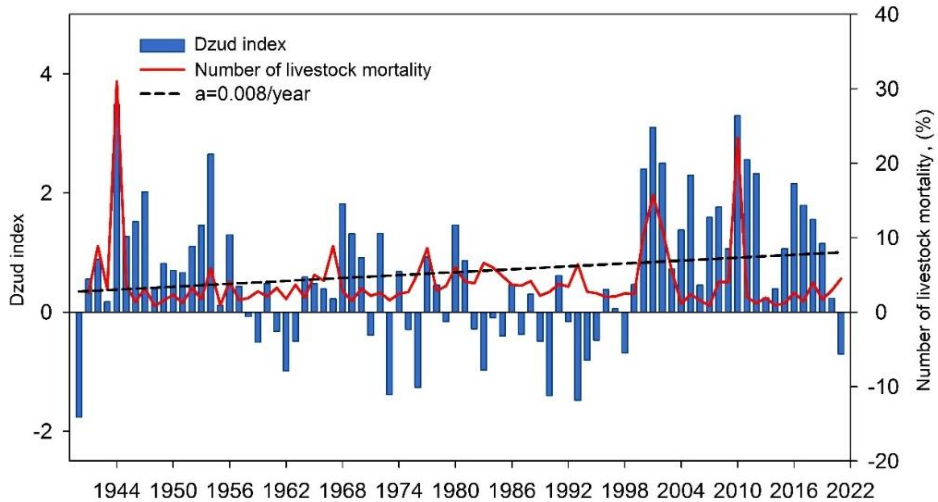


Figure 4.101 The interannual variations of dzud index and livestock mortality

Flood. According to the WMO report, flood and water related disaster is taken more than 30% in the global natural disaster loss. Disaster due to flood and high intensity rainfall is taken 21% among the mean annual total frequency of natural disaster in Mongolia (Figure 4.100 as shown prevously).

In historical record, 2 case study involved with flood were occurred due to convective rainfall on June 1982 and due to large scale precipitation on July 1966, have simulated by WRF-Hydro (Gochis et al., 2020). At the time, daily maximum discharge was measured 327 m^3/s and 976 m^3/s at the Tuul-Ulaanbaatar hydrological post as respective years (Table 4.30).

Table 4.30 Rainfall-runoff measurement in frontal and convective rainfall case study

Rive-gauging station	*Observed flood peak discharge, date*	*Duration of flooding*	*Amount of rainfall*
Tuul-Ulaanbaatar	01.Jul.1982, Qmax=327 m3/sec	28.Jun-6.Jul	21.7 mm (28.Jun)
Tuul-Ulaanbaatar	12.July.1966, Qmax=946 m3/sec	10-24.Jul	19.9 mm (10.Jul) and 74.1 mm (11.Jul)

During flood in 1966, the total direct and indirect damage of the flood was estimated as 135.4 million MNT (directly 125.2 million MNT and in direct way 10.2 million MNT), 38 organizations in many ministries and departments was suspended for 5-29 days. The sub-commissions noted that 4.3 million MNT was allocated from the state budget for the reconstruction of roads, bridges, dams and buildings, and finally the total of this flood was estimated to be 300 million MNT (rate to USD was different than at present).

Severe flush flooding event was occurred in Chingeltei and Khailaast district, northern Ulaanbaatar in 1982 and brought huge damage, loss and mortality. The convective rainfall have produced 44 mm rainfall within the 30 minutes. This rainfall amount which occurred within 30 minute was equal to 85% of whole August month's sum of rainfall in the Ulaanbaatar area. Human death was reached to 87 and, 119 and 92 families lost their shelters and properties as completely and partially as respectively. Totally 31 government and private organizations suffered from this flash flood in different ways, damaging and losing their properties. About 252 families are relocated from the flood prone areas. Total direct damage of this flash is estimated to be 13.9 million MNT and another 17.8 million MNT spent for flood recovery (D.Oyunbaatar, 2016).

In Ulaanbaatar region, the WRF-Hydro model has selected 30x30m spatial resolution over territory of Ulaanbaatar region, which is 10 times finer than the weather model. From the 30m resolution DEM data, input grid data of topography, surface flow direction, accumulated flow and stream order of river and channels have estimated for selected domain of the WRF-Hydro model. These hydrological geogrid data have prepared and configured by the GIS system for running of the WRF-Hydro model.

The results from above simulation were interpolated to the Tuul-Ulaanbaatar hydrological post point location and flow change are shown in Figure 4.102 together with simulated rainfall by weather model on hourly base.

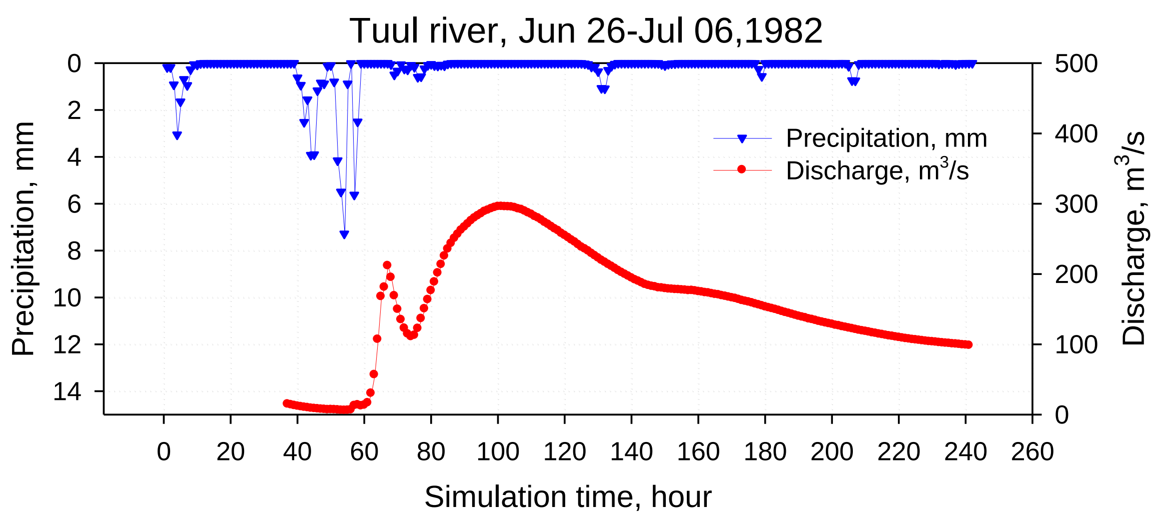


Figure 4.102 Simulated runoff and rainfall at the point of hydrological station at Tuul river (in terms of timing and magnitude) from 28th of June to 6 of July, 1982.

Simulation outputs of runoff and rainfall of the model on hourly base converted into daily mean and compared with observed values. Comparison results show that flood case of 1982 reasonable well simulated at the Tuul-Ulaanbaatar hydrological station. Amount of accumulated rainfall in first 60 hours was 51.3 mm and after around 6 hours runoff comes to the Tuul river channel and continues to increase and after another about 2 hours two flood peak discharge have been observed in the Tuul river. The maximum flood peak with value of 296.1 m^3/s have been observed after approximately 40 hours and then gradually decreased. For example, the correlation coefficient of the observed and modeled runoff is 0.84, the absolute error is 18.2% and the maximum flood well coincides with the observed value in terms of time and magnitude (Figure 4.103).

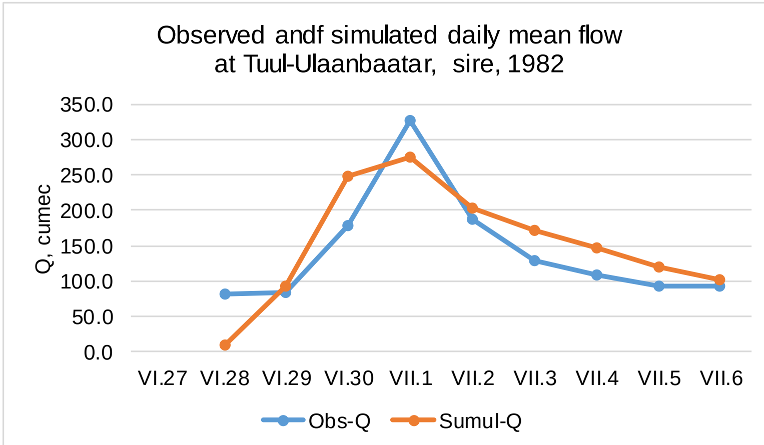


Figure 4.103 Simulated runoff and rainfall at the point of hydrological station at Tuul river (in terms of timing and magnitude) (from 28th of June to 6 of July, 1982)

According to the spatial distribution map of flood of 1982 produced by the model outputs, the maximum flood discharge is shown in Figure 4.104. In the further, we are going to select the 1982 floods and re-calculate the flood discharge of 1966 by increasing rainfall (sensitive method) and assess the impact of future climate change on flooding by considering above simulated flood as the current flood with 100 year return period.

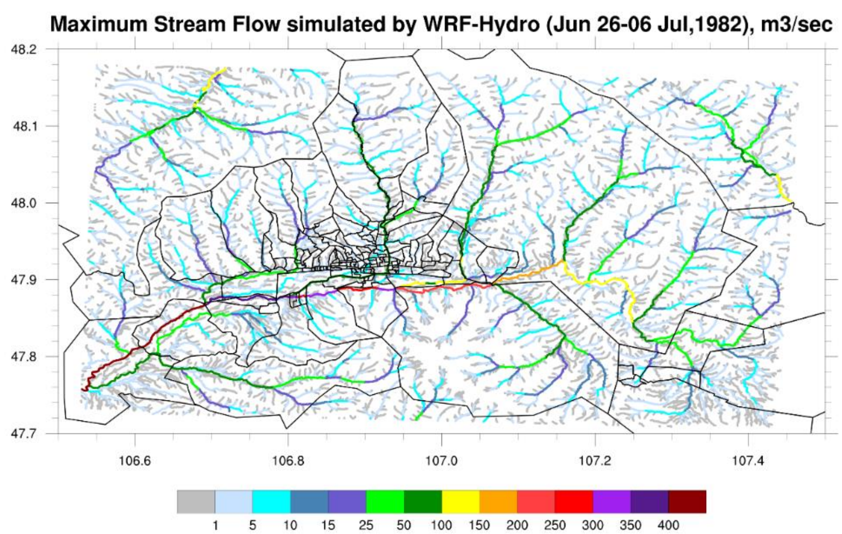


Figure 4.104 Spacial distribution of daily maximum flow

Daily maximum precpitation will be projected to incerase by 26% in 2030, 41% in 2050 and 53% in 2080 according to dymamic downsaling of RegCM4-HadGEM2 output as removed bias error daily precipitation (FRUGA, 2020). Since the results of flood case simulation of the 1982 by WRF-Hydro flood model are consistent with observed value, the flood of 1966 is simulated as case by increasing the rainfall amount (sensitive analysis) according to the future climate change project.

According to the our modelling results, about 24.9 km^2 area of the ger district of Ulaanbaatar city is expected to be inundated by the flood water under flooding condition of 1966 and inundation area will be increased by 12.5% in 2030, 20.8% in 2050 and 28.7% in 2080, respectively, due to the expected increase of daily rainfall in the future climate change projection.

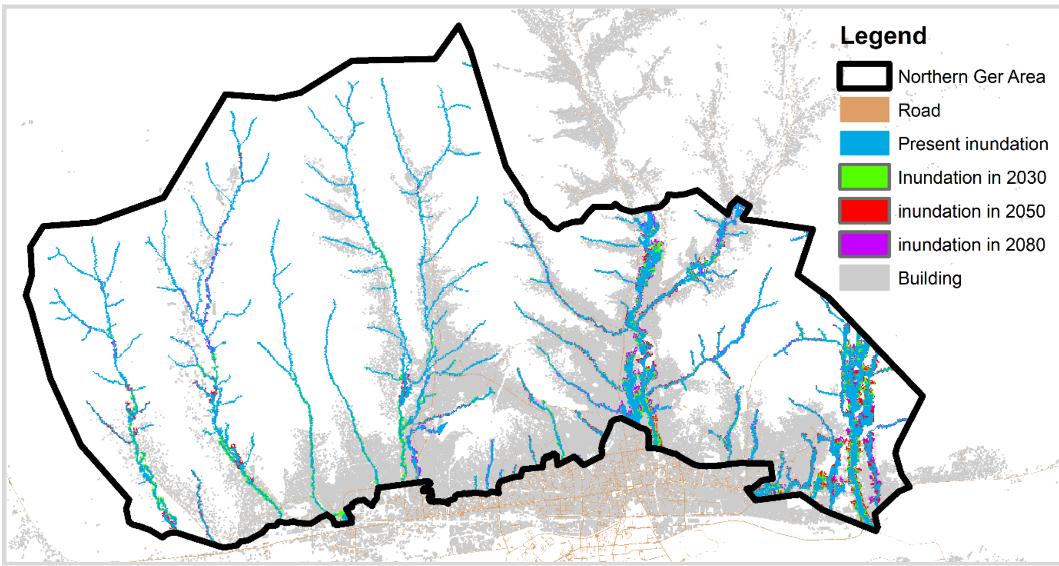


Figure 4.105 Current flood hazard map and future flood risk map of northern part of ger area of Ulaanbaatar city

Forest fire. The long-term trend of frequency of forest fire recurrence is shown in Figure 4.106. In Mongolia, forest fires occur an average of 172 times a year. These fires are the main factor in the depletion of natural resources and significant economic losses. For example, in 2020, there were 121 forest fires in Mongolia, and 225,874 hectares of land were burned, causing a loss of 161 million 700 thousand MNT (MET, 2020).

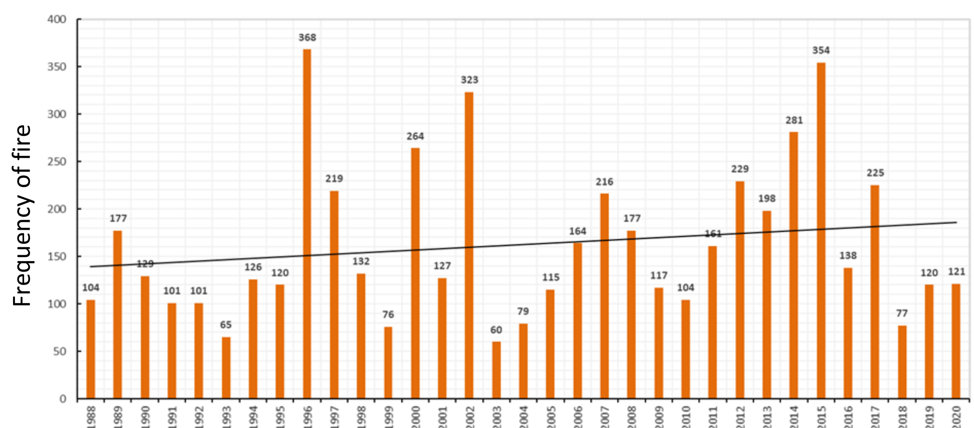


Figure 4.106 The frequency of wild fire in Mongolia

Forest and field fires are natural disasters caused by climate change and human activities. Especially when the fire risk increases depending on the season, it is the second largest disaster after dzud and drought because it causes significant damage and harm to nature. In this regard there are urgent need to analyze fire risk for nature, animals, and biological diversity and to develop more effective plan of preventive measures.

In Mongolia, the regions with a high risk of wildfires include the majority of forest resources, the critical central locations of wetlands, and the main areas of endangered migratory birds.

Therefore, reducing, preventing, and accurately estimating the risk of fires is very important not only for the country but also for the ecologically sensative regions of the world.

This study used the MaxEnt (Maximum Entrophy) model based on machine learning, fire point data from the Mongolian-Soviet Comprehensive Study, and low, medium, and high greenhouse gas emissions (ssp1- 2.6, ssp2-4.5, ssp5-8.5, AR6 IPCC, 2023) model results.

Based on model estimations, the focal (hot) risk area of wildfires in Mongolia is 105,932.05 km^2, and the area at risk of spreading is 458,095.11 km^2 (Figure 4.107). Additionally, the change in the area of the future hot risk will remain almost unchanged in 2021-2040 under the average greenhouse gas scenarios, but there is a risk of increasing by 1%-9% between 2041-2100 (Table 4.31).

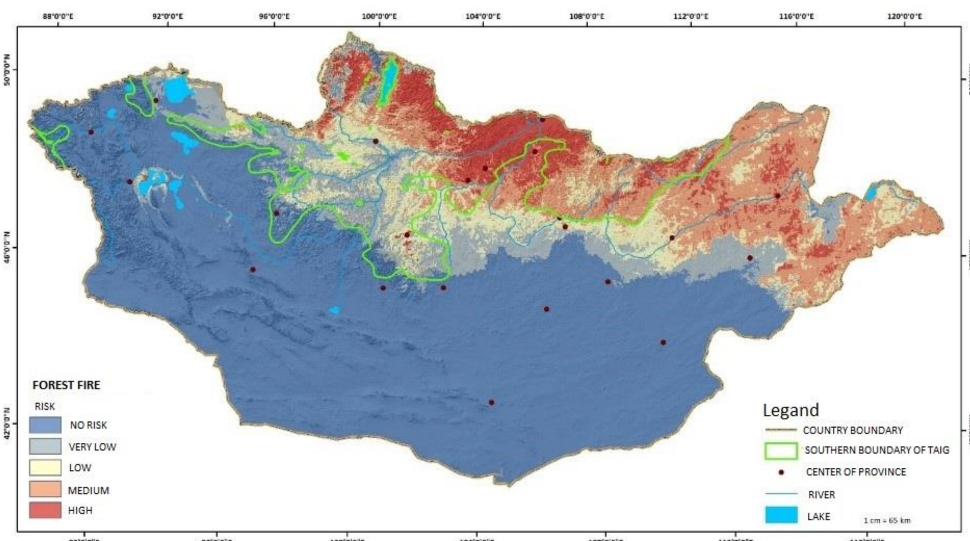


Figure 4.107 The hotpots area of wild fire risk in Mongolia

Table 4.31 The changes hotpots area of wild fires in Mongolia

Year and scenario	*Area of fire risk, км^2*			
	ssp1-2.6	ssp2-4.5	ssp5-8.5	*Average*
1970-2000	105,932.05 km^2			
2021-2040	108,997.8	110,626.3	96,019.5	*105,214.5*
2041-2060	109,679.0	117,888.4	101,100.6	*109,556.0*
2061-2080	120,507.5	114,011.9	113,577.2	*116,032.2*
2081-2100	109,300.7	110,386.1	101,476.1	*107,054.3*

Dust storm. Dust storms degrade the fertility of the soil surface layer, as well as have a long-term influence on soil erosion, sand migration, and desertification.

According to observational data obtained for dust storms at meteorological stations between 1960 and 2000, the number of dusty days in Mongolia increased 3-4 times per year (L. Natsagdorj, 2017, D. Jugder, 2006). A significant increase during the 2000s has been observed in the southern portion of the central and eastern region, as well as the northern portion of the Gobi, when data up to 2020 are combined. Particularly, starting from beyond Altai and the southern Gobi and the central region, the number of dust storm days around Bulgan in Khovd, Zamiin-Uud in Dornogobi, and Dalanzadgad in Umnugobi has been decreasing in recent years, whereas those in Mandalgobi, Choir, and Bayan have dramatically increased. Dusty days has decreased in the north part of the eastern region, although it has increased significantly in the southern part, in Sukhbaatar province. As for the western region, the number of days of dust storms has been increasing in the Gobi-Altai and Bayankhongor regions in the last ten years (L.Natsagdorj, 2017).

One of the causes of land degradation is the changing number of days of dust drifting (L.Natsagdorj, 2017). The vegetation cover on degraded land will be decreased, and dust will be released into the air and transported far distances. Based upon the findings of obtaining the threshold wind speed value for dust emission using meteorological observation data from 1999 to 2016,mean threshold wind speeds for dust emission with the 30, 50 and 70 percentiles averaged by 118 stations were 8.8 m/s, 10.2m/s and 11.7m/s, respectively, while it was 10.3m/s, 12.1m/s and 13.9m/s for wet years (Baljinnyam. N and Jugder. D, 2016, 2021). Wind speed, vegetation cover, soil surface characteristics, and soil moisture are the key elements determining the occurrence of dust storms. Hence, threshold wind speeds for wet, normal and dry summer years were classified into various natural zones. Threshold wind speeds were 11.0m/s - 16.2m/s for the high Mountain region, 9.2m/s - 14.7m/s for the forest steppe and steppe regions, 9.0m/s - 13.3m/s for the Desert steppe (Gobi) region and 8.2m/s -12.4m/s for Desert region (Figure 4.108).

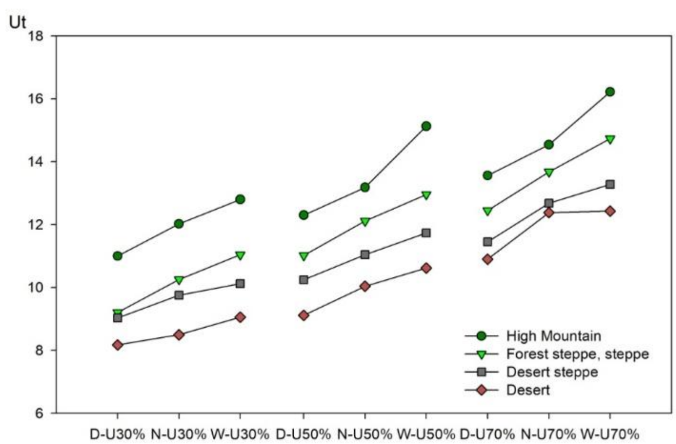
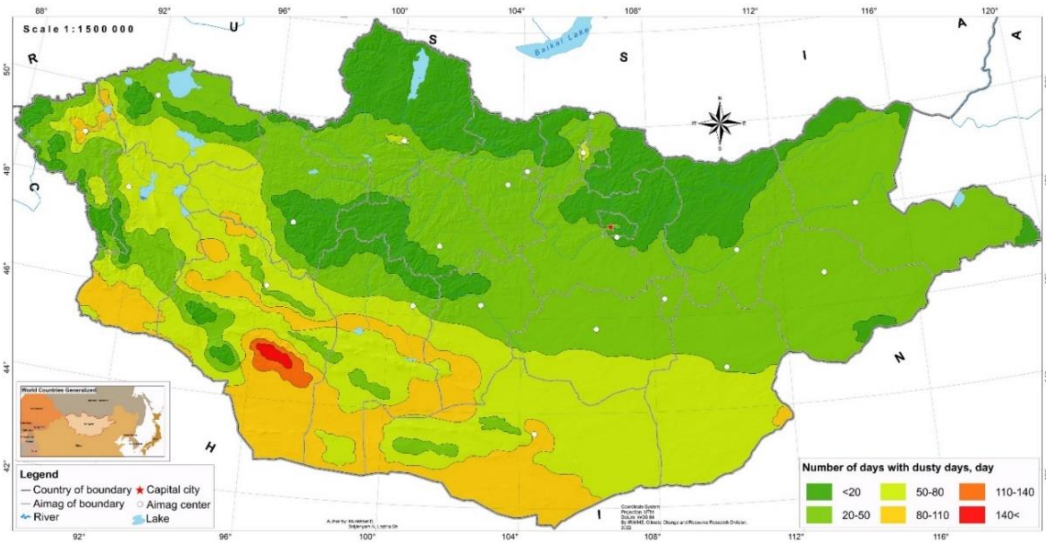


Figure 4.108 Mean threshold wind speeds with the 30, 50 and 70 percentiles for dry (D), normal (N) and wet (W) summer years in 2000-2017 by various natural zones over Mongolia

Figure 4.109 demonstrates the spatial distribution of Mongolia's dusty days (combined days with dust storms and dust drfting days) determined from last 30 year data (1991-2020). The number of dusty days is less than 20 in mountainous Altai, Khangai, Khuvsgul, and Khentii regions, more than 50 days in Gobi and Desert regions, and the Great Lakes depressions, and more than 110 days in regions Altai's Inner Gobi and Mongolian Sands areas.



Source: N.Baljinnyam, B.Munkhbat, 2022

Figure 4.109 Spatial distribution of dusty days in Mongolia

Dust storms form within a few meters of the surface, however finner dust particles are transported higher in the troposphere by strong wind across thousands of kilometres. In recent years, the visibility of distant objects has diminished dramatically when there are dust storms, and this has led to a decline in visibility. A variety of historical data and facts that have been observed for a long time suggest that dust storm is one of the effects of land degradation and desertification (Figure 4.110).

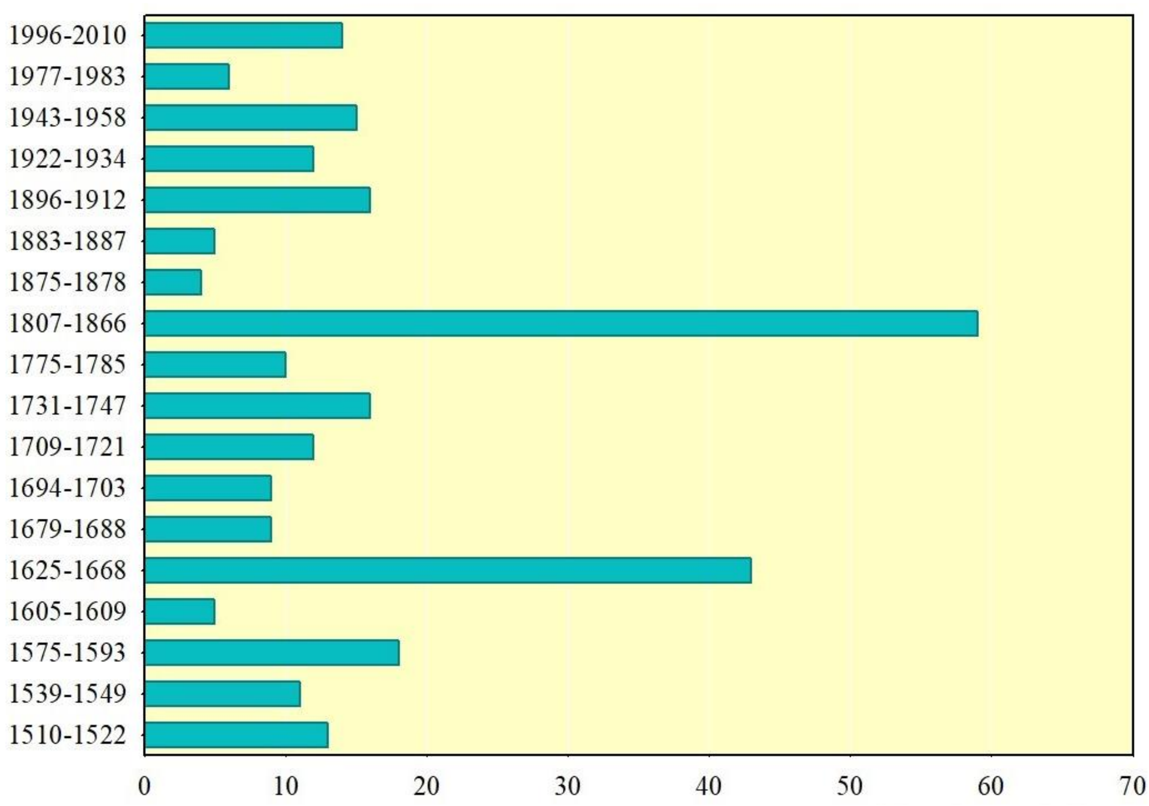
Figure 4.110 a) Dust storm observed on the 14-15th of March, 2021 covering the entire territory of Mongolia, b) a dust storm observed in Sainshand, Dornogobi, on 10th of June, 2022

Poverty and livelihood. According to a joint study by the National Statistics Office of Mongolia (NSO) and the World Bank (WB), the Mongolia's poverty rate was 28.4% in 2018 and 27.8% in 2020, which is a very high rate in the world.

Generally, population's livelihood source and poverty level highly depend on weather conditions. In other words, the main economic sectors of Mongolia, such as energy, animal husbandry, agriculture, and road transport sectors are directly dependent on weather and climate conditions.

The historical documents mentioned that natural disasters such as drought, dzud, flood, windstorm, sandstorm, and dust storm had caused many difficulties for Mongolian people, especially, herder's livelihood since ancient times (History of the Republic of Mongolia, 2003).

R. Mijiddorj and D. Dulamsuren studied the climate effect on Mongolian nomadic migration when the precipitation was above or below the average. According to their study, capital of Mongola was migrated several times in 1625-1668 period (Figure 4.111). For example, capital was migrated 29 times along Orkhon, Tamir and Tuul river valleys since 1639. Finally, it was settled in the current place was named "Ikh khuree". The main reason of migration is may be to related to pasture degradation due to drought and dryness.



Source:P.Mijiddorj,. 2021

Figure 4.111 The duration period of drought

Recently, during the last dry period in 1996-2007, many agricultural enterprises collapsed and unemployment and poverty have increased lead to an increased and migration to the cities and settlements. It overlapped with the migration of herder families and pastoralists to urban areas (R. Mijiddorj et al., 2021). On the other hand, according to some researchers, it has been reported that during the years of severe drought, herders who lost their animals migrated to cities (R. Mijiddorj, 2012; T. Chuluun et al., 2012; M. Altanbagana, 2011; Ch. Bayanchimeg et al., 2012). Acccording to these research works, in 1999-2000 there was severe drought in the summer followed be a heavy snow in the winter and as a consequence about 2,400,000 animals died (which is accounted 91.7 billion MNT at the local market rate), and more than 2,300 herder families were left with less than 100 animals, consequently and livilhood has fallen dramatically. More than 10 million head of livestock were lost during these three years with consecutive droughts between 2000 and 2002. Also, over 10 million head of livestock (23% of the total livestock) were lost during dzud in 2010, and herders who had less than 200 animals were lost all their animals and were affected by poverty.

Therefore, after the drought of 2000-2002, herders who lost their herds began to move to the city settlement, and it is reasonable to see that the number of people who moved to Ulaanbaatar increased in 2003 and 2004 and reached 40,000-60,000. Also, during 2009-2010 dzud, the largest number of livestock was lost in the history, and it coincided with the number of people who moved to Ulaanbaatar (Figure 4.112a). Thus, these natural disasters such as drought and dzud that have occurred in the agricultural sector since 2000 have had severe impact on herders faimly, their livelihoods, and unemployment and poverty have been increased in rural areas. In other words, the poverty rate in rural areas sharply increased to 43.4 in 2003 and 49.6 in 2010, which is a very important indicator for impact of dzud (Figure 4.112b).

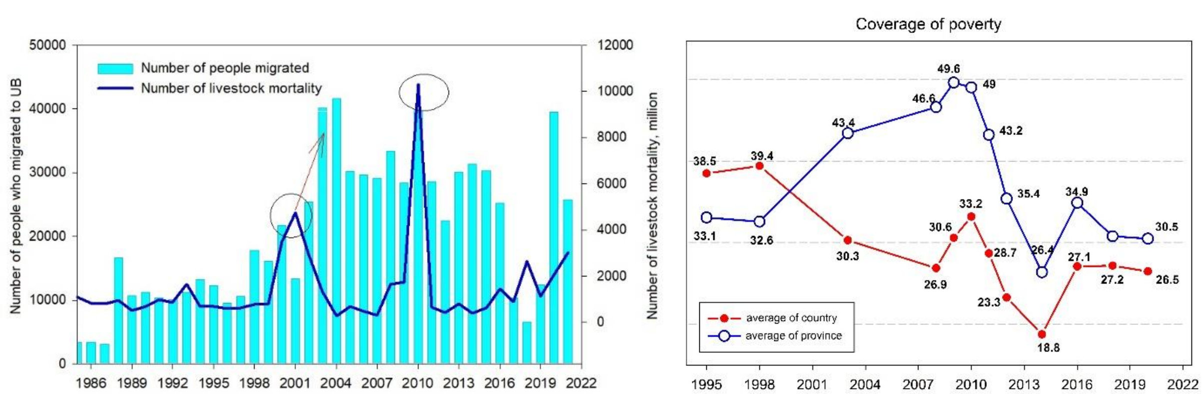


Figure 4.112 a) The comparison of the number of people who migrated to Ulaanbaatar city and the number of livestock deaths b) The interannual variation of poverty

In the sixth report of the IPCC noted that, 32-132 million people will be affected by extreme poverty in the next ten years due to climate change (IPCC, 2023).

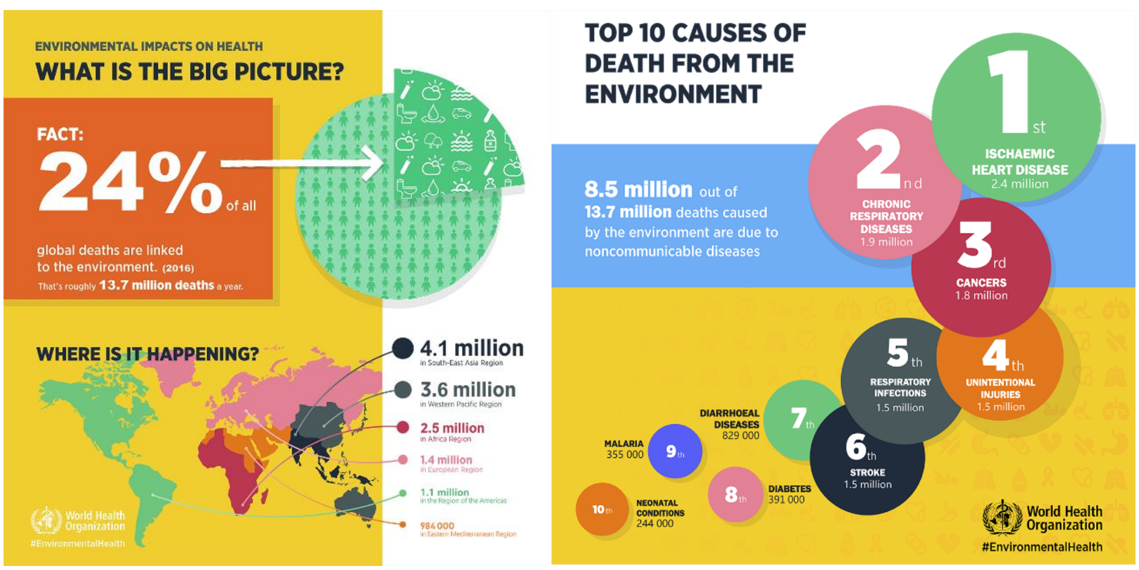
According to future climate projections, due to the intensity of drought and dzud, the livestock death will increase by 4.3% between 2011 and 2030, and 10% between 2046 and 2065, (L. Natsagdorj et al., 2011). Therefore, herder's households with less than 200 animals (42.3% of all herding households) and the middle-income households with 201-500 animals (34.4% of all herding households) have a high risk of poverty during the harsh winter. It is clear that thousands of people left their settlements and migrate to survive and prevent poverty caused by the increasing frequency and severity of natural disasters caused by climate change.

4.2.6 Public health

One of the main consequences of the adverse effects of climate change on society is the human health. The adverse effects of climate change threaten quality of air and drinking water, food supply, livelihoods, and safe housing, which are essential for human and public health.

For example, according to the AR6, IPCC 250,000 people will die prematurely from malnutrition, malaria, and heat stress between 2030 and 2050. In addition, direct health costs are estimated as $2-4 billion by 2030.

In the world, 12.6 million people die annually, and 1 person in 4 people (23%) die prematurely from diseases caused by the changes in the environment (Figure 4.113).



Source: WHO, https://www.who.int

Figure 4.113 Environmentally related deaths and it`s causes

Mongolia's health sector belongs to the WHO's Western Pacific region, which has a high rate of premature mortality due to environmental health.

In the Sustainable development concept - 2030 of Mongolia adopted by the Great Hural of Mongolia on February 5, 2016, was noted to increase the national capacity to adapt to climate change and strengthen the system to prevent dangerous weather phenomena and natural disasters in three stages as follows:

- Level I (2016-2020): Develop and implement climate change adaptation strategies, strengthen disaster risk management capabilities, improve the system for monitoring, early detection, and warning of potential natural disasters, and improve people's knowledge of adaptation and disaster protection.
- Level II (2021-2025): Implementing reference projects of good practices for adaptation to climate change.
- Level III (2026-2030): Mitigate the consequences of climate change and land degradation and reduce disaster risk.

Total of 12 laws have been implemented in the environmental health sector: health, hygiene, air pollution fees, water, waste, environmental protection, land, urban water supply, sewerage use, and minerals. However, there are no specific provisions for protecting human health affected by climate change.

According to the order of the Ministry of Health No. A/404 of 2011, the "Strategy to mitigate and adapt to climate change and protect human health," was implemented in 2011-2015.

Also, in the national program "Environmental Health" approved by the Government of Mongolia, Resolution No. 225 of 2017, the goal of strengthening the capacity to respond to threats and risks to human health caused by climate change has been put forward and implemented. During this period, the Ministry of Health successfully organized five national symposiums regarding climate change and health.

Stroke, heart disease, accidents, and respiratory diseases are the leading factors of death caused by environmental factors (Figure 4.114).

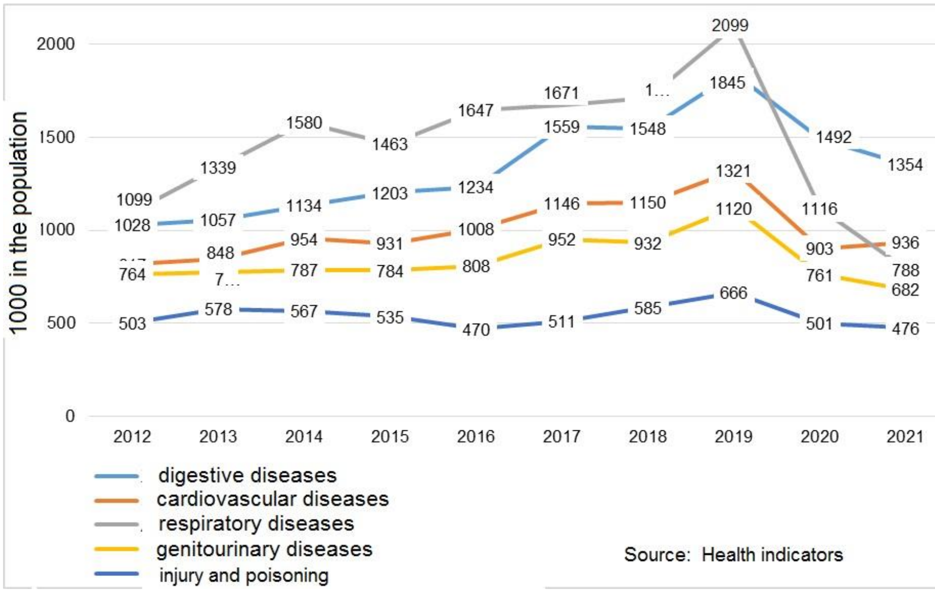


Figure 4.114 High ppriority of five reasons of human disease in Mongolia, 2012-2021

In Mongolia, diseases of the digestive, cardiovascular, and respiratory systems and injuries that are the leading causes of diseases, highly dependent on the environment. For example, cardiovascular diseases account for 11.1% of all diseases. Cardiovascular diseases are higher in women who live in Khangai, Central, and Western regions, have increased in the 15-44 age group compared with 2012 and decreased in the age group over 50.

The 4th objective of the National Environmental Health Program, approved by the Government of Mongolia (Resolution No. 225 of 2017), is to strengthen the capacity of response to threats and risks to human health caused by climate change. Within the framework of the program,it was successfully organized meetings with a participitation of 40 organizations regarding issues of Climate Change-Adaptation under the WHO fundings.

The following research results associated with public health and climate have been published :

- Climate change –human health, 2009
- Public knowledge and attitudes about climate change, 2011
- Climate change-water quality and availability-health, 2012
- Regional characteristics of climate change-health, 2010-2012
- Mosquito surveillance survey, 2011-2015
- Climate Change and Zoonotic Infections, 2018
- Outlook for Asthma, 2019
- Climate change-water quality and availability-health, 2020

Climate change-health in 2009 study found that there is a high probability of an increase in mortality of the population, especially cardiovascular diseases due to heat wave and high air temperature (MoH, 2010). Figure 4.115 shows the dynamics of cardiovascular diseases from 1974 to 2021.

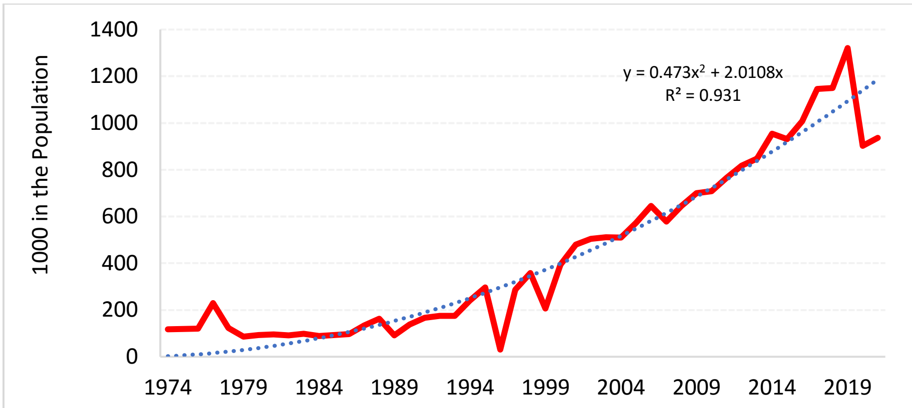


Figure 4.115 Diseases of the cardiovascular disease per 10,000 populations, 1974-2021, Mongolia

The Public Health Center has done survey in population's knowledge and attitudes towards climate change with fundings from the World Health Organization in some provinces (Figure 4.116).

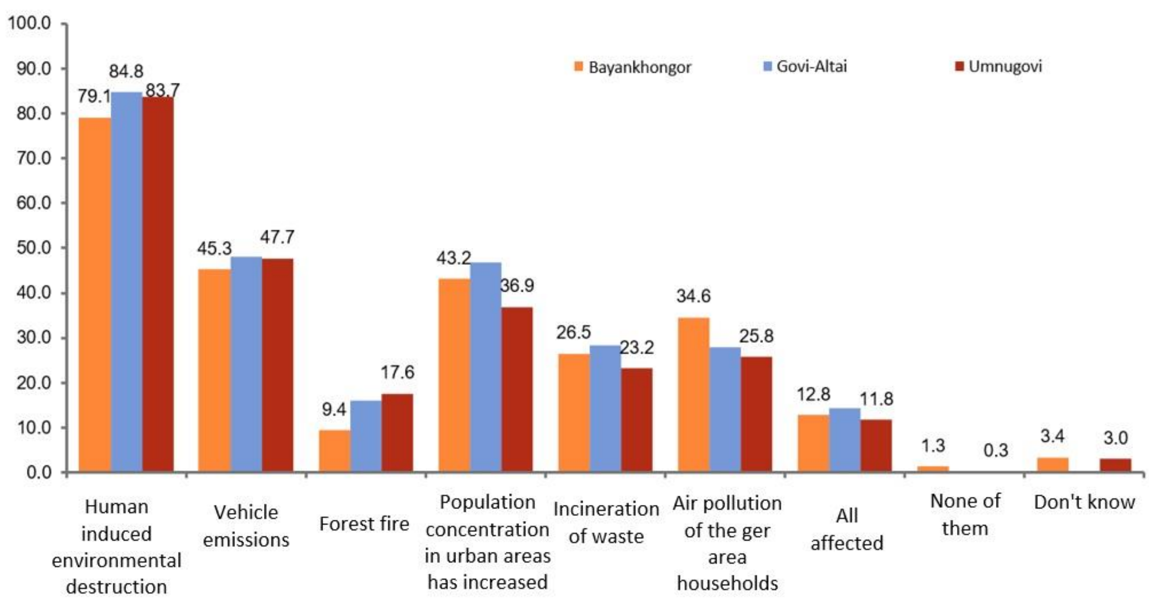


Figure 4.116 The situation of collected data and information in the countryside

The survey results showed the highest votes for living environment degradation due to climate change. In detail, it accounted for desertification (56.3%), increased frequency of strong winds and dust storms (43.1%), drying up of rivers and, changes in precipitation (33.8%), water pollution, changes in air temperature, soil degradation, and deforestation (27.6%). The 94.2% of the participants believe that climate change will harm human health (MoH, 2012a). However, participants needed more knowledge, attitudes, and practices regarding how it has been affected (which organ systems are affected) and how to adapt.

Except "Analysis of the Impact of Climate Change on Children" study conducted in 2018 supported by the United Nations Children's Fund, there has not been much progress in studying the consequences of climate change and its impact on human health.

Some progress made within the three actions framework, the nine activities were planned to strengthen the capacity to respond to threats and risks to human health caused by climate change following the order of the Minister of Health No. A/349 and the action plan for implementing the Environmental Health Program in 2021-2024.

The results of international research show that climate change will harm human physical and mental health, reduce the availability and quality of healthcare services, and exacerbate inequality in this sector.

Therefore, it needs to include preparedness plans for assisting vulnerable groups such as those far from the hospital, mining, construction workers and people with chronic respiratory and cardiovascular diseases, the elderly, children, disabled people, and homeless.

Climate change and dissease. Climate change-water quality, availability-health research (MoH, 2012b) has been conducted in 2012 (Figure 4.117).

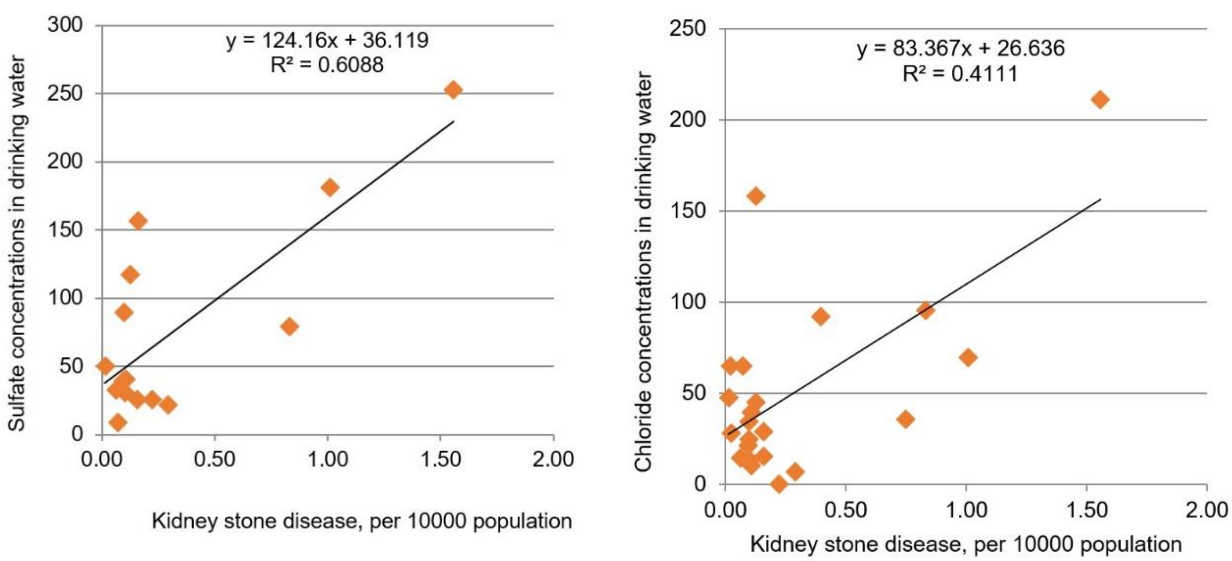


Figure 4.117 The correlation sulfate and chloride concentrations in drinking water and kidney stone disease

The health incedents have been highly occurred in Saikhandulaan, Ulaanbadrakh and Zamyn-Uud soums in Dornogobi province, Bayanjargalan and Ulziit soums in Dundgobi province, and Manlai and Tsogtsetsii soums in the Umnugobi province, respectively (Figure 4.118).

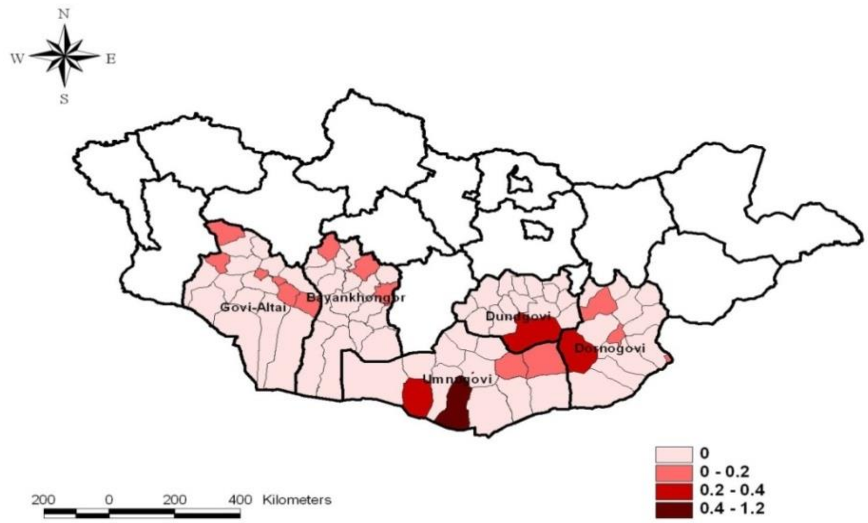


Figure 4.118 The distribution of kidney stone disease.Source: MOH, WHO, KOIKO, 2011-2012

Diarrhea and dysentery are significantly correlated with rainfall period (r=-0.8, p=0.01) and temperature (r=0.8, p=0.01) (Figure 4.119).

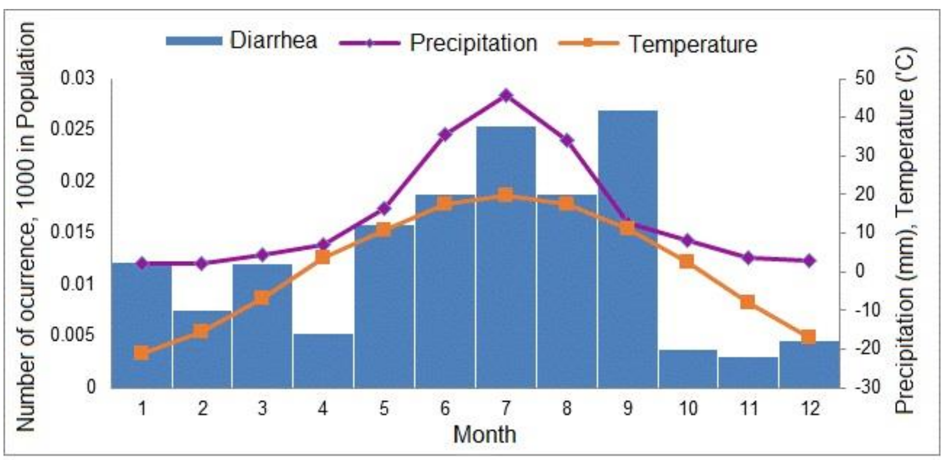


Figure 4.119 Correlation between diarrhea and infectious diseases, rainfall and temperature

In Mongolia, in 96% of human cases of anthrax, marsupial plague, rabies, malaria, dengue, West Nile fever, leprosy, and tick-borne infections were recorded. In 2005-2017, 1,728 cases reported were tick-borne infections, of which 287 (16.6%) were tick-borne encephalitis, 1,247 (72.2%) were tick-borne rickettsiosis, and 194 (11.2%) were tick-borne borreliosis. It has been found that the number of ticks is weakly inversely related to air and soil temperature, and moderately positively related to air humidity and precipitation. Thus, it was determined that the incidence of tick-borne encephalitis is moderately correlated with air temperature and rainfall (r=0.59) as the number of ticks increases. There is a direct strong correlation (r=0.78) with an increase in the number of of tick-borne and an increase in infections of population (Figure 4.120).

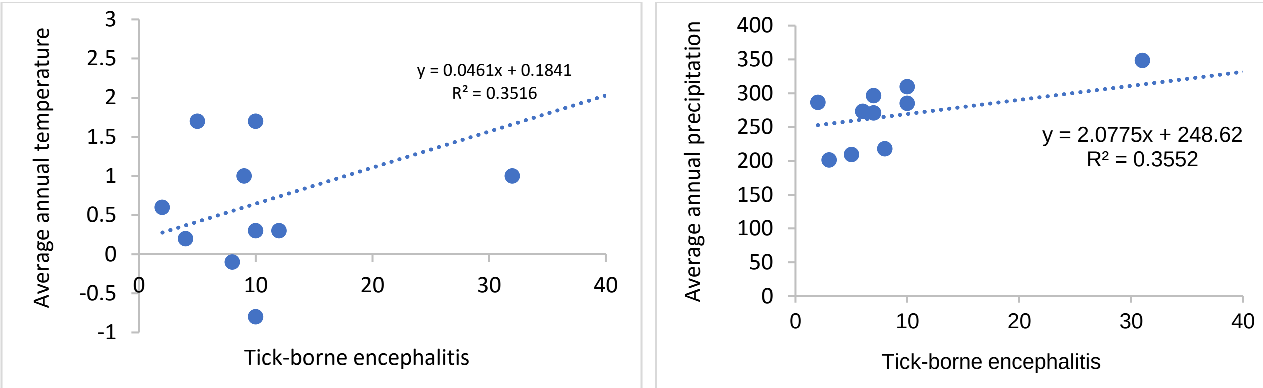


Figure 4.120 The relationship between tick-borne encephalitis and temperature and precipitation

By comparing tick-borne diseases associated with air temperature, drought indicators, and the number of fires, the number of suspected tick-borne infections registered nationwide will increase to 1,600 and confirmed cases to 600 in 2040. It was calculated that the drought indicator of central regions has a strong positive correlation with the number of tick-borne cases (r=0.7), the average air temperature of Selenge province has a moderate positive correlation with the number of tick-borne cases (r=0.59), and also a weak positive correlation with the number of fires (r=0.37). The researcher concluded that some climate parameters, specifically, influence the spread of ticks and tick-borne diseases (MoH, 2015a).

From 2011 to 2015, the Center for Zoonotic Disease Research selected 11 soums of 4 provinces, such as Selenge, Khovd, Dornod and Uvs, and 2 districts of Ulaanbaatar city, in the west, east, and central regions with more number of rivers and lakes. The researcher concluded that some climate parameters influence the spread of ***Anopheles, Aedes and Culex*** (MoH, 2015b) (Figure 4.121).

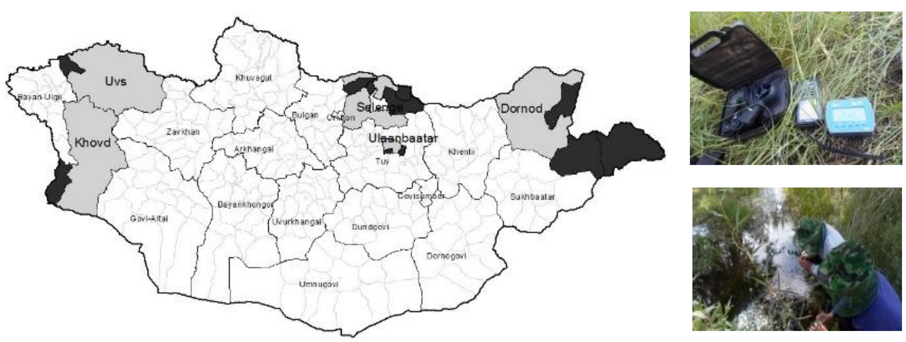


Figure 4.121 Mosquito surveillance in some soums and provinces

Research has shown a relationship between the activity and/or number of mosquitoes and some climatic parameters (air temperature and humidity). For example, mosquito activity peaks between 07-09 a.m. in the morning and 18-20 p.m. in the evening, when there is a high humidity and low wind speed. The researchers found a weak positive correlation between the number of mosquitoes and air temperature and relative humidity (Figure 4.122).

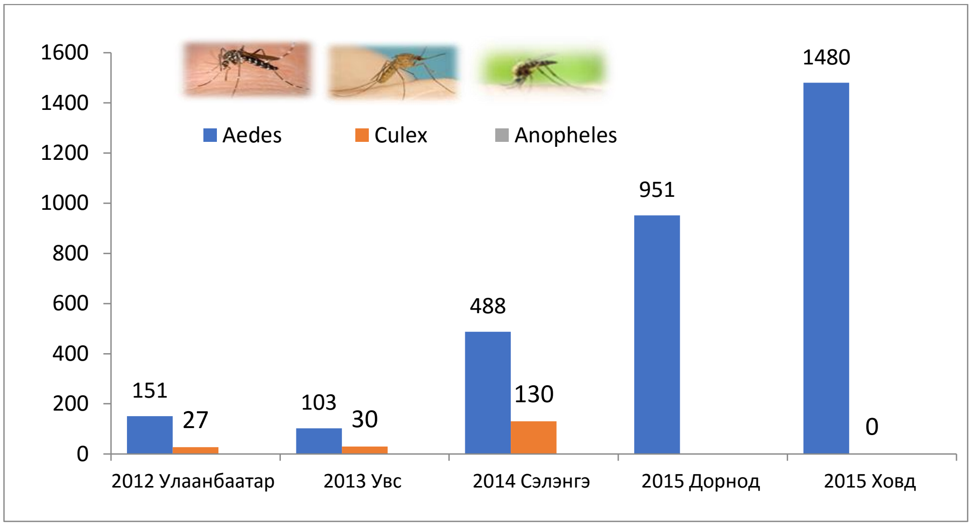


Figure 4.122 By mosquito type and area studied

West Nile fever, Japanese encephalitis, and Dengue infection have been found in mosquitoes spread in Mongolia, and some cases of some mosquito-borne diseases have been recorded.

In Mongolia, cases of human diseases transmitted by mosquitoes have been registered. In 2014, a new study was conducted regarding the relationship between natural marmot plague and climate warming at the Deren soum of Dundgobi Province, Ikhtamir soum of Arkhangai Province, and Tonkhil soum of Gobi-Altai Province, respectively. The study result shows that natural marmot disease is weakly correlated with the average annual temperature (r=0.33) and precipitation(r=0.28), respectively.

The drought will intensify according to future projections (the total annual rainfall will increase by no more than 20%, and the temperature will rise to 5.9°C). As a result, the number of plant species will decrease caused to dryness, and then the number of human diseases related to marmots will be reduced (Figure 4.123).

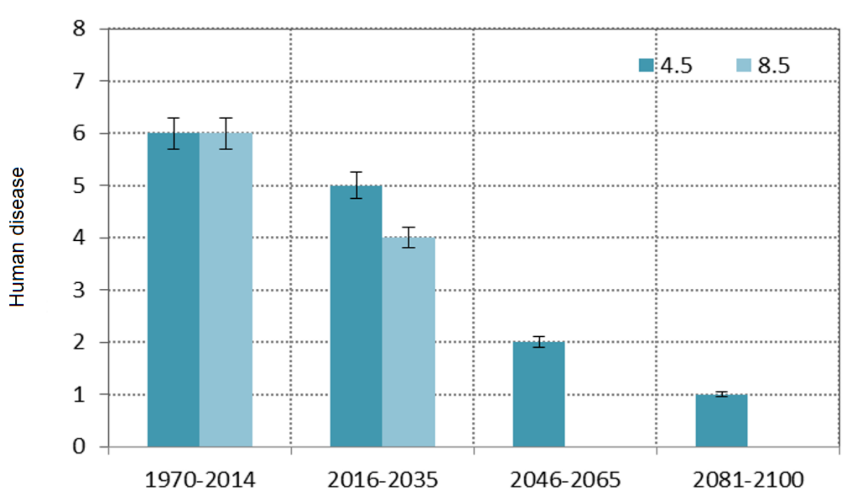


Figure 4.123 The calculation of human diseases caused by marmot until 2100

West Nile fever and Japanese encephalitis virus genes were identified from Tsagaanuur soum of Selenge in 2011, Ulaanbaatar in 2012, Bukhmuren soum of Uvs in 2013 and 4 soums of Selenge in 2014. West Nile fever and dengue virus genes were identified from 2 soums of Dornod province as well.

The researchers calculated the future trend of asthma disease using the ARIMA model based on the study using data from 2009-2017. Asthma disease is expected to overgrow through 2022, with a 1.5 times increase in new cases per 100,000 population, and increased from 8 in 2018 to 22 in 2022, respectively (Figure 4.124).

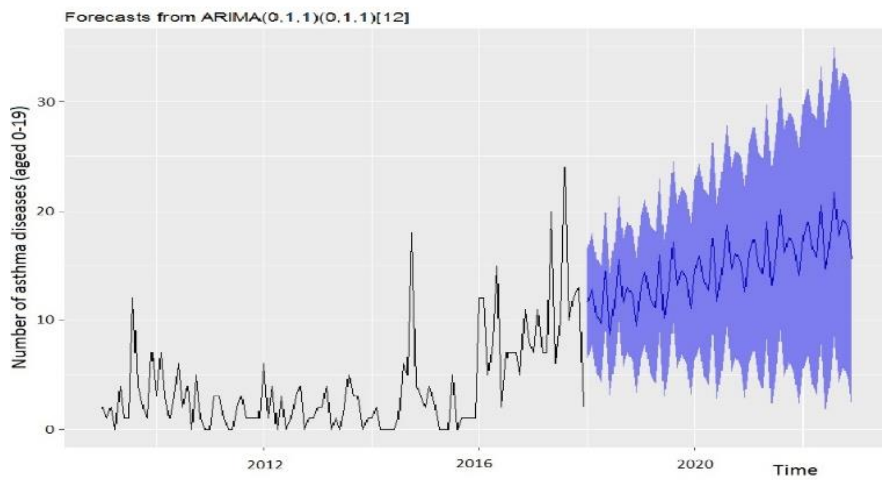


Figure 4.124 The future scenario of asthma diseases in population aged 0-19

Asthma in the elderly or over 60 is increasing each year, just like the disease in young children. In this age group, the number of asthma cases increased from 10 in 2018 to 25 by 2022, and it is a pressing public health problem. In the ARIMA model assessment of the outlook, if we did not do any intervention regarding air pollution, the frequency of asthma occurance is likely to increase (Figure 4.125).

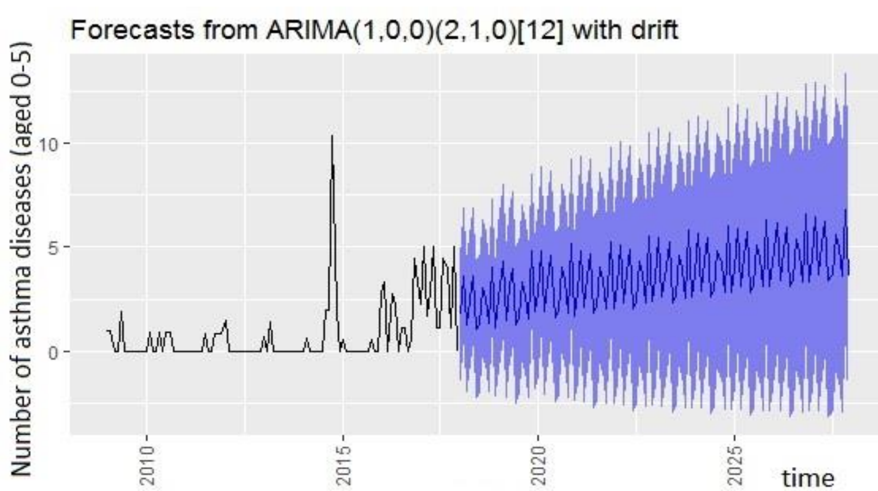
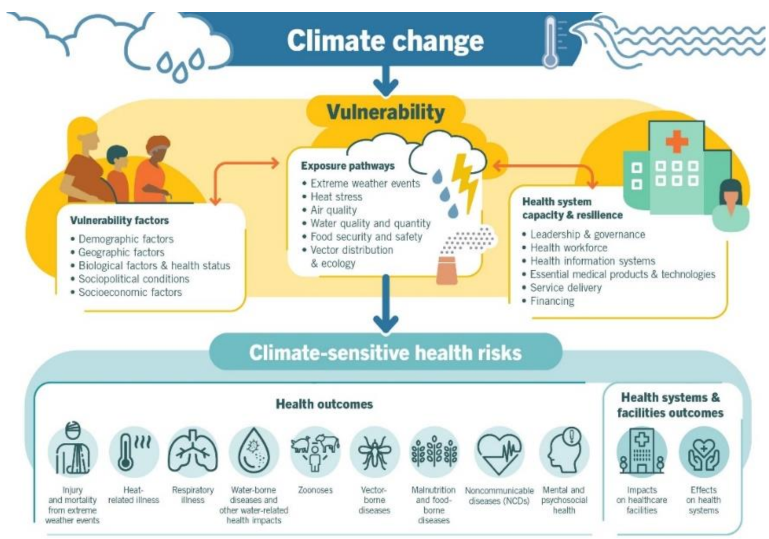


Figure 4.125 The future scenario of new incidence rates of asthma diseases (per 100 000 children) in children aged 0-5, up to 2027 year

Thus, research has shown that climate change, such as extreme coldness and dryness, creates harmful air pollution and affects the health of the most vulnerable groups of the population, those are children and elderly people.

Most research on climate change-health risks and impacts has been undertaken by researchers with international financial support. However, among the research report's limited aspects, many underlined the lack of multi-year quantitative data to study climate change-related health impacts.

Public health vulnerability and risk assessment. The impact, vulnerability, and risk of climate change in our country will be high, and by early recognition of the positive and negative effects that may occur due to it, and taking preventive measures, it is possible to improve the guarantee of our people living in a healthy and safe environment and being provided with healthy and quality food. Climate change effects on health directly and indirectly through environmental, social and public health determinants. An overview of health risks, pathways and vulnerability factors sensitive to climate change is shown in Figure 4.126 (WHO, 2021).



Source: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

Figure 4.126 An overview of health risks sensitive to climate change, their exposure pathways and vulnerability factors

Since the main impact of climate change is damage to human health, it is very important to involve public health organizations and experts in the projects and programs implementing in the field of climate change mitigation and adaptation of other sectors.

In the densely populated Ulaanbaatar city, province, and the center of soum, when a flood occurs, pit latrines overflow, contaminating the soil and increasing intestinal infectious diseases, which indirectly puts pressure on human health and the health sectors. For example, a total of 144,992 pit latrines are detected in the 7 districts of Ulaanbaatar city center using the high-resolution satellite images applying remote sensing methods (MAS, 2022). According to this research, pit latrines are divided into 4 zones according to their negative impacts on the environment: 9,443 (6.5%) in zone IV to prohibit the use of pit toilets, 43,377 (29.9%) in zone III to ban, 71,150 (49.1%) in zone II to limit, and 21,022 (14.5%) in zone I to protect (Figure 4.127).

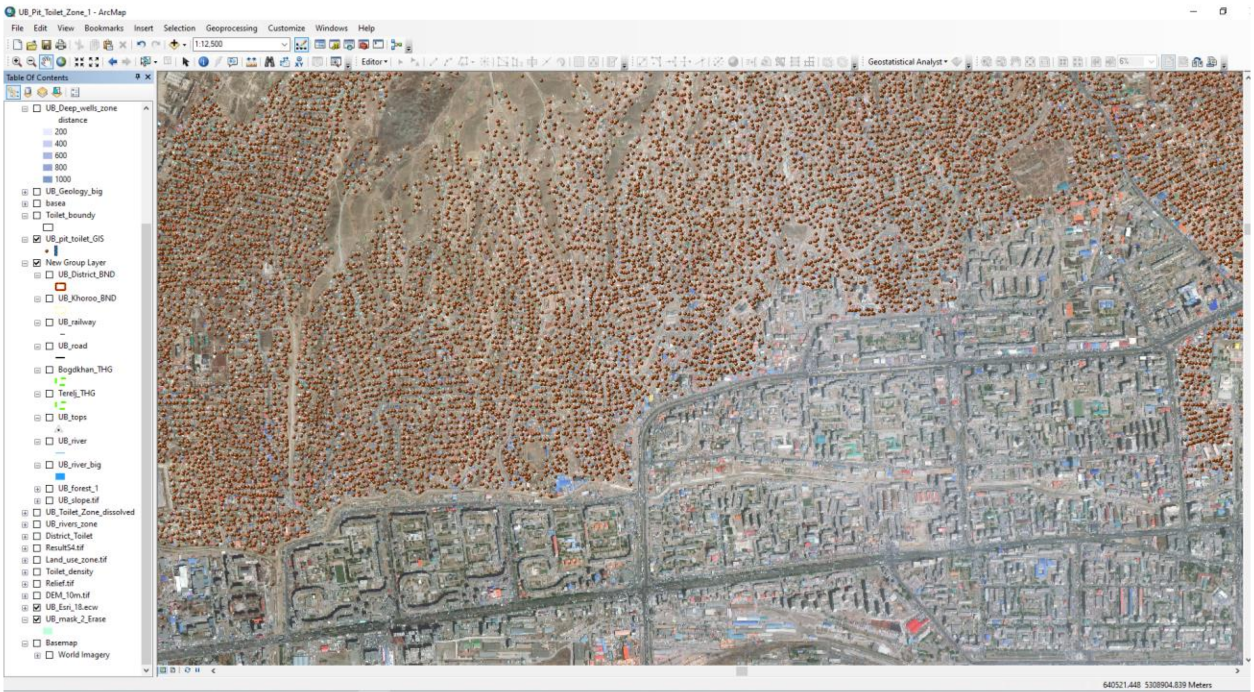


Figure 4.127 Location of pit toilet in Ger khoroolol of Ulaanbaatar city

Therefore, if measures are not taken to build pit latrines in the community according to standards, and to have disinfect the contaminated soil by professional organizations, it is necessary to work together to solve many problems that have reached the level of negatively affecting the health and life of people, especially children, due to the effects of climate change. In this way, the inability to solve the health problems of the old environment will be more burdened by the current changing climate, which will cause a significant damage to the health sector.

A number of further research and surveillance activities are needed in the health sector as following:

- In order to assess the risk of disruption of health care services due to climate change, conduct a risk assessment of primary health care, referral level, specialized medical facilities, soil and water conditions, electricity and road damage, and take measures to eliminate them;
- Expansion of research in the field of health system;
- To study and spread the experience of adapting to health protection and prevention of the population of high mountain regions, Gobi region and Khangai region.
- Investigate the knowledge, attitudes and practices of health workers and administrators about climate change;
- Assess the impact of climate change on food security, nutrition and human health;

- Coordinated evaluation and study of interdisciplinary activities based on diseases included zoonotic diseases with in the priorities
- At the national level, by expanding the environmental health surveillance system of the National Center for Public Health, and strengthening the capacity to protect public health and take appropriate response measures, by strengthening the surveillance capacity of districts and provinces
- In order to protect the most vulnerable groups to climate change, which will be transmitted by local health organizations, their research will be used for future activities;

Implementation of strengthening activities

- Develop and implement a health care emergency response preparedness plan;
- Build capacity by training and supporting career development of young researchers in relevant fields;
- The health impacts of climate change are addressed through public health and public education, disease control, disaster preparedness, food hygiene and control, food supplementation, vaccination, and primary mental health care and training. strengthen the adaptive capacity of the health sector by improving prevention and control systems using health assistance measures;
- Developing awareness programs for health workers, all citizens, policy makers and politicians at all levels about climate change, its mitigation and adaptation, and implementing training and capacity building activities for national trainers;
- Strengthen the control and surveillance system: control and surveillance of insects, drinking water, sanitation, waste control, food safety, healthy food control, energy, supply, service control, etc.
- Create a system for providing early warning measures to vulnerable groups (those with cardiovascular and chronic respiratory diseases, outdoor workers, etc.) by delivering information on natural extreme weather events such as heat wave and cold wave from the National Health Service to all levels of health care institutions, and protect public health through
- Through the environmental health surveillance system of the National Center for Public Health, introduce a system that predicts the number of emergency calls and the number of clients who will go to the emergency reception of health institutions, and takes response measures;
- Develop and implement a program to increase the coping and stress management skills of health workers in order to provide uninterrupted health care services during disasters and epidemics;
- Based on the results of the research, the safety of health care facilities, electricity, air exchange, cooling equipment in case of overheating, climate change-resistant and safe sanitary facilities will be organized in stages;

4.2.7 Climate change integrated assessment of impact, vulnerability and risk

In this report, impact of climate change, vulnerability and risk assessment of natural resources and socio-economic sectors, including water resources, glaciers, permafrostt, grasslands, forest resources, wild animals, natural disasters, animal husbandry, arable farming, tourism, infrastructure, and public health sectors, and quantitative assessments were performed using the impact models.

Table 4.32 summarizes the main results of the current and future impact assessments of these sectors. These results of the future impact assessment are based on ssp8.5 and RCP8.5 maximum greenhouse gas emissions scenarios of the 6th and 5th Assessment Report as respectively, the Intergovernmental Panel on Climate Change (IPCC) for the period 2046-2065 (2050.)

Table 4.32 Main findings of climate change impact assessments

No	*Climate change*	*Present change*	*Main result of impact asessment*
1	Water resource	-The total flow of rivers in Mongolia gradually increased after 1978, reached 78.4 km^3 in 1993, and gradually decreased after that, reaching a minimum of 16.7 km^3 in 2002. The low flow period lasted for 23 years from 1996 to 2017, but the water level has been increasing since 2018. -In accordance with the recommendations of the WMO, for the period of the revised norm, i.e., 1991-2020, it is 30.6 km^3/year, which is 10% less than the previous norm of 34.6 km^3/year. -The water level of most of Mongolia's lakes has generally decreased in the last 25 years from 1996 to 2020. Compared to the data of 1945, the total area of the lake was decreased by 7.79%.	-By the middle of this century, the flow of rivers in the Arctic Ocean basin will increase by an average of 8%, while that of the Pacific Ocean will decrease by about 40%, and the flow of rivers in Mongolia will decrease by an average of 24%.
2	Glacier	-The area of glaciers in Mongolia is rapidly decreasing to 535 km^2 in the 1940s, 470 km^2 in 1990, 453.8 km^2 in 2002, and 338 km^2 in 2019.	-The melting of the ice and glaciers of Turgan, Potanin, Tsambagarav, and Sutai Khairkhan is expected to be 40-86% by 2050, and it is expected to melt by 65% on average.
3	Permafrost	-Potential area for the spread of premafrost has decreased by 33.7% in the last 45 years (1971-2016). Also, the southern boundary of permafrost was moved 178 km in the Khenti range, 94 km in the Khangai range, and 240-900 m in the Altai range.	Mongolia's permafrost area is expected to decrease by 33-61% by 2050.
4	Pasture and land degradation	-Based on the assessment of the state of grasslands report in Mongolia as of 2020, the composition of plant species has changed from the reference level in about 70% of grassland.	-The content of organic carbon in the soil of our country will continue to decrease throughout the country, and it will decrease by 18-28% in different

		-According to desertification assessment in 2020, 76.9% of Mongolia's total territory has been affected by desertification with certain degree. -According to the 2020 assessment of land cover, desert area increased by 2.4%, steppe by 2.6%, and dry steppe by 13.9%, while the area of mixed forest increased from 126,084 km^2 to 122,692 km^2, and the area of glacier was increased from 945 to 733 km^2 during the same period.	natural zone areas in the middle of this century.
5	Forest resource	-The area covered by forests decreased by 729 thousand ha or 5.5% in 2006-2020. -Burned forest area increased by 939 thousand ha or 133 percent between 2006 and 2020. -The forest area destroyed by insects increased by 76 thousand ha or 127% between 2010 and 2015.	-The change in forest area is expected to decrease by 0.32% (723.1 km^2) in 2050.
6	Biodiversity	-Climate change has a positive or negative effect on the habitats and core habitats areas of some species of animal groups in our country.	-The habitat area of Grey long-eared bat (Plecotus austriacus) will expand by 14.7%, Demoiselle Cranes (Grus virgo) by 7.1%, while the area of the Mongolian ground Jay (Podoces hendersoni) will decrease by 6.8%.
7	Livestock	-The number of goat herds has been constantly increasing since the 1990s, and it accounts for 41% of the total herd in 2020. -The decrease in the live weight of mature Mongolian ewes is shown by long-term measurements of livestock in the forest and steppe natural zone. -Due to the warming of the climate, the time of shed for goat cashmere has been delayed by 5-10 days in spring. -There is a tendency to increase the number of days the animals are watered.	-The decrease in winter live weight of grazing sheep is up to 4.47 kg in 2050. The decrease in livestock weight is greater in Bayan-Ovoo and Bayan-Onjuul soum representing steppe zone. -Due to the increasing intensity of drought and dzud, mortality of livestock will incerased 5.5% compare to numer of animal of beginning of the year in middle of this century. According to this estimation, the mortality is projected to incerase 50% in the middle of this century.
8	Arable farming	-In Mongolia, 80% of agricultural land belongs to the central region, 11% in the eastern region, and 9% in the western region according to 2020. These are mainly non-irrigated crops and are directly dependent on agro-weather conditions. -According to the long-term trend of wheat and potatoe yield per hectare, although thier fluctuation depends on the weather conditions of actual year, it was increased until 1990, then decreased dramatically, and the general trend is gradually increased from 2003.	-Wheat yield is expected to decrease by 26.1% in the western region, 36.0% in the central region, and 11.0% in the eastern region, with an average of 24.4% in 2050.
9	Tourism	-Over the past twenty years, the number of tourists coming to Mongolia has been continuously increasing,	-The tourism index value is expected to increase by 3.4% in the future 2050.

		and in 2019, it received a maximum of 577.3 thousand tourists. But in 2020 and 2021, the number of tourists dropped sharply due to the coronavirus (COVID-19) epidemic, and compared to 2019, it decreased by 95%. -The average value of tourism climate index (Umnugobi, Ulaanbaatar, Bayan-Ulgii, Uvs, Khuvsgul) is 61.3, which is suitable (good category).	
10	Infrastructure	-The land of roads and network in our country increased from 407 hectares in 2010 to 477.2 thousand hectares in 2021. Of this, 69.2% of roads, 7.5% of railways, 2.0% of air transport, and 21.0% of network line are respectively. -In the last 20 years (2000-2020), the frequency of disasters has doubled. Observed daily rainfalls are classified by intense within time, and intense rainfalls after 2000 account for 54% of all cases.	-The maximum daily rainfall will increase by 41% in Ulaanbaatar and 19.2% in Mongolia.
11	Natural disaster maangment	-When we divide the last 30 years into 3 decades and consider the average annual recurrence, 29 times in 1989-1998, 53 times in 1999-2008, and 80 times in the last 10 years, the their trend is increasing. -In Mongolia from 2001 to 2021, 539 people lost their lives, 29.773 million animals were killed and 681.8 billion MNT were caused due to extreme weather and disasters.	-The frequency of drought will increase by 5-45%, and the frequency of dzud will increase by 5-40%. -Under the conditions of the 1966 flood, an area of 24.9 km^2 is likely to be inundated, and this area is projected to increase by 20.8% in 2050 with an increase in maximum daily precipitation projected for future climate change. -Risk of fire area is expected to increase by 9%.
12	Public health	-Diseases of the cardiovascular system, which is the third cause of diseases of the population, account for 11.1 percent of all diseases. -West Nile fever, Japanese encephalitis, and Dengue infection have been detected in mosquitoes spread in Mongolia, and cases of human diseases of some mosquito-borne infections have been reported.	-The duration of summer heat waves will increase by 3.5 days in 2050.

The research results of the sectoral researchers are not comparable to each other due to different units thus demonstrated different values. Therefore, the numerical values obtained by their current and future assessment were normalized and converted to a value from 0 to 1, and made the comparisons. The normalized average current value is considered as the **current vulnerability/risk** index, and the future average value is considered as the **future vulnerability/risk** index.

The current and future indicators selected for the natural, social and economic sectors are chosen from the climate change impact assessments as follows.

1. Water resource
    a. Current average flow of rivers and streams in North and Pacific basins, m^3/s
    b. The future flow change
2. Glacier, glacier rivers
    a. Melting of glaciers Turgen, Potanin, Tsambagarav, Sutai Khairkhan, cm
    b. The future change in melting
3. Permafrost
    a. Spread area of permafrost, thous. km^2
    b. The future change (according to Third National Communication)
4. Pasture, soil
    a. Soil organic content, g
    b. The future change of its value
5. Forest resource
    a. Forest area, km^2
    b. Disease infected area, km^2 (according to Third National Communication)
    c. The future changes in forest area
6. Wild animal
    a. Habitat and core habitat area, km^2
    b. The future change
7. Natural disaster
    a. Drought, dzud frequency
    b. The future change (according to Third National Communication)
8. Livestock
    a. Live weight, kg
    b. The future changes of live weight
9. Arable farming
    a. Wheat yield, kg/ha
    b. Its future change
10. Tourism
    a. Tourism index value, no-unit
    b. Its future change
11. Infrastructure
    a. Daily maximum preciptation, mm
    b. Its future change

12. Public health
    a. The 90th percentile of maximum temperature and heat wave duration in summer season, days
    b. Its future change value

The indicators shown above were normalized by each sector and converted to one dimension, which are vulnerability and risk index of the sector with value between 0-1. The value of this index was divided into 5 categories, and the maximum value corresponding to the index indicates very vulnerable and high risk (Table 4.33).

Table 4.33 Threshold values for vulnerability and risk categories used in the assessment

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

Figures 4.128 and 4.129 show the risk of natural resources and socio-economic sector of Mongolia. In general, climate change impacts, vulnerabilities and risks are increasing in sectors except tourism. In other words, the negative impact of climate change is likely to dominate in the future. For tourism, the risk will decrease slightly due to the increase in favorable climate conditions, especially, in winter. But for other sectors, it will move to the risky level by 1-2 categories degree. For example, pasture, soil, forest resources, and animal husbandry sectors will enter the risky level by 2 categories, and others in 1 category (Table 4.34).

Figure 4.130 shows the difference between the value of the future and present risk index for these sectors. In this way, it is possible to see which sectors will be more vulnerable and risky to climate change compared with the current level. Relatively, the change of index value for agriculture, pasture soil, forest resources, frost, animal husbandry, infrastructure, and glaciers will increase by 0.23-0.38 compared to the current level.

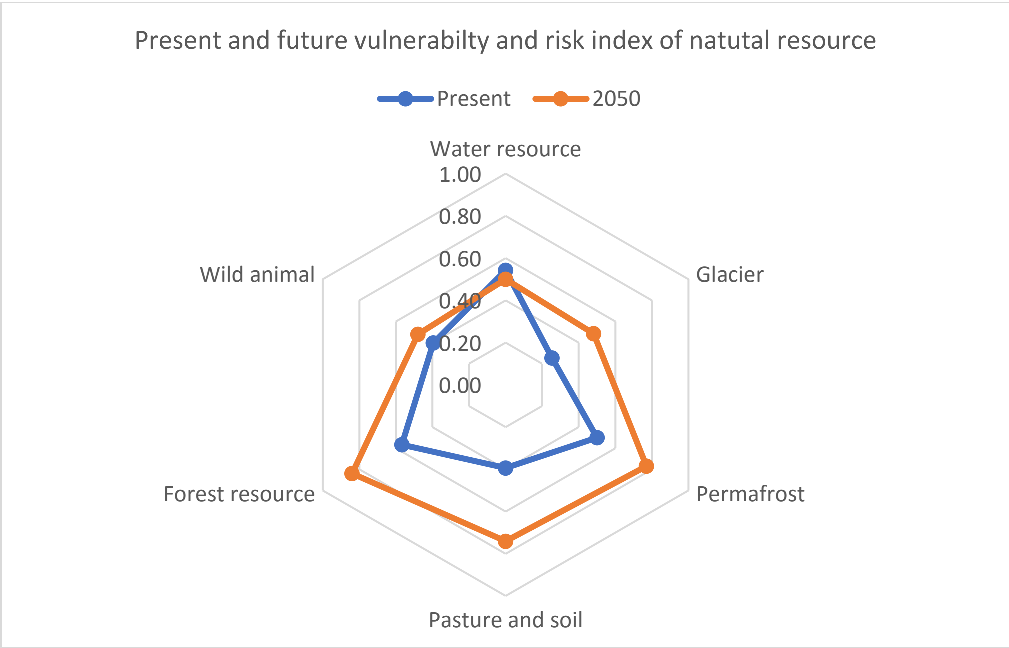


Figure 4.128 Climate change vulnerability and risk index of Mongolian natural resource sectors

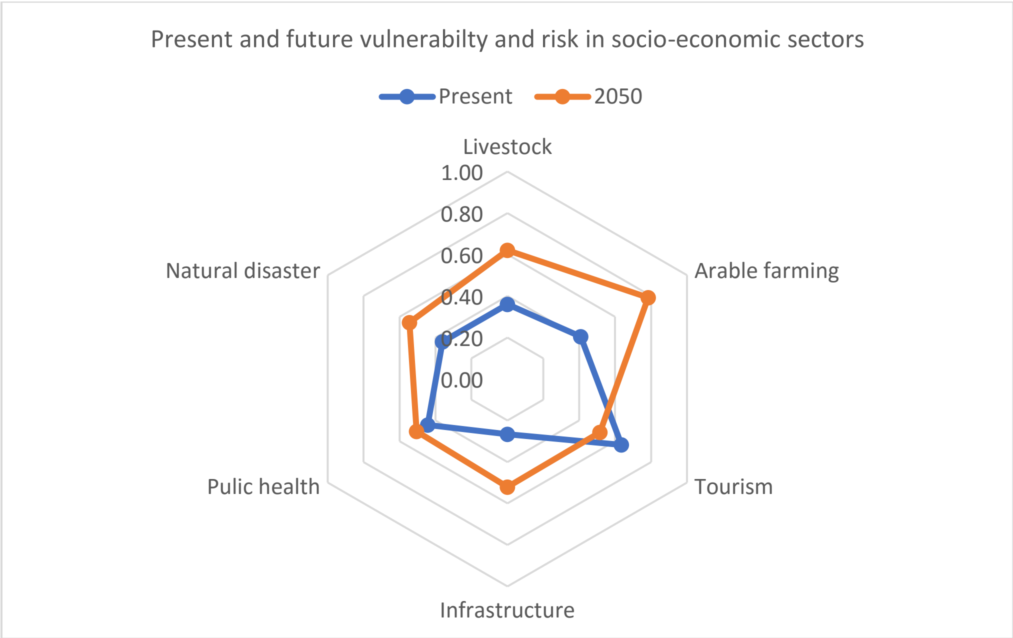


Figure 4.129 Climate change vulnerability and risk index of Mongolian socio-economic sectors

Table 4.34 Changes in current and future vulnerability and risk classification of natural, socio-economic sectors

№	Sector	Present vulnerability/risk category	Future vulnerability/risk category (2050)
		Natural resource	
1	Water resource	3	3
2	Glacier	4	3
3	Permafrost	3	2
4	Pasture, soil	4	2
5	Forest resource	3	1
6	Wild animal	4	3
7	Natural disaster	4	3
		Socio-economic sector	
8	Livestock	4	2
9	Arable farming	3	2
10	Tourism	2	3
11	Infrastructure	4	3
12	Public health	3	3

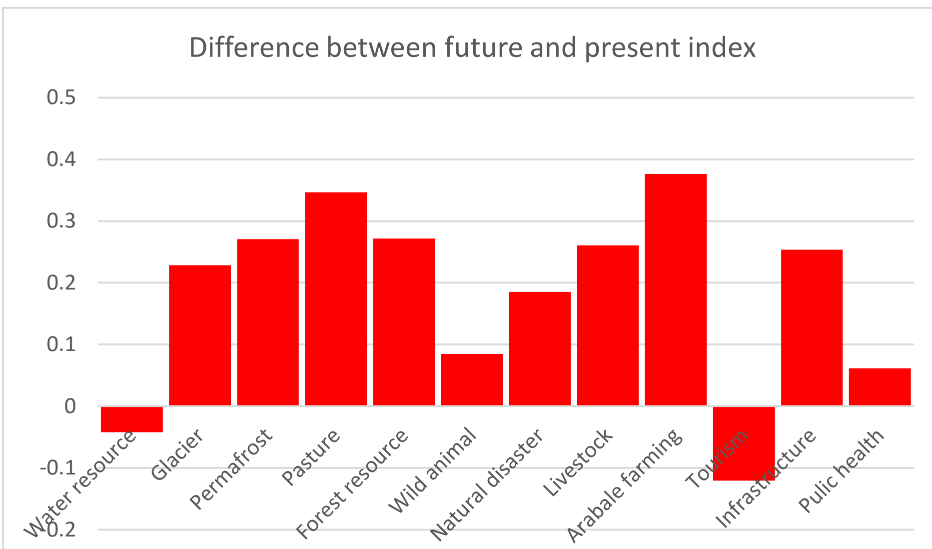


Figure 4.130 Change of vulnerability and risk index of natural and socio-sconomic sectors

4.2.8 Policy issues for reducing socio-economic impact and vulnerability to climate change and strengthening adaptive capacity

The pastoral system in Mongolia is one of the most vulnerable sectors to the adverse effects of ongoing climate change because of the country climatic condition, geographical location, and community lifestyle (Myagmarsuren and Batkhuyag, 2021). According to the global climate risk assessment, Mongolia is ranked 17th, which is a relatively high risk, considering the location of Mongolia with a lower risk of hurricanes, high tides (tsunamis), and earthquakes (Eckstein et al., 2020).

Due to climate change, the frequency and intensity of drought and dzud, surface evaporation, the number of hot days, and aridity are expected to increase, as well as the acceleration of desertification and deterioration of grassland ecosystems in Mongolia (TNC, 2018). These phenomena are causing an increased livestock loss, poverty rate, and migration of herders toward the cities. In Mongolia, poverty and migration are mainly originating from rural areas, and climate change has a large impact on this matter (Altanbagana and Saruul, 2021). This chain effect has the potential to ultimately hinder the implementation of Mongolia's major development goals.

Animal husbandry and the agriculture sector are more vulnerable to climate change compared to other economic sectors. As well as the rural herders who have nomadic lifestyles, and women, children, elderly herders living in the rural areas, female-headed households, households with a small number of livestock, or low income are also more vulnerable to climate change. Being socially and economically highly dependent on climate conditions and being vulnerable indicates a higher risk of exposure to natural disasters that may occur in the future (IPCC, 2014a). Therefore, it is important to conduct a detailed study of the vulnerability and exposure of social and economic sectors to climate change, analyze where and for what reasons are causing vulnerability in different ecological regions and areas, implement policy measures against climate change, and strengthen capacity for social and economic adaptation.

Adaptation is the process of adjustment to actual or expected climate and its effects (IPCC, 2014b), and it includes an adaptation of planning processes, vulnerable groups, key economic sectors, and ultimately adaptation of the “human” (Battulga, 2021).

Specific objectives related to climate change are included in the long-term development policy of Mongolia, "Vision 2050" (PoM, 2020a) in 2020 and in other medium and short-term policies. For example, in 2021-2030, a number of goals were set including "Strengthening the ability to adapt and withstand climate change and reduce possible risks" and "Implementation of productive and inclusive green development policies to mitigate and adapt to climate change, and reduce greenhouse gas emissions by 12.3%". On the other hand, the monitoring and evaluation criteria of "Vision 2050" includes increasing the share of middle and upper-class citizens (baseline 71.6% in 2020) to 80% in 2025, 85% in 2030, and 95% by 2050, decreasing the poverty rate (baseline 28.4% in 2020) to 20% in 2025, 15% in 2030, and 5% by 2050, decreasing unemployment rate (baseline 8.6% in 2020) to 7.8% in 2025, 7% in 2030%, and 3% by 2050, and to maintain the average annual economic growth at 6% until 2050.

Climate change is a long-term issue, and to a certain extent, the achievement of the above policy goals and objectives will depend on how the adaptive capacity of key and vulnerable social and economic sectors is strengthened. The evaluation report on the implementation of Mongolia's Millennium Development Goals states that 3 out of 4 goals set within the objective of "1. Reducing poverty and hunger", including the goals related to living standards[2], employment[3], concentration and migration[4] was concluded as insufficient (MED, 2013). One of the factors contributing to this result is climate change, drought, and dzud. The report states that "due to the severe adverse effects of dzud, the production of agricultural products fell sharply, and when it recovered after the last dzud of 2010, there was relatively little growth, which led to the migration of rural people to cities in large numbers."

Climate change and the economy. As of 2020, Mongolia's GDP is 37.4 trillion MNT, of which 24.1% is mining and extraction, 14.7% is wholesale and retail trade, car and motorcycle repair and service, and 12.8% is agriculture, forestry, fishing, and hunting, 9.2% is the processing industry. In the regional, provincial, and rural areas, the role and participation of the agricultural sector, especially the animal husbandry sector is high, which accounts for 48.1% of the GDP of the western region and 39.2% of the GDP of the eastern region of Mongolia. Also, the production of the agriculture sector within the total GDP is high in 16 out of 21 provinces. For example, in Khovd province, at the province level, 39.3% of the total GDP is produced by the agriculture sector, while at the level of primary units, about 90% is produced by the livestock sector.

In 1990, the animal husbandry sector was responsible for using 83.5% of the total land, accounting for 36.5% of the total workforce and 9.1% of the total GDP. The following Figure 4.132 shows the share of GDP, the share of land use, and the share of employment in mining, construction, transport, manufacturing, arable farming, and animal husbandry sectors as of 2020. The important role of the animal husbandry sector is not only through the economic aspects but also through the social aspects.

As of 2020, the animal husbandry sector uses 71.7% of the total land area, absorbs 22.8% of the total labor force, and produces 11.9% of the total GDP. On the other hand, the mining industry uses 0.2% of the total land area and produces 24.1% of the total GDP, while employing 4.4% of the workforce. Although the animal husbandry sector is the second largest industry in terms of economy, in terms of total labor force absorption, it is 3-4 times more than the employment of the mining industry.

[2] Target 1: Halve, between 1990 and 2015, the proportion of people whose income is below the minimum living standard. Mongolia's Millennium Development Goals.

[3] Target 3: Increase employment rate, reduce youth unemployment rate who are newly entering to the labour market. Mongolia's Millennium Development Goals.

[4] Target 4: Reduce negative effects of population concentration and migration, provide migrants with basic social services. Mongolia's Millennium Development Goals.

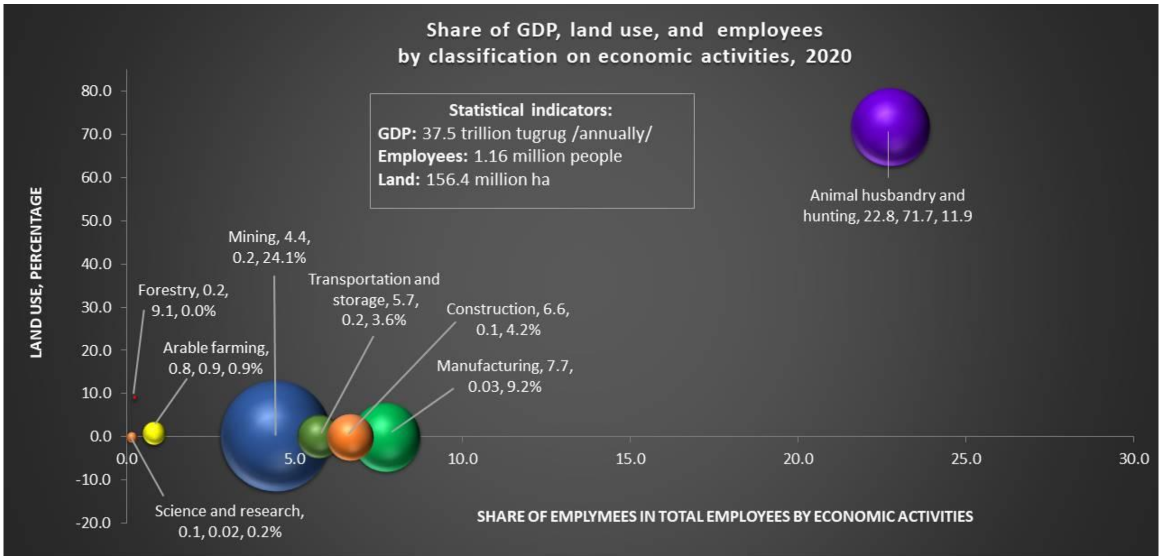
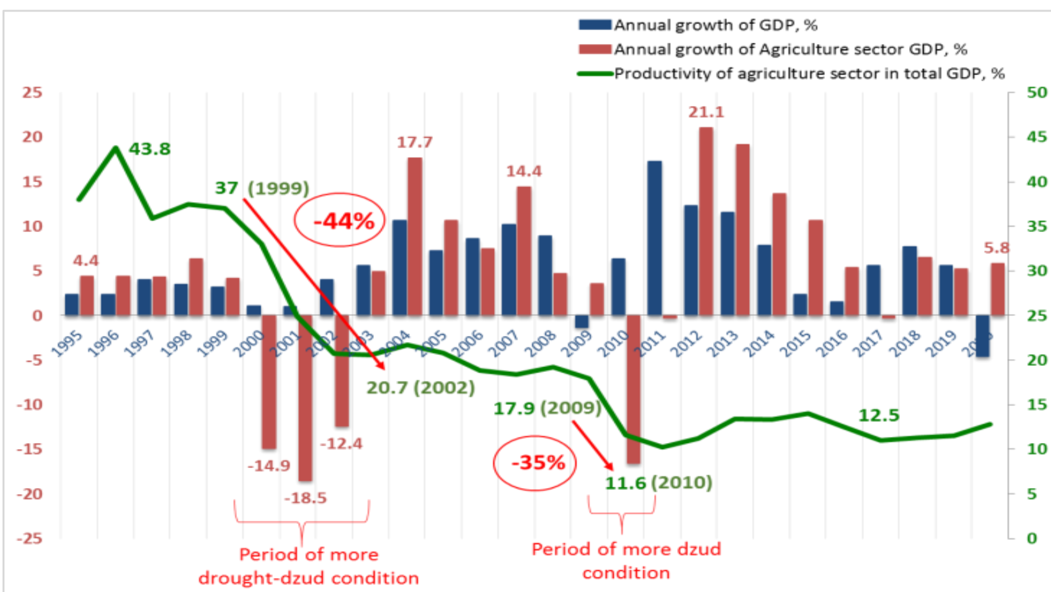


Figure 4.131 Share GDP, land use, and employees by classification of economic activities, 2020

Therefore, it can be concluded that although the animal husbandry sector plays a major role in the social and economic development of Mongolia, it is a sector that is dependent on nature and is more vulnerable to climate change, drought, and dzud. If natural disasters such as drought and dzud affect the animal husbandry sector, not only livestock loss will increase, but also thousands of herders will experience unemployment and poverty. On the other hand, if the government does not strengthen the adaptive capacity of the animal husbandry sector to climate change at the national level, it will further increase the vulnerability of the economic and social situation.



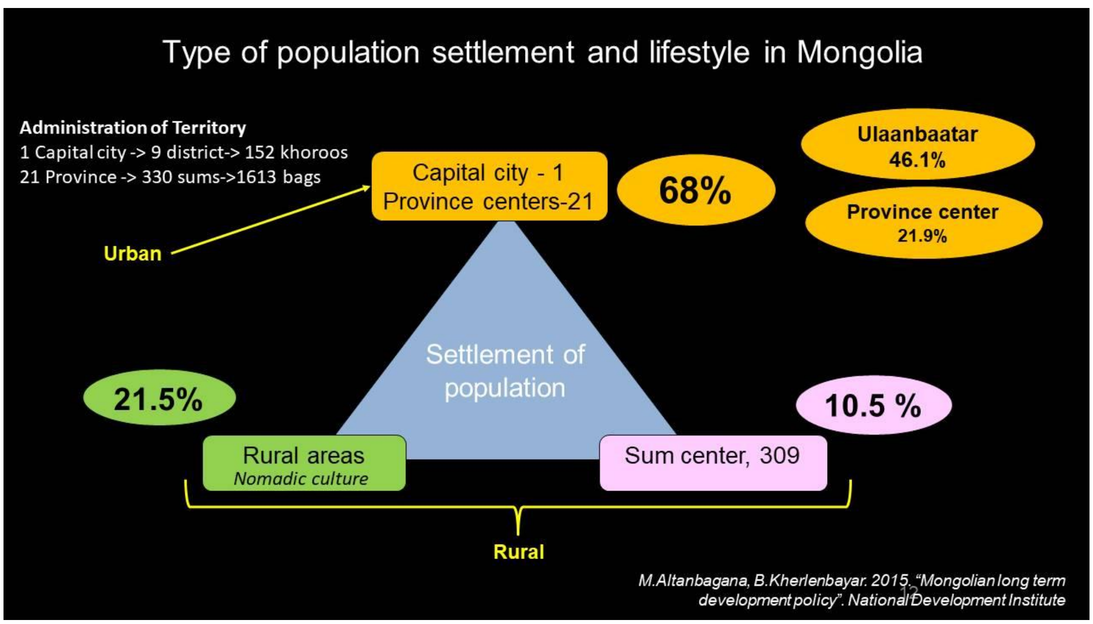
Source: Altanbagana & Saruul, 2021

Figure 4.132 GDP and annual net growth of the agricultural sector, changes over time as a percentage of the agricultural sector in GDP (1995-2020)

In 2000-2002, more than 80% of the total area in Mongolia was affected by dzud, causing 11.17 million livestock loss, and in 2009-2010, more than 90% of the total area was affected, causing 10.32 million livestock loss. The effects of climate change, drought, and dzud on the production of agricultural products, especially in the livestock sector, can be seen in Figure 4.132, which is showing annual total GDP growth rate, the annual GDP growth rate of the agriculture sector, and production of the agricultural sector in total GDP. After the 2000-2002 dzud, the production of the agricultural sector decreased from 37% in 1999 to 20.7% in 2002 which was a 44% decrease, and after the dzud of 2009-2010, it decreased by 35%. In the years of drought and dzud, the GDP growth rate of the agricultural sector was negative.

Climate change and population settlement. Depending on the characteristics of the lifestyle of the population, there are 3 main settlement types: cities, soum centers (semi-settled), and rural areas.

As of 2020, 46.1% of the total population is settling in Ulaanbaatar, 21.9% in other cities and villages, 10.5%, in the center of 309 soums, and 21.5% in rural areas practicising animal husbandry (Figure 4.133). For example, Khovd province has a total population of about 90,000, of which 33% live in the central city of the province, and the remaining 67% live in rural areas (SOoKh, 2019).



Source: M. Altanbagana and G. Saruul, 2021

Figure 4.133 The types of settlement in Mongolia and the distribution of the population

Out of the above 3 main types of settlement, the most exposed and vulnerable to the direct effects of climate change and natural disasters are those living in rural areas. Therefore, it is necessary to direct policy measures aimed at reducing vulnerability and risk to climate change and strengthening adaptive capacity towards herders who carry their traditional nomadic culture and live in a nomadic lifestyle, distanced from economy, culture, and service centers.

A spatial analysis of the population change between 2003 and 2013 in the above 3 types of settlement was carried out using the average annual population growth method (NSO, 2013) (Figure 4.134). According to the results of the analysis, the population growth in the capital and central cities of 21 provinces is relatively stable, while the population in rural areas has decreased. In particular, the rural population (herders) decreased more than the population of sum center. Specifically, the population of 4 cities decreased, while the population of the remaining 18 cities increased. However, among the rural population, the population of 166 soum centers decreased, while the rural population of 215 soums also decreased. This shows that the source of internal migration is from the rural areas in terms of settlement and the livestock industry in terms of the economic sector. Thus, the rural population is more unstable than the urban population, and in the future, the population living in rural areas and working in the animal husbandry sector is more exposed and vulnerable to climate change.

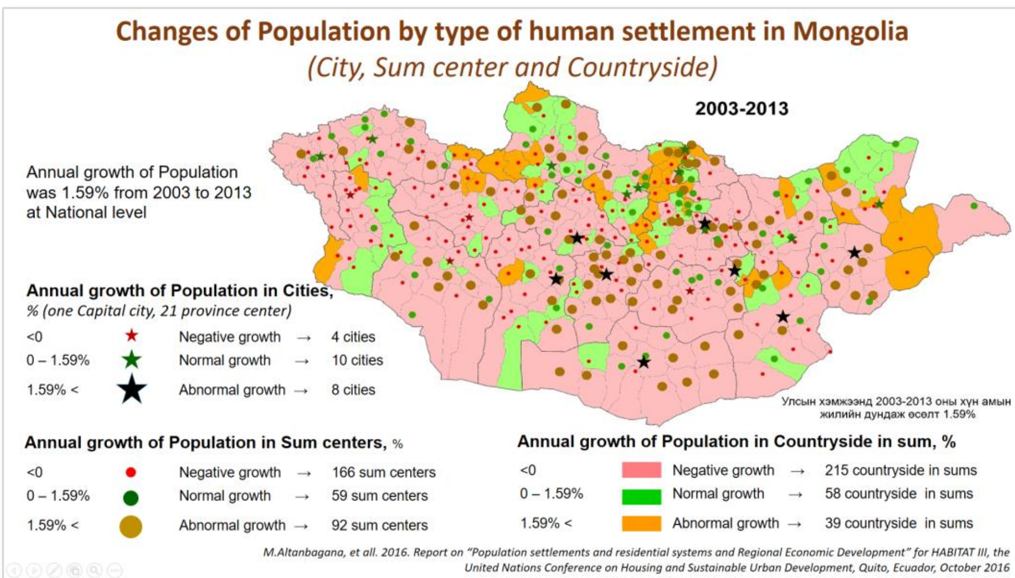
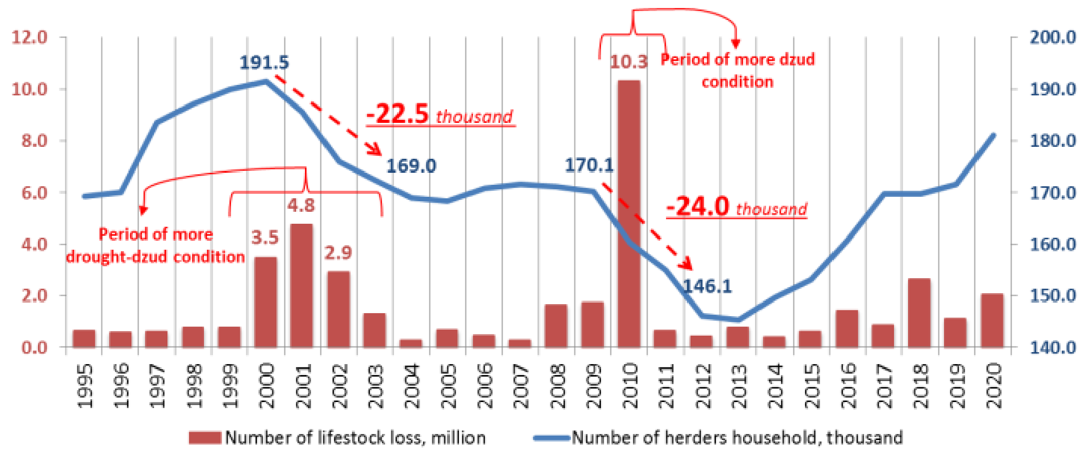


Figure 4.134 Population changes and settlement types (city, sum center and rural areas), 2003-2013

Climate change and migration. Climate change and natural disasters are one of the causes of population migration from rural to urban areas. During the 25 years from 1995 to 2020, a total of 636.3 thousand people migrated to Ulaanbaatar from provinces and rural areas.

Herders' main source of livelihood is livestock, thus, during the years of dzud, herders who lost their livestock moved to Ulaanbaatar city, and the number of herder households in the rural areas decreased (Figure 4.135). In 2000, the number of herder households was 191.5 thousand, but after the dzud, it decreased by 22.5 thousand or 11%, reaching 169 thousand in 2004. After this event, the number of herder households was relatively stable and slightly increased until 2008, and decreased again by 24 thousand during the dzud of 2009-2010, and reached 146.1 thousand by 2012.

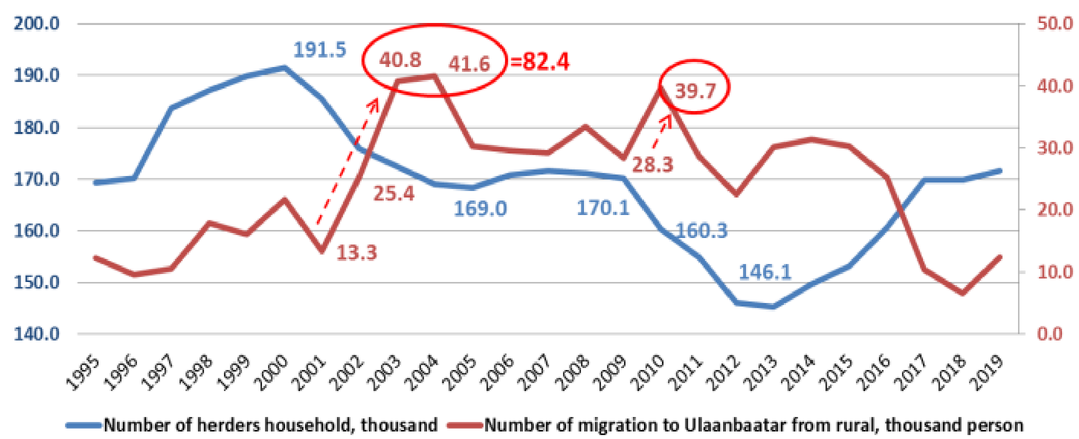


Source: Altanbagana & Saruul, 2021

Figure 4.135 Trend of livestock loss and the number of herder households (1995-2020)

Climate change and population's livelihood and poverty. This section aims to show how the effects of climate change, drought, and dzud affect on rural poverty and social vulnerability through the animal husbandry sector. The first results of climate change and its negative impacts are affecting the most vulnerable groups of society and the people with lower income (UN, 2008). Habitat degradation and natural disasters caused by climate change make vulnerable groups of society more vulnerable and increase the level of poverty.

As of 2018, the poverty headcount at the national level was 28.4%, the poverty gap was 7.2%, and the poverty severity is 2.7%. The poverty headcount is 27.2% in urban areas and 30.8% in rural areas. If we look at the percentage of poverty in cities, provincial centers, sum centers, and rural areas, the highest poverty rate is 32.9% in rural areas, followed by 30.1% in provincial centers, 28.9% in sum centers, and 25.9% in the capital (Figure 4.136).



Source: Altanbagana & Saruul, 2021

Figure 4.136 Number of herder households and number of migration from rural areas to Ulaanbaatar city (1995-2019)

Between 1995 and 2013, at the national level, a total of 414.4 thousand people migrated to Ulaanbaatar from provinces and rural areas. During the same period, 122.1 thousand people migrated to Ulaanbaatar city due to dzuds, which is 29% of the total migrants. In the future, if the frequency and intensity of droughts and dzuds increase due to climate change, migration to cities will likely increase with it. Therefore, any policy or program aimed at reducing migration needs to be considered in connection with climate change and strengthening the adaptative capacity of the livestock sector and herders.

Climate change and population's livelihood and poverty. This section aims to show how the effects of climate change, drought, and dzud affect rural poverty and social vulnerability through the animal husbandry sector. The first results of climate change and its negative impacts are the serious burden on the most vulnerable groups of society and the people with lower income (UN, 2008). Habitat degradation and natural disasters caused by climate change make vulnerable groups of society more vulnerable and increase the level of poverty.

In respect of percentage of poverty in cities, provincial centers, soum centers, and rural areas, the highest poverty rate is 32.9% in rural areas, followed by 30.1% in provincial centers, 28.9% in soum centers, and 25.9 % in the capital (Figure 4.137). At the provincial and local levels, poverty is high in soum centers and rural areas. Thus, the animal husbandry sector and the pastoral social-ecological system of rural areas are fragile and vulnerable to climate change.

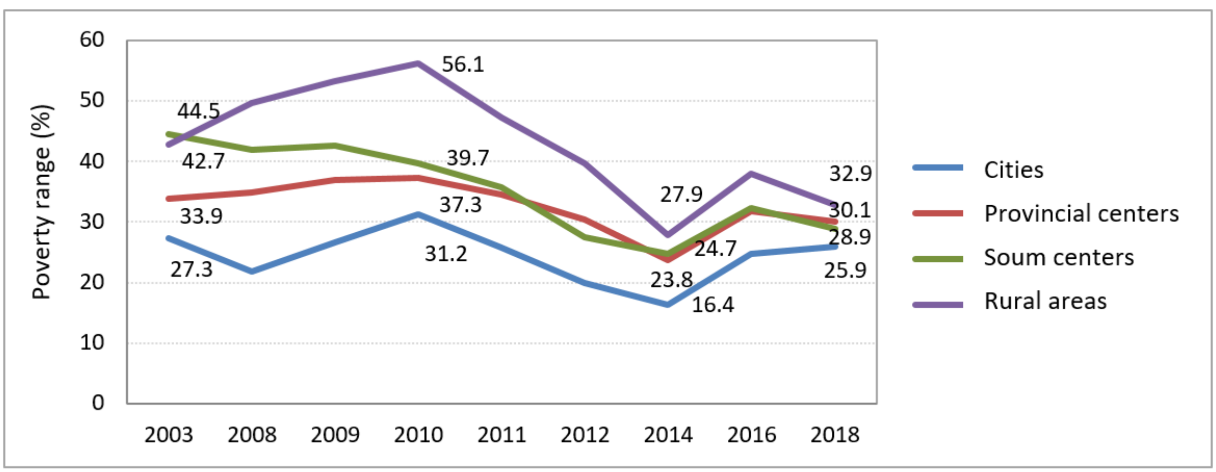


Figure 4.137 Poverty rate by settlement types (2003 – 2018)

The ability of herders to overcome and adapt to the risks of drought and dzud varies depending on factors such as geographical location, traditional knowledge, management methods of animal husbandry, and the number of livestock. However, low-income herders are more affected by climate change. Table 4.35 shows how the number of herder households and rural poverty changed for herder households with up to 200 animals or low-income and more than 201 animals or relatively high-income herders, before and after the dzud of 1999-2002 and 2009-2010.

Table 4.35 Comparative analysis of damage in social and economic sector caused by the drought-dzud of 1999-2002 and dzud of 2009-2010

Grouping of households with livestock		*Drought-dzud condition during from 2000 to 2002*				*Dzud condition in winter of 2009-2010*			
		1998	*2003*	*Gap (-/+)*		*2008*	*2011*	*Gap (-/+)*	
				Number	*Percent*			*Number*	*Percent*
Less than 200 livestock		232'645	201'898	-30'747	Decreased by 13%	155'937	165'043	+9'106	Increased by 5%
More than 201 livestock		42'342	34'312	- 8'030	Decreased by 18%	71'610	51'531	-20'079	Decreased by 28
Total household with livestock		274'987	236'210	-38'777	Decreased by 14%	227'547	216'574	-10'973	Decreased by 4.8%
Poverty,%	Urban	39.4	30.3	- 9.1	Decreased by 23%	26.9	32.2	+ 5.3	Increased by 19%
	Rural	32.6	43.4	+ 10.8	Increased by 33%	46.6	47.8	+ 1.2	Increased by 2.5%

Sources: Altanbagana & Davaanyam, 2012; Bayaraa & Damdin, 2006; GoM & MOFALI, 2003

According to this, after the dzud of 2000-2002, the number of households with fewer than 200 livestock decreased by 30 thousand, which shows that households with a small number of livestock are more affected by natural disasters. These herder households have less economic capacity and adaptive capacity to cope with natural disasters. Nationwide, as of 2020, out of 242 thousand herder households, 82.4 thousand, or 34.0% have up to 100 animals, and 51.2 thousand households, or 21.1% have 100 to 200 livestock, which are not a small number. There is a high possibility for these households to fall into poverty due to the loss of livestock which is the main source of livelihood to droughts and dzuds that are increasing in frequency due to climate change.

According to the research conducted by the Research Institute of Labor and Social Protection, 90.0% - 96.4% of the income of herder households in the capital, provincial center, soum center, and rural areas comes from animal husbandry. 1 out of every 2 herder households in provincial centers and rural areas, 3 out of 5 herder household in capital and sum centers has a loan, and 54.6% of all surveyed households have a loan from a commercial bank. As for the hardships related to animal husbandry, 95.8% of the participants in the survey answered drought, 90.3% answered dzud, 90.4% answered lack of pasture, 80.9% answered rivers and springs drying up and a lack of water (RILSP, 2018)

Hence, one of the important goals of the policy to prevent poverty, raise the living standards of herders, and reduce poverty is the measures aimed at reducing vulnerability to climate change and strengthening the adaptive capacity of vulnerable groups in rural areas with a small number of livestock and lower income.

Conclusion. Due to the impact of the dzud, the loss of livestock has increased and the number of herding households has decreased, which not only increases the economic loss, it increases the poverty of herders and their migration to cities. In this situation, there is a lack of preparation and resources for providing education and jobs to the herders who became unemployed, and do not have an education or profession. This shows that Mongolia's society and economy are vulnerable and exposed to the negative effects of drought and dzud exacerbated by climate change, through the animal husbandry sector. Therefore, it is necessary to increase the adaptive capacity and resilience of the livestock sector, and study what are the priority issues and how to support and improve those problems in the livestock sector. On the other hand, it is necessary to define the adaptation goals based on climate change vulnerability considering the social, economic, and environmental features at the local level, and reflect them in the short and medium-term development policy of the province.

Policy issues for strengthening adaptive capacity (Recommendation)

Policy issue 1. After climate change related disaster occurs, measures to return the life of the disaster victims to normal conditions are not planned and implemented in the long and medium term, as a result, social reconstruction is insufficient and abandoned. The Law on disaster protection has provisions for immediate reconstruction, but these are short-term measures and mainly focused on prompt government action to deliver food, medicine, and fodder to affected households (GoM, 2017).

Specifically, the number of herder households decreased by 22.5 thousand and 24 thousand during the two-time droughts and dzuds which covered more than 80% of the total area of Mongolia, due to losing their livestock, and moving to Ulaanbaatar city. At the household level, migration is an important decision that requires confronting and overcoming difficult risks, such as 1) changing the settlement type from a rural to an urban settlement, 2) if they were working in the animal husbandry sector, this work conditions and income sources will change, 3) need to transition to another sector of the economy, 4) there is a lack of experience, education, and technical expertise when finding a job and employment in a new field, 5) there is a lack of targeted training and capacity building measures for migrated social groups and herders.

As of 2020, there are more than 180 thousand herder households. At the national level, the adaptation capacity of key economic sectors and social groups to climate change has not been sufficiently strengthened, thus impact of climate change, such as large-scale droughts and dzud may have significant negative consequences. Therefore, there is an urgent need for support from the government to plan and implement long and medium-term measures to prepare for natural disasters, to reduce vulnerability, to strengthen the ability to cope with risks, and perhaps to recover the life of people who are affected by disasters to normal conditions, and to support the transition of settlement, employment, and economic environments.

Policy issue 2. There is a need to consider the issue of reducing vulnerability to climate change and strengthening adaptative capacity at the local and regional levels in terms of planning, government organizations, and legal systems. According to the Law on development policy, planning and management, it is necessary to adhere to the principle that development policy and planning should be based on research and analysis, goals and objectives should be measurable, planning should be result-oriented, and top-down and bottom-up planning should be balanced. However, in reality, at the local level, this principle of planning is not sufficiently performed. In 2020, Mongolia's long-term development policy "Vision 2050", the medium-term policy "Five-year development guidelines for 2021-2025"(PoM, 2020b), and the short-term policy reflected in the 2020-2024 Action plan of the Government of Mongolia (PoM, 2020c) were approved but is not clear how the goals related to adaptation to climate change can be implemented at the local level.

Policy issue 3. It is more important to strengthen the adaptive capacity of key economic sectors and social groups at the regional and local levels. On the other hand, depending on the geographical location of provinces and districts, ecological, social, and economic vulnerability differs, and as a result, the methods and mechanisms for reducing vulnerability and adapting to climate change will be different in each sums. In other words, there is a lack of goals and measures aimed at reducing vulnerability and strengthening adaptive capacity based on research results, taking into account the local social, economic, and environmental characteristics and conditions. Therefore, it is necessary to assess the environmental, social, and economic vulnerability to climate change at the level of 330 soums using an integrated method, to analyze the interaction of the vulnerability variables, and to implement adaptation measures based on the complex assessment of the vulnerability, and coordinating those with policy planning and budgeting of the respective provinces and sums.

Policy issue 4. Poverty is the highest in rural areas of Mongolia, and herders who lost their livestock in dzuds account for a large part of the migration to cities, which indicates that the effects of natural disasters such as drought and dzud are not negligible. It is necessary to review the adaptation capacity to climate change in a systemic manner because 21.5% of the population is living in rural areas, 22.8% of the total labor force is employed in the animal husbandry sector, 32.9% of the rural population is living in poverty, and agriculture sector is producing the third biggest GDP. Therefore, it is necessary to increase the adaptive capacity and resilience of the livestock sector, study what are the priority issues, how to support and improve those problems in the livestock sector, and make policies based on science.

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CHAPTER 5. POLICY ON CLIMATE CHANGE, ADAPTATION STRATEGY AND PROJECT PROPOSAL

5.1 Sectoral policy linkage

The issue of climate change has been reflected in Mongolia's legislation and long, medium, and short-term policies at the sectoral level to a certain extent. In 1992, adopting a set of environmental laws made it possible to regulate the issue of environmental protection and control the management of natural resources within the legislation framework. However, with the ratification of the United NationsFramework Convention on Climate Change in 1992, there was a clear obligation to take measures against climate change at the level of international agreements. In this regard, measures to reduce carbon emissions and adapt to the effects of climate change have been included in the laws and policies of the main sectors affected by the impact of the climate change. As one of the main challenges for the future development, some measures and policies on adaptation is reflected in policy documents such as "Millennium Development Goals-based Comprehensive National Development Strategy" of 2008, "National security concept of Mongolia" 2010 and "National action program on climate change" (NAPCC), 2011.

NAPCC was considered at the Cabinet meeting and approved by Parliament in January 2011. Goal of the program is to ensure ecological balances, development of socio economic sectors adapted to climate change, reducing of vulnerabilities and risks, mitigation of GHG as well as promoting economic effectiveness and efficiencies and implementation of 'Green growth' policies by that time. NAPCC includes Adaptation and Mitigation strategies and measures for key socio-economic sectors of the country and the climate change adaptation measures and actions were reflected in certain extent in Mongolia's National Action Plan on Climate Change under general strategic objectives and indicators with II implementation phases. In the first phase (2011-2016), both the national mitigation and adaptation capacities were planned to be strengthened, legal, structural and management systems was planned to be set up and community and public participation was to be improved. However, unlike the foundation work implemented in the 1st phase, the second phase (2017-2021) was planned to move the climate change adaptation measures to the implementation phase. The implementation period of the national program ended in 2021, and the implementation of the two phases of the program was monitored by the government, and no special evaluation was made. Since the completion of the implementation of the program, the tasks necessary to determine the National Adaptation Strategy and Measures, to ensure their implementation at the policy level, and to reflect them in the next level of policies and strategies have been carried out within the framework of the National Determined Contribution and the National Adaptation Planning process (NAP).

Currently, there is no specific law regulating the issue of climate change in Mongolia. Since climate change is an interdisciplinary issue, it is regulated by the laws of the relevant sectors. In the framework, the Mongolian government has started the initiative of drafting the Climate Change Law, which is currently under discussion by the national working groups of experts. The objective of the law is to create a national regulatory resolution to promote joint cooperation against climate change, address emerging issues arising from climate change, promote climate change mitigation and adaptation measures, support climate change research and innovation, fulfil Mongolia's obligations under international agreements; towards managing and creating climate finance.

Long and short-term adaptation policy planning updates

Mongolia's long-term development policy, "Vision - 2050", was adopted by Parliament resolution No.52 on May 13th, 2020. The adoption of "Vision - 2050" policy document integrated the existing long-term and medium-term policy documents into one pillar, causing rearrangements and consolidations among the previous strategies and concepts. The policy sets out three phases of achieving the objective in 2021-2030, 2031-2040, 2041-2050. Chapter 6 of "Vision - 2050", fully considered "Green Development", included the objective of maintaining ecosystem balance, ensuring environmental sustainability, creating benefits for present and future generations, and improving human quality of life. Within this policy framework, it was approved for implementation activity in 2021-2030. Adaptive activities related to climate change were reflected under the main contents of "Nature and Primary Ecosystems", "Benefits of Natural Resources", "Valuable Water", and "Green Development with Low Carbon, Efficient and Accessible" as follows:

- Improving ecosystem services, updating and introducing socio-economic assessment
- Evaluating the current state of natural resources and doing sustainable management
- Take special land important for freshwater resources, forming runoff water, forest reservoirs, and biodiversity
- Replacing traditional agricultural technologies with advanced technologies, which are introduced with agro-technology and irrigation water savings, and protect and recover soil
- To increase the efficiency of weather modification activities
- Develop technologies to enhance and rehabilitate water resources by establishing dams and wells and penetrating ponds to floodwaters in Gobi and semi-arid region
- Promote economic incentives for environmentally friendly, affordable and efficient green technology
- Support and implement a national adaptation plan for climate change
- Establishing a climate change risk insurance system
- Strengthening the capacity to predict and warning hazardous natural and weather events and install radar stations in at least five locations

The Parliament of Mongolia approved (Decree No.106, 2021) a medium-term "New Revival Policy" that will be implemented over ten years aimed at creating an effective implementation of Mongolia's long-term development policy "Vision - 2050", for improving the economy, infrastructure, and government accessibility. This includes the following instructions for adaptation relating items:

- Effectively promote the "Billion Tree Campaign" and create a legal environment to support civil, industrial, and organization
- Protecting water resources, providing safe and reliable drinking water to the citizens, watering pastures, increasing water supply in the Gobi region, reusing grey water, establishing artificial ponds and water reservoirs and recharging rivers, springs and ponds

Also on the list of development projects to implement in the Action are proposed as following:

- Eco-friendly, science and advanced technology-based energy projects /Nuclear, green-hydrogen, natural gas and renewable energy projects/
- Climate change mitigation projects based on environmentally friendly advanced technologies /"A Billion Tree" National Campaign, a project to establish a centralized eco-facility for normal and hazardous waste/
- Projects to accumulate water resources and increase access to water supply in the Gobi region /"Blue Horse" project/

Adaptation in NDC

Mongolia's commitment to global climate action was underscored by its ratification of the Paris Agreement of the United Nations Framework Convention on Climate Change in 2016. In line with this, the Mongolian government approved the "Nationally Determined Contributions (NDCs)" on November 19, 2019. These contributions outline measures to reduce the negative impacts and risks of climate change and adapt to projected scenarios. The NDCs specifically address the most vulnerable sectors, demonstrating Mongolia's proactive stance in climate change adaptation.

- Livestock: Reduce the impacts and risks of climate change in the livestock sector, ensure its sustainability, increase productivity
- Arable farming: Establishing a sustainable supply of healthy food for the population, feeding for livestock, raw materials for light and food industries through the rational use of the positive impacts of climate change in the agricultural sector as reducing negative impacts
- Water resource: Improving capacity by increasing water resources and introducing rational water consumption
- Forest resource: To implement sustainable forest management and introduce climate change-adapted forest ecosystems and increase carbon accumulation
- Biodiversity: Enabling adaptation for biodiversity, which is sensitive and vulnerable to climate changes

- Natural disaster: Establishing national disaster resilience by reducing disaster risk from extreme weather and climate, and hazardous events and adapting to climate change
- Public health: Studying climate change's impact on human health, early warning of potential risks, taking measures and improving health care
- Livelihood and social protection: Identifying vulnerable social groups for climate change and creating a system for welfare, security, insurance and prevention aimed at overcoming their vulnerability

National adaptation planning process

In 2019, Mongolia started to refine its adaptation planning process at the national level to strengthen the institutional and technical capacity of the government and to advance the process to formulate and implement a National Adaptation Plan for future climate resilience. The main expected output of this process was to formulate Mongolia's first ever "National Adaptation Plan" with the help of the multi-stakeholders while prioritizing the national-level adaptation actions. In addition, identifying the financing mechanisms and strategies for sustainable implementation of the NAP in the medium and long-term, ensuring the community participation and capacity building in the development process of NAPs, improving the system for information development and sharing was crucial. As part of this work, the "National Adaptation Plan of Mongolia" was completed between 2019-2024. Subsequently, the National Climate Committee officially approved this plan in March 2024 as a list of actions.

According to the summary of the approved version of Mongolia's climate change adaptation plan, it consists of 3 main sections with 10 overarching Targets, 27 goals to facilitate their achievement, and a comprehensive set of 107 specific measures identified in 8 high-priority vulnerable sectors for the period 2023-2030. The sector coverages and some specific measures of Mongolia's NAP are summarized below (Table 5.1).

Table 5.1 Some specific measures of Mongolia's NAP

№	Planned number		
	Target	**Goal**	**Measure**
I.	**ESTABLISH AN ENABLING ENVIRONMENT FOR IMPLEMENTATION OF NATIONAL ADAPTATION PLAN, INCLUDING LEGAL AND POLICY FRAMEWORK AND INSTITUTIONAL ARRANGEMENT** Objective: Strengthen the legal, policy and institutional arrangement for climate adaptation in environmental and socio-economic sectors.		
	Ensure the natural balance of the environment, ecosystems and biodiversity.		7
	Establish the adaptation policy and legal framework for key economic sectors, while strengthening inter sectoral coordination and implementation mechanisms		4

	Establish the adaptation policy and legal framework for the social sector and improve inter -sectoral coordination mechanisms.		3
II.	**IMPROVE CLIMATE CHANGE ADAPTATION SCIENCE, TECHNOLOGY, KNOWLEDGE AND INFORMATION DISSEMINATION SERVICES TO STAKEHOLDERS** Objective: Expand the research on the climate impact, overcoming the risks, and adaptation, and provide knowledge and information to the relevant stakeholders.		
	Strengthen the knowledge and capacity of stakeholders in environmental and socio-economic sectors in the field of climate adaptation and improve provision of science and technology information services.		10
III.	**PLANNING OF ADAPTATION MEASURES TO ADDRESS CLIMATE CHANGE AND REDUCE IMPACTS AND RISKS IN THE ENVIRONMENTAL AND SOCIO-ECONOMIC SECTORS** Objective: Enable the opportunities and conducive environment for ecosystems and biodiversity to adapt to climate change.		
3.1	ECOSYSTEMS, BIODIVERSITY, LAND DEGRADATION AND DESERTIFICATION	Strengthen the capacity to adapt to climate change by protecting biodiversity, flora and ecosystems, and reducing land degradation and desertification.	4
		Strengthen adaptive capacities through implementation of interventions to reduce the impacts of climate change and human activities on grassland ecosystems, land degradation, desertification and permafrost loss.	5
3.2	WATER REGIME, RESOURCES, AND SUPPLY	Advance the legal framework and governance structure to ensure water security and inter-sectoral coordination.	3
		Establish and maintain a permanent, state-of -art network for continuous monitoring of water resources and its quality to ensure the timely delivery of information and services.	4
		Build adaptive capacity through the adoption of advanced technologies for the sustainable use, protection, and restoration of water resources, with a focus on enhancing surface water availability.	10
3.3	FORESTRY SECTOR	Enhance the resilience and adaptive capacities of Mongolian forests to climate change.	3
		Enhance ecosystem services, protect natural forests and meet the needs of population through sustainable production and utilization of the forest waste resources, dead woods and non-timber products.	3
3.4	WEATHER- AND CLIMATE-DRIVEN NATURAL DISASTERS	Ensure the preparedness, resilience and adaptive capacities by conducting comprehensive disaster risk assessments	3
		Establish an early warning system based on the multi hazards impact.	4

		Reduce disaster risks and socio-economic damages.	3
3.5	LIVESTOCK AND GRASSLAND	Adapting the number of livestock to the carrying capacity of the pastures and adopting a sustainable management of proper use of the pastures.	4
		Improve herd quality and economic turnover, reduce grazing load.	3
		Upgrade incentives and supports based on sustainability assessment of livestock producers.	2
3.6	ARABLE FARMING	Reduce the loss of soil moisture and mechanical structure by adopting technologies to reduce and eliminate mechanical tillage of cultivated soils.	2
		Protect the moisture evaporation and soil fertility of grain, fodder and technical plant fields from wind and water erosion and damage.	4
		Introduce modern and advanced technologies in crop production.	4
3.7	PUBLIC HEALTH	Expand research and training and knowledge sharing events among health professionals about the consequences of climate change on human health.	5
		Strengthen early warnings and response measures against adverse impacts and risks to human health caused by climate change.	3
		Establish a system of participation of sub-national stakeholders and improve cross-sectorial coordination mechanism in adapting to climate change and protecting the health of the population.	2
3.8	SOCIAL SECURITY AND LIVELIHOOD OF CITIZENS	Identify vulnerable groups that may be affected by climate change and include adaptation measures in the policy plan	3
		Increase the share of middle and upper class citizens by increasing stable and guaranteed jobs, gradually reducing population poverty, and increasing income	4
		Increase employment and create equality by providing knowledge and education to citizens	5

**The measures and actions identified in the first TWO sections are common for all sectors.*

5.2 Adaptation and technology needs assessment

Climate and Adaptation Technology is an integrated target mechanism that includes in-depth technical knowledge and engineering know-how related to solving the objectives of reducing greenhouse gas emissions and adapting to climate change in various sectors such as economy, industry, agriculture, forestry, etc. It is necessary to reduce carbon dioxide emissions caused by the destruction and degradation of forests due to climate change throughout Mongolia. In addition, it is important to implement adaptation technologies on a large scale to prevent the increase of pests and fires, to improve forest growth through planting, afforestation, maintenance, and cutting, and to increase the carbon sequestration in forests. The first Mongolian technological needs assessment of adaptation has been conducted in 2013 (TNA, 2013). Within this assessment have prioritization technologies for the most vulnerable sub-sectors such as arable farming and livestock.

In 2018, the latest impacts, vulnerabilities and risk assessments on water resources, permafrost, forest resources, pasture-soil, wildlife, natural disasters, agriculture, livestock and human health sectors have been done within the framework of the Third National Communication, and attempted to conduct adaptation technologies needs assessment (TNC, 2018). Based on these findings, it is necessary to consider following directions and concepts in reducing vulnerabilities and risks in each sector. Where:

- Water resources
    - reducing evaporation from open surfaces and evapotranspiration, creation of water accumulation using snow and ice melting, increasing water resource, proper use of water resources, preservation of headwater of river basins and their unigue 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 highly productive animals, pasture management, increasing livestock forage and decreasing animal diseases and early warning system against drought-zud risks.

- Natural hazards and disasters
  - Monitoring network, monitoring and early warning system, disaster preparedness
- Public health
  - Establish human health, disease registration systems, early warning systems against disaster, training, awareness, practices and attitudes.

During assessment, prioritized and ranked adaptation technologies were listed for each socio-economic sector. However, updated and additional adaptation technologies have been added to the livestock, arable farming, and forest sectors.

Livestock. The livestock sector is included in Mongolia's NDC as part of the main goals aimed at increasing the quality of animals and reducing the impact of risks rather than increasing the number of animals. Table 5.2 summarizes the objectives, technologies, and measures proposed for climate change adaptation in the agricultural sector in this Nationally Determined Contribution (NDC) document.

Table 5.2 The main areas of adaptation of the livestock sector in the goals and plans of the NDC

<table>
<tr><th></th><th>Target</th><th>The main focus of the measures</th></tr>
<tr><td>Targets of the NDC</td><td rowspan="2">Reduce the impact of livestock husbandry risks, ensure sustainable sector development and increase production.</td><td>1. To improve pasture law and management
2. To increase the use of livestock water supply and the cultivation of fodder plants
3. Improving the system of protection against natural disasters such as drought and dzud</td></tr>
<tr><td rowspan="2">Plan of the NDC</td><td>1. Increase water resources and livestock feed production by building watering points and engineering wells
2. Carry out assessment and exploration of water resources to increase pastures and their circulating resources
3. Update/Renew feed preparation equipment</td></tr>
<tr><td>Reduce greenhouse gas emissions by reducing livestock numbers and improving livestock quality and productivity.</td><td>1. To increase the number of quality/highly productive livestock by implementing management based on genetic resources and insemination methods
2. To establish a work service unit for breeding and selection technology and create control
3. To limit the number of livestock, create meat reserves and increase meat exports
4. Research to develop a methodology for calculating the greenhouse gas emissions from pastoral livestock</td></tr>
</table>

As the table above shows, reducing the impact of livestock husbandry risks, ensuring sustainable development of the industry, limiting the increase in the number of livestock, and improving quality are the main objectives of this industry. To meet this goal of adapting to climate change, create a legal framework for the use and protection of grasslands and management; increase the supply of water and feed for livestock; strengthen the system of protection of livestock from natural disasters; improve livestock breeding and increase the number of quality and productive livestock; It is important to increase meat exports and implement measures to bring the number of livestock into line with the pasture carrying capacity. Based on these reasons, it is necessary to implement the following measures in the field of adaptation to climate change in livestock husbandry.

Develop pasture management. To reduce pasture degradation, to create a legal framework aimed at sustainable protection and appropriate use, and to foster collective management of pastures at the herders level. For it:

Adopt and implement the Pasture Law. This law should clearly legislate the rights, duties, and responsibilities of the stakeholders for the protection and proper use of pastures at the national, local, and herdsmen's levels.

- Adjust the amount of livestock annually to the pasture carrying capacity by increasing the export of disease-free meat.
- Reduce grazing pressure by increasing the number of high-yielding breeds of livestock.
- Reducing pasture load by feeding young livestock (lambs and calves) and preparing them for meat.
- Expanding the monitoring network of grassland vegetation and desertification, introducing modern methods and technologies in grassland assessment.
- Use livestock tax as an economic incentive for properly using and protecting pastures.
- To support herdsmen who have adjusted the number of their livestock to the pasture carrying capacity with a discounted "Green Loan" policy.
- *Expanding the healthy zone from livestock infectious and highly infectious diseases.* Improve the surveillance and control system to prevent highly contagious and infectious diseases in livestock, fully introduce tracking technology in the national network of livestock movement control and verification of the origin of livestock and livestock products, and expand meat production for export from protected areas.
- *Strengthening the resilience of pastoral livestock.* At the same time, while maintaining the gene pool and resilience of pastoral livestock adapted to climate change, introducing modern, advanced technologies in livestock breeding will breed more livestock that are more resistant to climate change.
- *Development of intensive livestock husbandry*. Support initiatives of citizens and the private sector to raise high-yielding livestock and engage in intensive livestock husbandry, breed fast-

growing meat-productive livestock, introduce efficient methods and technologies for intensive fattening meat production in adolescence, and reduce the number of wintering livestock.

- *Improve livestock feed supply.* A "Risk Fund" should be established in each sub-district with the income from the tax on the number of livestock. The fund will be spent on growing fodder, improving pastures, and increasing the supply of fodder.
- *Strengthening the natural disaster protection system*. Improve the early warning system for livestock herds against drought and dzud and create an opportunity to deliver information to herders based on modern information technology quickly.
- *Develop and improve access to livestock advisory services.* Establish a service system for introducing (extension) science and technology achievements and innovations in livestock husbandry production, disseminate technology and innovation information in the field of adaptation to climate change, and change their thinking, attitudes, and methods. To provide herders with information and recommendations in the scientific management of livestock husbandry and to increase their participation in the proper use and improvement of their pastures.

Arable farming. Generally, the arable farming sector has a crucial impact on livestock productivity and resilience toward climate change. In NDCs and its implementation plan, the government targeted to establish an enabling environment for the sustainable food chain based on defined measures.

Table 5.3 shows the general objectives and measures proposed in Mongolia's "Nationally Determined Contribution" and its implementation plan regarding adaptation to climate change in the agricultural sector.

Table 5.3 The main areas of adaptation of the agricultural sector in the goals and plans of the NDC

	Target	The main focus of the measures
Targets of NDC	By making proper use of the positive effects of climate change in the agricultural sector and mitigating its negative effects, creating conditions for the sustainable provision of healthy food for the population with agricultural products, fodder for livestock husbandry, and raw materials for the food industry	1. Use plastic mulch in irrigated potato and vegetable crops to save irrigation labor 2. To reduce water and irrigation costs and increase yields by introducing drip and permeation irrigation technologies in the production of irrigated potatoes, vegetables and fruits 3. Irrigated grain, fodder, and technical plant fields should be mulched with straw to protect them from evaporation, wind and water erosion, and mechanical structure damage and increase yield. 4. Introducing technology to reduce and eliminate mechanical soil erosion, to reduce the loss of soil moisture, mechanical structure, and the direct cost of soil erosion

Plan of the NDC		1. In the production of irrigated potatoes, vegetables and fruits to reduce water and irrigation costs and save labor: ▪ introduce drip and seepage irrigation technologies ▪ introduce synthetic film covering 2. Crops, fodder and technical plants to prevent the effects of climate change and drought: ▪ fence the area ▪ construction of forest strip

The main goal of this sector is to make proper use of the positive effects of climate change on agricultural production and to sustainably meet the country's needs with agricultural products by mitigating the negative effects. To meet this goal and adapt to climate change, the use of synthetic film and straw mulch in agricultural production, the introduction of drip and seepage irrigation technologies, the introduction of reduced and zero irrigation technologies, and the establishment of forest strips have been included.

Soil treatment. To protect fertile soil from wind erosion by reducing the number of tillages and the loss of soil moisture and mechanical structure, zero and reduced tillage technologies are introduced in agricultural production, and the area where these technologies are used is increased.

Crop seeds and sorts/varieties. The development and domestication of new crop seed varieties that are drought—and disease-resistant, ecologically adaptable, and short-maturing produce quality seeds and increase supply.

Straw mulch. Introduce the technology of mulching the surface of the field with grain straw to protect Mongolia’s fragile soil with a thin layer of humus and light mechanical components under conditions of severe drought and dryness, reduce the evaporation of soil moisture, and enrich the soil with organic matter.

Plastic film mulch. The introduction of synthetic film mulching in the production of potatoes, vegetables, and fruits is needed to reduce soil evaporation, increase heat, and reduce the growth of weeds.

Drip irrigation. Smart water-saving drip irrigation technology will be introduced to the production of potatoes, vegetables, and fruits, and the amount of cultivated land will be expanded with this type of irrigation.

Irrigated agriculture. Increase the amount of irrigated agricultural land based on advanced technology to use water resources appropriately, reduce water consumption, and create opportunities for sustainable harvests.

Sponge, pond. Using the natural water resources of snow and rain, build ponds in small agricultural fields, absorb excess water into the soil, and introduce irrigation technology to create opportunities for sustainable harvests.

Fertilize. To keep humus content stable without reducing soil fertility, systematic fertilization of agricultural land with mineral and organic fertilizers should be combined with modern smart technology.

Forest strip. Expand the construction of forest strips to protect the soil of agricultural fields from wind erosion, protect crops from cold shock, stabilize snow, and reduce water evaporation.

Crop rotation. Appropriate crop rotation can increase the variety of crops in the rotation that are suitable for Mongolia's climatic characteristics, reduce the specific weight of solid fallow, and improve the fertility of agricultural soil.

Forest. Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Dorjsuren et al., 2017; UN REDD program. REDD+Glossary. tttps://www.unredd .net/ knowledge/glossary.html). For the forestry sector, adaptation includes a range of activities that support sustainable forest management, forest conservation, restoration, ecosystem integrity, and environmental benefits.

In today's rapidly changing climate, developing and using advanced technologies to create favorable environmental conditions and economic growth is of particular importance to ensure sustainable development. An important condition for the successful implementation of technology is the preservation, increase, and efficient use of natural resources, reduction of pollution, low carbon emissions, improvement of the quality of ecosystem services, and prevention of the loss of biodiversity.

In Mongolia’s NDC and its implementation plan, carbon sequestration related measures while introducing the sustainable management and encouraging actions to improve the natural ecosystem of the forest were included in the forestry sector targets and measures. In particular, the possibility of using technology in the forestry sector to adapt to climate change is defined in the plan for the implementation of the NDC in the form of "strengthening the capacity of forestry professionals and organizing training courses on forest clearing technologies and methods" in order to create adaptive capacity. The table 5.4 emphasized the targets and measures of the forestry sector that are included in both NDC and its implementation plan.

Table 5.4 The main areas of adaptation of the forestry sector in the goals and plans of the NDC

	Target	The main focus of the measures
Targets of NDC	Create forest ecosystems that are well adapted to climate change and enhance carbon sink by implementing sustainable forest management.	• Implementing forestry measures such as thinning and deadwood removal to improve forest structure and conditions and to create a highly productive and climate change-resilient forest; • Increasing the non-carbon and socio-economic benefits of forests by implementing sustainable forest management.
Plan of the NDC	Increase resilience to climate change and build adaptive capacity.	Create forest ecosystems well adapted to climate change and enhance carbon sequestration by implementing sustainable forest management

		▪ Organize training on climate change resilience and adaptation of forest ecosystem, accreditation of professional forestry organizations, adopt forest maintenance and cleaning technologies and processes, determining and assessing degrading forest

5.3 Adaptation project proposal

Project name	***1. To develop collective pasture management***
Project direction	Comprehensive implementation of the management and legal environment to match the number of livestock to the pasture carrying capacity in soum

Background of the project. Since the transition of Mongolia to the market system, the number of herds in all provinces, soums, and herder families has continuously increased, the herd structure has changed in a way that affects pastures, and the traditional regulation of herdsmen's use and protection of pastures has tended to be lost. As a result, the pasture carrying capacity is exceeded and the state of the pastures continues to deteriorate. On the other hand, the implementation of the state law on the use and protection of pastures is insufficient. Therefore, it is important to form collective pasture management based on the initiative of herders at the sub-district level. In other words, it is necessary for herders to develop and implement procedures and plans for the proper use of pastures together.

Project description. At the level of soum, their own initiative organizations such as the Herdsmen's Association and the Grassland Users' Group, with the support of the "Representative Assembly of soum citizens" and the "Governor's Office of soum", will implement the following activities to develop collective management of pastures. It includes:

- Developing and approving collective management procedures for pastures in soum. In this, the functions and responsibilities of the parties involved in the collective management of grasslands should be implemented in detail.
- To develop and implement a collective management plan for pastures. In this, it is necessary to clearly reflect and implement the measures to alternate use, leave, restore, and keep the number of livestock to the pasture carrying capacity.
- Capacity building training will be conducted to spread the good practices of other soum and provinces that have effectively implemented joint management of pastures in soum, where the project will be implemented.

Project name	***2. To support livestock marketing cooperatives***
Project direction	Empowering herdsmen's marketing cooperatives, improving livestock, raw material and product preparation networks, and increasing sales

Background of the project. Herders are far away from the market and are scattered, so they cannot efficiently supply livestock raw materials and products to the market in a unified manner. Because of this, they provide their raw materials and products mainly to small businessmen at low prices. On the other hand, they only want to increase the number of livestock to increase their income. This not only has a negative impact on the livelihood of herders, but also leads to the overcapacity of pastures. Therefore, it is important to support marketing organization based on herdsmen's cooperatives at the sub level and it is in their common interests.

Project description. Responsible for receiving, storing and sorting livestock raw materials and products at the soum level, performing primary processing, packaging, preparing for the next stage of sale, providing price information to herders, making contracts, taking orders for consumer goods from herders and supplying them. Establish a cooperative based on the initiative of the herdsmen. If already established, the infrastructure and management capacity of the cooperative will be strengthened. The new infrastructure will be:

- storage warehouse for livestock raw materials and products;

- a fence for receiving and temporarily detaining livestock;
- along with related equipment such as raw materials sorting and primary weighing facilities, weighing equipment;
- an information center that provides information on prices and commodity deals.
- Capacity building training will be conducted for members on cooperative management and marketing activities.

Project name	***3. To support the business of livestock feeding and meat processing***
Project direction	Business activities focused on livestock feeding, slaughtering, and primary processing of raw materials

Background of the project. Herdsmen and people with livestock are not able to sell their livestock and meat for business purposes. As a result, the income of herdsmen is not increasing, and the number of livestock is increasing, which is the main condition for overgrazing. In addition, in rural areas, livestock are slaughtered in the open and the meat is stored in inappropriate places, which do not meet food hygiene and sanitation requirements. Since there is little opportunity to supply the population with meat from pasture-raised livestock throughout the year, especially in the spring and early summer months, the increase in the price of meat has a negative impact on their livelihood. Therefore, it is important to support the business activities of intensively fattening, industrial slaughtering and storage of meat cattle and young livestock of the people who own livestock living in and around the center of soum.

Project description. Based on the above needs, this project will be implemented in order to feed out livestock, slaughter livestock, process meat, store it, and supply it to the market. The following activities will be implemented in order to feed beef cattle and young livestock at the soum level, fatten them in a short period of time, process them for slaughter and supply them to the market. It includes:

- establish a field for feeding livestock and providing necessary fodder;
- establishment of a small-scale workshop for llivestock slaughtering;
- providing equipment for primary meat processing and packaging;
- building a dedicated meat cellar;
- creating conditions for a stable supply of meat for schools, kindergartens, hospitals and local markets in soum.
- Empowerment training on livestock feeding, meat processing and storage technology will be conducted for the target group of project implementation.

Project name	***4. To support development of intensive livestock husbandry***
Project direction	Development of intensive dairy and meat farming

Background of the project. Herdsmen have focused mainly on the increase in the number of their herds, not the quality, which on the one hand leads to pasture degradation, and on the other hand, it makes it difficult to meet the growing population's need for meat and milk. On the other hand, in recent years, citizens and business owners have tended to increase the initiative of intensive livestock husbandry in the areas around cities and towns. However, herders and citizens have a lack of experience in intensive livestock husbandry, as well as lack of capital for their start-up business. In addition, the price of highly productive breeding livestock is high and there is a lack of feed resources. Therefore, based on the citizens' initiative on intensive livestock husbandry at the soum level, supporting and developing intensive meat and dairy livestock husbandry will not only contribute to meeting the meat and milk needs of the population with a small number of high-quality livestock, but also be beneficial in reducing the burden on pastures.

Project description. Within the framework of this project, supporting citizen’s initiatives to establish intensive livestock husbandry in order to meet the population's meat and milk needs throughout the year with a small number of high-yielding meat and milk breeds will be implemented. It includes:

- planting and watering the pastures of perennial plants, planting forage plants and creating fodder reserves;
- construction of fences, sheds and other buildings for intensive livestock farming according to standards
- to provide highly profitable breeding and dairy cattle and organize breeding work on a scientific basis

- efficient sale of produced meat and milk to the target market.
- It is important to include the issue of intensive livestock husbandry development in the province and soum in the relevant plans of the province and to support these entrepreneurs in every way.

Project name	***5. Formation/Create food reserves in soum***
Project direction	Creation of security reserve fund for hay and fodder

Background of the project. Researchers warn that due to the deterioration of pastures and the lack of fodder for livestock, the quality of livestock is deteriorating, and their bodies are becoming more and more vulnerable. On the other hand, as the frequency and risk of natural disasters are increasing due to climate change, there is a need to create safe fodder reserves with the cooperation of local government organizations and herders. Therefore, it is very important to create a safe stock of fodder and grass in order to reduce the risk of livestock husbandry production at the soum level and to protect the livelihood of herders from the negative effects of natural disasters. Supporting the project to be implemented in this area with the source of livestock tax revenue will be in line with the common interests of the herdsmen.

Project description. With the implementation of this project, the ability to protect livestock from natural risks will be created in soum, and for this purpose, the following activities will be implemented. It includes:

- increase fodder resources by growing irrigated fodder crops and irrigating hayfields in areas where there is a possibility;
- if there is no such possibility, buy grass and fodder from the nearest province and soum and store it under contract
- building fences and warehouses for fodder storage, providing necessary machinery and equipment for fodder production
- to develop and follow the procedure for spending the soum grass and fodder safety reserve fund, and it is important to clearly reflect the participation and functions of the herdsmen and the state administrative organization in the soum.

Project name	6. **Crop feed production**
Project direction	Increase the amount of forage production

Background of the project. There is a lack of high-protein forage for intensive livestock husbandry development in Mongolia's agricultural areas. Pastoral families and cooperatives of pastoralists are in great demand to cultivate perennial forage plants such as alfalfa in order to improve their pastures and hayfields in addition to growing fodder crops such as oats, barley, and sudan. To solve this problem, it is important to provide the necessary seeds, techniques and equipment. However, farmers in agricultural areas lack the financial means to solve this problem. Therefore, it is necessary to grow annual and perennial fodder crops based on the suggestions of herders and experts in the agricultural area, and improve the supply of intensive livestock feed. Supporting the project in this area with the source of livestock tax revenue will be in the interest of intensive livestock herders in agricultural areas.

Project description. Within the framework of this project, herders and their cooperatives in agricultural areas will supported their initiatives to grow fodder plants and improve their feed supply. Within the framework of the project, the following activities will be supported in order to improve the feed supply of intensive livestock farming. It includes:

- To provide the necessary equipment, seeds and other inputs for the cultivation of fodder plants in the small area of the herdsmen engaged in intensive livestock husbandry and their cooperatives.
- Technological training on forage cultivation will be conducted for project farmers and members of their cooperatives, and their capacity will be strengthened.

Project name	**7. Straw mulch**
Project direction	Protection of soil moisture in grain fields with straw mulch

Background of the project. The negative effects of climate change are clearly visible in the agricultural areas of Mongolia. Due to high evaporation of soil moisture in grain fields, yield is reduced due to lack of soil moisture supply during planting. Also, the humus layer of the soil is blown away by the wind and is losing its fertility. Therefore, based on the initiative of farmers and local government administration, it is possible to solve the above problem by introducing straw mulch farming technology in grain production. It is necessary to finance the project in this field through foreign projects.
Project description. In the framework of this project, straw mulching technology will be introduced in the fields with abundant grain straw resources in the central agricultural area. Within the framework of the project, the following activities will be implemented in order to reduce the evaporation of moisture from the agricultural fields and enrich the soil with organic matter. It includes: - development of the location and size of the straw mulching area, calculation of required straw, technological basis, and mulching according to the technology; - build a fence to protect the straw-covered area from livestock and animals; - farmers will be trained on sustainable and efficient use of straw mulch.

Project name	**8. Plastic film mulch**
Project direction	Reduce evaporation in potato, vegetable and fruit fields
Background of the project. Potatoes, vegetables, and fruits cultivated at the household level are irrigated, but there are problems with protecting soil moisture from evaporation, maintaining soil heat, and protecting crops from weeds during summer extreme heat. The main way to solve this problem is to use synthetic film mulching in relatively small areas of these types of crops. Therefore, it is necessary to implement this project to supply quality acrylic film according to the demand and interest of potato, vegetable, greenhouse and fruit farmers. Funding required for the implementation of this project can be provided from the Agricultural Support Fund.	
Project description. Within the framework of this project, high-quality plastic film will be supplied on the basis of repayment terms in accordance with the request of potato, vegetable, greenhouse, and fruit producers. The following activities will be implemented within the project. - to study in advance the interest and demand of producers of potatoes, vegetables, greenhouses and fruits in using synthetic film mulch; - find and prepare synthetic film coating to be supplied from the foreign market; - enter into contracts with farmers and supply with repayment conditions; - in the future, training will be given to farmers on how to use synthetic film mulch and how to dispose of waste products without polluting the environment.	

Project name	**9. Drip irrigation**
Project direction	Introduce water-saving irrigation technology in the production of potatoes, vegetables, greenhouses and fruits
Background of the project. In the context of climate change, the importance of using advanced technologies that conserve natural resources is growing greatly. There is a need to introduce smart drip irrigation based on solar energy in potato, vegetable, greenhouse and fruit crops. Therefore, a common drip irrigation project will be implemented for potato, vegetable, greenhouse, and fruit producers (choose one of these sectors) with integrated irrigation systems. Funding needed for the implementation of this project can be provided by the Foreign Project Program, the Agricultural Support Fund, and the Joint financing of farmers.	

Project description. Within this project, smart drip irrigation technology using solar energy will be introduced according to the demand of potato, vegetable, greenhouse and fruit producers. The following activities will be implemented within the project. It includes:

- to study in advance the interests and demands of potato, vegetable, greenhouse, and fruit producers regarding the introduction of smart technology of drip irrigation with solar energy, and to select the location of the implementation site and the project implementers;
- finding and preparing smart drip irrigation technology kits and related equipment from foreign and domestic markets;
- development of solutions for solar energy and shared water sources;
- enter into contracts with farmers and supply with repayment terms;
- in the future, farmers will be trained on how to introduce smart drip irrigation technology.

Project name	**10. Forest strip**
Project direction	Construction of protective forest strips in grain, fodder and technical cultivation areas

Background of the project. In Mongolia's weather conditions, it is very important to build a forest strip around the cultivated fields to protect the soil from wind erosion, to create a microenvironment and to maintain moisture. The establishment of forest strips is important for contributing to the implementation of the "Billion Trees" national program and for adapting agriculture to climate change. Therefore, the project of establishing a protective forest strip will be implemented in the owned grain, fodder, and technical cultivation areas. Funding sources for the implementation of this project can be provided through the Agricultural Support Fund, farmers' own funds, foreign projects, and joint financing.

Project description. As part of this project, a protective forest strip will be established in the fields of grain, fodder and technical cultivation. The following activities will be implemented within the project. It includes:

- to select the place, its location, and project implementers for the construction of the forest strip, and to develop the technical and economic basis for the construction of the forest strip;
- developing solutions for planting, irrigation and care of trees in the forest strip, finding and preparing the necessary technical and technological sets and equipment from the foreign and domestic markets;
- sign contracts with farmers and negotiate and implement payment terms;
- provide training to farmers on how to build and maintain forest strips.

Project name	**11. Sponge, pond**
Project direction	Build lakes and ponds with surplus water from snow and rain, and use it to irrigate hay and crops

Background of the project. Water supply for pastures and hay is insufficient in most regions of Mongolia. However, during the winter, spring and summer when there is a lot of snow and rain, we cannot take advantage of the opportunity to improve the water supply for hay and crops. In recent years, in some provinces, there has been an experience of improving the water supply of pastures and hay by building artificial lakes, ponds, and ponds with excess water from snow and rain. Such ponds can be used to water livestock in water-deficient areas and to irrigate hayfields to increase fodder reserves. Therefore, it is important to build artificial lakes, marshes, and ponds for spring and summer pastures, as well as hay fields, based on the opinions of herdsmen and the survey of areas where marshes and ponds can be built. Supporting the project to be implemented in this area with the source of livestock tax revenue will be in the common interests of the herdsmen.

Project description. Within the scope of this project, we will build ponds to be used by herders to irrigate the spring and summer pastures, hayfields, and fodder fields of the land that are available under natural conditions. Within the framework of the project, the following activities will be implemented in order to improve water supply for pastures, hay, and cultivated fodder. It includes:

- construction of ponds according to appropriate plans;
- construction of dams to collect snow and rainwater in ponds

-	Training will be conducted for herders, groups of herders, and pasture users on how to use the ponds established in the future in a sustainable and efficient manner.

12. Technology: Forestry Project name: Reforestation technology of planting the containerized seedlings	
1. Technological parameters	
Intoduction	Mongolia is implementing a national campaign to plant “One Billion Trees”, which initiated by President of Mongolia as part of a global green revolution to combat global warming and reduce the impact of climate change. In recent years, it is started planting containerized seedlings for reforestation. It ensures the transport of seedlings without drying in various weather conditions, increases the planting period, seedlings planted on open areas grow well, the survival rate of seedlings is increased. The project is important for the national tree-planting of "One Billion Tree” national movement.
The implemention necessity	Mongolia has a harsh continental climate with sharply defined seasons, high annual and diurnal temperature fluctuations and low rainfall. There are generally two types of tree seedlings grown for large-scale plantings: bareroot and container. The planting period coincides roughly with the dormant period of the seedlings. This period is usually from September form 20-25th to April 20-25th in Mongolia, Using containerized seedlings has several advantages over using bare root seedlings. A containerized seedling can be produced at any time of the year. Producing containerized seedlings makes more efficient use of limited numbers of seeds. Using containerized seedlings extends the planting season, often improves growth of seedlins planted on adverse sites, and survival is increased generally.
The features of the technology	The seeds of trees are sown in a container with a mixed nutrient substrate of semi-decomposed peat and perlite and will be grown in a greenhouse for 1-2 years. In one greenhouse 6 m x 30 m, 75,000 pieces of seedlings will be grown. Remove 20 cm x 20 cm surface soil and plant 2,000 pieces of containerized seedlings per hectare.
Institutional organization	Polyethylene film, greenhouse, container, substrate for growing seeds with peat, irrigation equipment and other equipment necessary for growing seedlings of coniferous species in greenhouses should be ordered by the request of entities and organizations and received from China, Israel, Japan, South Korea, Finland and other countries. It is necessary to organize a training on growing seedlings and planting.
Permanent activity	Reforestation technology of planting the containerized seedlings will be carried out by forest user groups forest entities and organizations. The process of growing seedlings in container usually takes 2 years. Starting from the 3rd year, 4,000 hectares of land will be regularly reforested by containerized seedlings every year. The government should support the import of greenhouse, container, peat, fertilizers, tools and equipments, and and customs duties should be reduced.
Countries implementing this technology	The technology of afforestation with the containerized seedlings is widely used in China, Korea, Japan, Australia, USA, Canada and Scandinavian countries.
Climate compatibility	For Mongolia, which has a harsh and dry climate and a short growing season, above mentioned technology is more suitable for dry habitat and necessary. This technology improves the survival rate of seedlings planted for afforestation or reforestation.
Framework of social beneficiaries	The beneficiaries of the technological results will be more than 700 citizens, also urban gardening and forestry organizations involved in growing trees, fruit and berry bushes and tree planting. All citizens of Mongolia will receive environmental benefits from the project.

2. Costs and expenses: The cost of 1 hectare afforestation in the boreal forest area by planting coniferous seedlins is 7.0 million MNT. If Mongolia will plant seedlings on 4,000 hectares, the cost would be 28.0 billion MNT.	
Required total costs From the State Budget From companies and organizations and proviences	28.0 million MNT 7.0 million MNT (1000 ha, 2 million seedlings) 7.0 million MNT (1000 ha, 2 million seedlings) 14.0 million MNT (2000 ha, 4 million seedlings)
Additional costs in the "business as usual" scenario	This technology can also be used for planting fruit trees and urban gardening. There will no additional costs if the dollar exchange rate and global economic conditions are stable.
3. Efficiency and impact on the country's development	
Economic working place	Growing seedlings in a container will create 39,162 man-days (366 man-days x 107 greenhouses) working places and planting seedlings 8,000 man-days (2 man-days x 4,000 ha), a total of 47,162 man-days working places of new seasonal jobs.
Investment	Investment 2 billion 712 million MNT
Social	
Income	More than 700 citizens-foresters have a monthly income of more than 600,000 MNT for up to 7 months.
Education	More than 700 new workers will be trained to breed tree seedlings in conainer and plant trees.
Health	Large-scale planting of seedlings and saplins of deciduous, coniferous and fruit trees will improve human health and ecological environment.
Environmental importance	Planting the containerized seedlings in afforestation areas will increase results and area of forest restoration and afforestation in Mongolia. Afforestation of 4,000 hectares annually will reduce deforestation and greenhouse gas emissions.
4. Local features and conditions	
Opportunities and barriers	At present, nursery producers have grown seedlings in greenhouses and planting trees, but do not have sufficient knowledge of the technology of growing the containeried seedlingsas well as stocks of seeds, equipment and material base are also not enough, financial capabilities are weak
Time	The project can be introduced in 2-3 years. After that, the operation will be smooth.
Spatial dimensions	It can be implemented in all provinces where afforestation and tree breeding activities are carried out.

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CHAPTER 6. POLICIES AND MEASURES TO REDUCE GREENHOUSE GAS EMISSIONS

Mongolia's key national policies and programs with documentation on GHG emission reduction are "Vision-2050", "Mongolia's new revival policy 2021", "Mongolia's nationally determined contribution" (NDC) (2019-2030), "Sustainable development vision 2030 (2016)", "Action program of the government of Mongolia (2016-2020, 2020-2024)", "National action program on climate change (NAPCC) (2011-2021)", "Green Development Policy (2014-2030)", "Mongolia's five-year development guidelines for 2021-2025, (2020)", "Mongolian National Program for Reducing Air and Environment Pollution, 2017–2025" (Government of Mongolia, 2017b). These documents are reflecting the government policies, programs, and sectors' plans.

Mongolia's updated Nationally Determined Contribution (NDC) document was approved by the Government Resolution No.407 of November 2019 to contribute to the Paris Agreement. The previous goal of reducing GHG emissions was recalculated to 22.7% in 2030. If removals of the forest are calculated, the reduction of GHG emissions can be up to 38.4%, and by implementing some conditional measures, the result can be as 44.9%. The policy and reform program of the GHG emission sector is considered as follows.

6.1 Policy and measures to reduce the GHG emissions in the energy sector

The energy sector is not only a vital economic sector that needs to be developed ahead to ensure the country's security and economic and social development but also represents half of the total GHG emissions. Most GHG emissions are related to the burning, mining, and transporting of coal and liquid fuels. According to future economic and social development trends, GHG emissions in the energy sector are expected to increase sharply.

The GHG emissions associated with this sector are divided into subsectors: energy production and consumption. In addition to heat and electricity generation, fuel quarrying is included in the power generation sub-sector, while the energy consumption sub-sector includes the amount of fuel and energy used in construction, industry, transportation, and agricultural activities (iBUR, 2017; NDC, 2019).

In addition to heat and electricity production, the energy sector has developed closely with the construction, transportation, and agriculture sectors, which use a large amount of energy. Therefore, GHG emissions from the above sectors and mitigation measures are directly related to the laws, legal and policy documents for the development of those sectors, as well as the planning and implementation of related projects and programs. Table 6.1 shows the primary documents of policies and measures related to climate change mitigation and reducing GHG emissions in the Mongolian energy sector.

Table 6.1 Updates on policies and programs to reduce GHG emissions from the energy sector

Legal documents	Policy documents	Related programs and actions
- Law of Mongolia on Energy (PoM, 2001, updated by 2023) - Law of Mongolia on Renewable Energy (PoM, 2007 and 2015) - Law of Mongolia on The Energy Conservation (PoM, 2015	- Green Development Policy, 2014-2030 (PoM, 2014a) - State policy on energy 2015-2030 (PoM, 2015a) - *State policy on railway transport (PoM, 2010a and 2018) - *State policy on transportation 2018-2026 (GoM, 2018a) - *State policy on the construction industry 2018-2029 (GoM, 2019a) - *Vision-2050 (PoM, 2020c) - *State policy on the development of the petroleum sector for 2018-2027 (GoM, 2018f) - "The Government action program 2016-2022 and 2020-2024" (GoM, 2020)	- *Action plan for the implementation of Mongolia's Green Development Policy for 2016-2030 (GoM, 2016) - *National program to reduce air and environmental pollution 2017-2025 (GoM, 2017a) - *Mongolian national energy conservation action program 2018-2022 (GoM, 2017c) - *The national midterm program to develop the state policy on energy 2018-2023 (GoM, 2018e) - *The national program "150 thousand households- apartments" 2018-2023 (GoM, 2019b) - *Action plan for the implementation of Nationally Determined Contribution (NCC, 2021) - Medium term Strategy on Energy, 2019-2030 (GoM, 2019)

** Newly approved and amended documents after submitting iBUR and TNC*

Note: Some policy documents in this table were annulled by decision of Parliament resolution No 89, Nov 12th 2021, Government of Mongolia, Resolution No 314, Oct 13th 2021.

The following measures were included in iBUR:

- Increasing the share of renewable energy in energy production,
- Reducing heat and electricity loss in transmission and distribution systems and ineffective consumption,
- Decreasing heat loss in buildings and increasing energy efficiency,
- Reducing the consumption of solid and liquid fuels by improving road and transport infrastructure,
- Increasing the number of vehicles that use gas fuel and low fuel.

In addition to the above measures, following policies and measures reflected in the newly approved and revised policies and programs were included in this report:

- Banning the use of raw coal in Ulaanbaatar and use improved fuel,
- Implementing advanced technology in integrated energy systems to store energy in the power grid.

6.1.1 Implementation of policies and measures in the energy sector

Within the framework of policies and programs issued for the sector, the main measures taken to reduce greenhouse gas emissions are divided into two main groups: *increasing the use of renewable energy and improving energy efficiency*. This is detailed in the "iBUR Report on GHG Emissions and Removals" as follows, and the implementation of the goals set for 2015-2020 for these measures is shown in Table 6.2.

Table 6.2 Implementation of policies and measures for the energy sector reported in iBUR and TNC

No	Policies and measures	Targets reported in iBUR. (In 2020)	Implementation
1	Increasing the share of renewable energy in energy production	Optimizing the pricing policy will increase energy efficiency, and the share of renewable energy in energy production will reach 20% by 2020. The share of renewable energy in the total installed capacity for domestic needs will reach 20% in 2023.	Renewable energy sources account for 9.1% of the total energy production, and the utilization rate is 46% (ERC, 2021) by January 2021. However, the share of installed capacity share reached 17.2% in 2020, and the implementation is 86% (MoE, 2021). In 2017, a 10 MW solar plant in Darkhan-Uul province, a 10 MW solar plant in suburb of Ulaanbaatar, in 2018 15 MW solar power plant in Zamyn-Uud, Dornogovi province, and a 10 MW solar plant in Sumber soum, Gobisumber province, have been put into operation. In 2019, 15 MW of Solar Power Plant in Khushigt valley in Sergelen soum of the Tuv province started its operation. In accordance with the Renewable Energy Promotion Program from 2019 to 2023 endorsed in 2020, in western region of Mongolia would be installed renewable energy sources with capacity of 40.5 MW (GoM, 2021b). In that way, the western region of Mongolia is expected to be the first region in Mongolia which is able to meet its electricity demand using renewable energy sources.
2	Reducing heat and electricity loss in transmission and distribution systems and ineffective consumption	By renewing energy production and industrial technology, the internal consumption of thermal power plants will be reduced from 14.4% in 2014 to 11.2% in 2023, and the loss of electricity transmission and distribution networks will be reduced by 15.29% in 2014 to 10.8% in 2023.	As of January 2021, the internal consumption of electricity by Thermal Power Plants accounts for 13.3%, the losses of transmission and distribution networks account for 13.6%. The implementation related to internal consumption is 34% and target related to transmission loss is 51%, respectively (ERC, 2020; MoE, 2021). "The Second Energy Sector Project" /2017-2022/ is being implemented to reduce the loss of the distribution network, with the loan funds of the World Bank. Reducing losses in the transmission and distribution network, installing smart meters, introducing intelligent

			meters, and integrating sales software are in progress (GoM, 2021b).
3	Decreasing heat loss in buildings and increasing energy efficiency	Localization of green solutions, advanced technologies, and standards, such as the green building evaluation system and energy audits, implementation of incentives and discount mechanisms to support them, and reduction of building heat loss by 20% in 2020.	A 10% target corresponds to a 2% decrease in building heat loss by 2020. (MoE, 2021). Some of the implementations are already under the NAMA for construction sector.
4	Reduce the consumption of solid and liquid fuels by improving road and transport infrastructure.	Increase the length of paved roads to 8,000 km in 2015 and 11,000 km in 2021 and reduce coal and liquid fuel consumption by electrifying railways (PoM, 2008; PoM, 2016a).	In January 2021, the length of paved roads reached 10,151 km (NSO, 2021). Implementation is 96%.
5	Increasing the number of vehicles that use gas fuel and low fuel cars	Development of new gas emission standards for vehicles and engines, a transition of fuel-powered vehicles to liquefied gas fuel by improving environmental tax and payment systems, and increasing the share of vehicles with low fuel consumption in total vehicles from 6.5% in 2014 to 13% in 2030.	As of 2018, 18.53% of all vehicles registered in Mongolia are vehicles with a hybrid engine, 2.34% with a gas engine, and 0.02% with an electric engine (NRTC, 2018) In 2020, compared to 2016, the number of electric vehicles increased by 4.3 times and cars using gas fuel increased by 1.7 times. The number of gasoline and hybrid vehicles was 816,800, or 72.5%; diesel vehicles were 284,600, or 25.3%, and gas vehicles were 24,100, or 2.1% (MRTD, 2021).
6	Development of the chemical industry sector, the needs of major brands, and the demand for fuel types for domestic production products that meet international standards	In 2020, 20% of the main fuel demand will be fully met with fuel meeting the Euro 4 standard in 2025, 70% of the demand with fuel meeting the Euro 5 standard in 2030, 100% of the demand with fuel meeting the Euro 5 standard (PoM, 2016a).	In 2020, 20% of domestic production did not meet the need for Euro 4 fuel, but imports accounted for 26.2% of Euro 4 fuel (MRPA, 2021), and the implementation is 106.2%. Gasoline and diesel fuel meeting the requirements of the Euro-5 standard accounted for 12.8% of the total imported fuel (MET, 2021a).

6.2 Policy and measures to reduce the GHG emissions in the industry sector

The industrial sector is crucial for the country's economic development. Considering this, the Mongolian Government has been actively supporting the sector through policies to increase its share of GDP to satisfy the domestic and international demand for manufactured products and services to achieve the goal of being a competitive exporter of manufactured products. As the Mongolian economy develops and industries shift to more modern, GHG emissions from production and consumption are expected to arise.

According to Mongolia's 2017 National Biennial Update Report, the industrial process and product consumption sector produced 321.8 thousand tonnes of CO_2 in 2014 or 0.95% of the country's GHG emissions. This estimate has grown tremendously, and GHG emissions from industrial processes and product consumption will total 2233 thousand t CO_2 in 2020, 7930 thousand tonnes of CO_2 in 2025, and 12,288.6 thousand tonnes of CO_2 in 2030. In addition to cement and lime production, this calculation considered methane emissions from coal mining and oil extraction and future GHG emissions from large projects included in the government policy.

Mongolia produced 322.5 thousand tonnes of cement in 2010, 410.1 thousand tonnes in 2015, and 1182 thousand tonnes in 2020, based solely on the cement industry. For example, along with this sharp increase in production, there is also a rise in the consumption of building supplies, iron, cashmere, leather, food production, refrigeration, and air conditioning equipment. Between 2010 and 2020, the output growth of the main types of products in the industrial sector will have tripled.

The primary policy documents for reducing GHG emissions in Mongolia's industrial sector are displayed in Table 6.3.

Table 6.3 Updates on policies and programs to reduce GHG emissions from the industry sector

Legal documents	Policy Documents	Related programs and measures
- Law on Small and Medium Enterprises (SME) (PoM, 2007c, 2016) - Law on Manufacturing Promotion (PoM, 2015c)	- Green Development Policy 2014-2030 (PoM, 2014) - ‘The State Industrial Policy of Mongolia’ (PoM, 2015b) - ‘Mongolia Sustainable Development Vision-2030” (PoM, 2016) - Government Action Programme 2016-2020” (PoM, 2016) - *State policy on the construction industry of Mongolia 2018-2029 (GoM, 2019a) - *Vision - 2050 (PoM, 2020c) - *National Program for the Development of Heavy Industry (GoM, 2019c) - *Mongolia’s Five-Year Development Guidelines for 2021-2025 (PoM, 2020b)	- *Action plan for the implementation of the Green Development Policy 2016-2030 (GoM, 2016) - *National program for the reduction of air and Environmental Pollution 2017-2025 (GoM, 2017a) - *’National programs’ industrialization 21: 100’ (2018-2021), (GoM, 2018g) - ‘Cashmere’ (2018-2021), (GoM, 2018h). - *“150,000 Family Housing” National Program 2018-2023 (GoM, 2019b) - *Action plan for the implementation of Nationally Determined Contribution (NCC, 2021) - *Implementation plan of the Action Plan of the Government of Mongolia for 2020-2024 (PoM, 2020a). - *National Program for the Development of Heavy Industry (GoM, 2019c)

**Newly approved and amended documents after submitting iBUR and TNC*

After analysing these documents, the following policies, and measures to reduce GHG emissions were included in iBUR and TNC.

- Introduce dry technology in cement production,

- Increase productivity through advanced technology,
- Supply fuel demand by domestic production.

After the iBUR and TNC submission, NDC, 2019 included several policies and measures to reduce greenhouse gas emissions. These are as follows:

- Use waste heat from cement plants
- Use of fly ash in cement production

6.2.1 Implementation of policies and measures in the industry sector

The directions and provisions related to the reduction of GHG emissions related to industrialization, growth, and technical and technological innovation of Mongolia's industrial sector are detailed in iBUR and TNC, and the implementation of the goals set for 2015-2020 for these measures is shown in Table 6.4.

Table 6.4 Implementation of policies and measures for the industry sector reported in iBUR and TNC

No	Policies and measures	Targets reported in iBUR (in 2020)	Implementation
1	Development of industries based on advanced techniques, technology, and innovation, increase productivity	The share of processed manufacturing in total exports will increase to 15% in 2020 and 25% in 2025, and the full processing of raw materials such as leather, wool, and cashmere will be increased to 60% in 2020, 70% in 2025, and 80% in 2030 (PoM, 2016a).	As of January 2020, the share of the processing industry in total exports was 16.9% (NSO, 2021), and the implementation is 112.7%.
2	Introduction of dry technology in cement production	In 2030, Mongolian cement factories will be completely transferred to dry technology, and the product price will be reduced by 30-40% (PoM, 2011a).	On November 15, 2021, 6 complete cement factories and four clinker mills (dry technology) were operating in Mongolia, with a total annual cement production capacity of 3.6 million tonnes; in addition, to meet the demand of the domestic market 100%, but also it is possible to export up to 2.0 million tonnes of cement per year (MCUD, No. 3/4468, 2021).
3	Development of processing industries and complete processing of raw materials such as leather, wool, and cashmere	Complete processing will reach 60% in 2020, 70% in 2025, and 80% in 2030, and the share of processing and service sector products in the total domestic product will have doubled from the level of 2014 (PoM, 2016a, PoM, 2015e)	Depending on the type of production, the installed capacity of the factories is utilized by 5-61% due to conditions such as the state of the country's socioeconomic status, the income level of the population, and relatively low sales in domestic and foreign markets. Of this, 41% are used for washing, 51% for combing, 46% for spinning, 48% for knitting and weaving, 45% for carpets, 57% for non-woven goods, 61% for felting, and 5% for wool insulation materials (MOFALI, 2021). In 2020, the production rate for complete leather processing was 41%. 50% of the leather processing industry is semi-processed, 38% is leather, and 12% is

			processing factory wool cashmere, which is industrial waste (GoM, 2021b). 44.48% of the leather is semi-processed, 6.17% is deep-processed, and the remaining 55.52% is devalued (MOFALI, 2020b).

6.3 Policy and measures to reduce the GHG emissions in the AFOLU sector

The Ministry of Food, Agriculture and Light Industries (MOFALI) has approved the implementation of the Mongolian Sustainable Livestock Development Plan (2018-2020) to address issues in the livestock sector at an adequate level, to ensure consistency with approved programs, and to increase Mongolia's contribution to the Global Agenda for Sustainable Livestock Action Plan (GASL, 2022).

Regarding the current agricultural (arable farming) situation, the cultivated land area increases every year, and the area of abandoned land decreases. The appropriate solution to reducing GHG emissions from cropland is not to plough additional land and use advanced technology.

The increasing number of livestock is one of the leading causes of overgrazing and pasture degradation. In 2018, the National Statistical Office conducted a structural survey of herds to match the current overgrazing capacity of Mongolia and identified 51.6 million heads of herds suitable for grazing resources, compared to 2017, which was 22.0% or 14.6 million heads of livestock. ("Livestock herds report on pasture carrying capacity and conditions" NSO, 2018).

Regarding the current agricultural (arable farming) situation, the cultivated land area increases every year, and the area of abandoned land decreases. The appropriate solution to reducing greenhouse gas emissions from cropland is not to plough additional land and use advanced technology. Greenhouse gases emitted by agricultural activities depend on changes in soil properties. Since 2015, the primary Law that has been updated in agriculture has been the law on "Crop farming", which was approved in 2016.

The main law on arable land is the Law on Crop Farming (2016), which addresses the issue of protection of the physicochemical properties and improvement of soil fertility. In addition, the following government resolutions were approved: "The National Vegetables Program", "National Program on Fruits and Berries", and "The Atar-IV Campaign".

Forests are the main removals of GHG and are subject to depletion due to improper use associated with human activities, the impact of forest fires on pests, and grassland degradation (MET, 2018a). In 2020, Mongolia had an area of 14.2 million hectares of forest land, of which 12.1 million hectares are covered with forests, 133 thousand hectares of forest-felled area, 719.2 thousand hectares of forest expansion reserve and 62.3 thousand hectares of tree farming area, and 955.3 thousand m^3 of logging per year (NSO, 2021).

Mongolian forests are vulnerable to drought, fire, and pests, have low productivity, slow growth, quickly lose their ecological balance, and have poor regeneration, and sustainable forest management is essential to prevent forest degradation. Throughout 2014-2016, Mongolia conducted a "multitarget forest census" (2014-2016), and the "National UN-REDD program for Mongolia" was carried out. (2016-2019). In 2019, the "National Strategy Action Plan for the Reduction of GHG Caused by forest depletion and degradation" was certified. On January 9 22, 2021, the President of Mongolia announced at the 76th session of the UN General Assembly that 'Mongolia plans to grow a billion trees by 2030'. In 2021, Resolution No. 350 of the Government approved the measures to be implemented within the framework of the national movement Billion trees (Government of Mongolia 2021a).

Mongolia's forest policy programs mainly focus on reducing GHG caused by deforestation and degradation and increasing forest removal (Table 6.5).

Table 6.5 Update on policies and programs to reduce GHG emissions in the agriculture and forest sectors

Legal documents	Policy documents	Related programs and measures
- Law on Crop Farming (PoM, 2016b) - Law on Animal Health (PoM, 2017c) - Law on Livestock Tax (PoM, 2020d) - Resolution on the announcement of the “Atar-IV campaign” for sustainable agricultural development (GoM, 2019d) - Presidential Resolution No. 58 Instructions to the Government to initiate the national campaign ‘One billion trees” (PO, 2021))	- *Vision-2050 (PoM, 2020c) - *Nationally Determined Contribution to the implementation of the Paris Agreement (NDC, 2019) - Green Development Policy (PoM, 2014) - State Policy on Agriculture (PoM, 2015b) - *State policy on forests (Parliament of Mongolia, 2015d) - *Mongolia’s Five-Year Development Guidelines for 2021-2025 (PoM, 2020b)	- Implementation Plan of the Mongolian Government Action Plan for 2020-2024 (PoM, 2020a) - Action Plan for Implementation of Nationally Determined Contributions (NCC, 2021) - *Action plan for the implementation of the Green Development Policy 2016-2030 (GoM, 2016) - Implementation measures for the national campaign for “One billion trees” 2022-2030 (GoM, 2021a) - National Program on Promoting the Development of Intensive Livestock Farming in 2019-2023 (GoM, 2018d) - National Program on Fruit and Berries 2018-2022 (GoM, Resolution No. 223, 2017b) - National Program on Livestock Health 2018-2021 (GoM, 2018b) - Action Plan of Mongolian Agenda for Sustainable Livestock (MASL), 2018-2020 (MOFALI, 2018) - Action Plan for the implementation of the “Atar IV” campaign for sustainable agriculture development in 2020-2025 (Resolution of MOFALI Minister, 2020; GoM, 2018c) - National Strategy and Action Plan to Reduce Emissions from Deforestation and Forest Degradation (REDD+) in 2020-2025 (MET, 2019)

**Newly approved and amended documents after submitting iBUR and TNC*

Note: Some policy documents in this table were annulled by decision of Parliament resolution No 89, Nov 12th 2021, Government of Mongolia, Resolution No 314, Oct 13th 2021.

The above documents provide an overview of the policies in the field of AFOLU (Agriculture, Forest, and Land Use):

In the livestock:

- Establishing upper limits on the number, type, and structure of animals in harmony with natural ecology and grazing capacity and reducing the number of livestock,
- Improve animal manure management,
- Protect animal health and improve the quality and productivity of livestock,
- Increase the level of agricultural products processing and animal export.

In arable land:

- Adopt advanced agrotechnical and irrigation-efficient technology to replace traditional crop ploughing processing technology,
- No new land ploughing only abandoned land circulation and soil reticulation,
- Fully adopt zero and reduced till technology in crop production, develop the use of eco-friendly fertilizers, protect, and improve soil fertility,
- ensure that domestic demand for drought, disease, and pest-resistant crops is fully met through the introduction, reintroduction, and adoption of certified varieties,
- Implement comprehensive eco-friendly plant protection measures against the spread of plant diseases, weeds, insects, and rodents and adopt appropriate practices.

In the forest:

- Prevent forest loss through forest expansion, restoration, and forest protection measures, increase the amount of forest covered area in 2030 to 9% of the total land area in 2050 to 10.5%, and gain carbon dioxide removal,
- Increase the amount of green space in Ulaanbaatar, stimulate urban greening activities, and support funds, taxes, loans, and incentives to create optimal leverage.

6.3.1 Implementation of the measures to reduce GHG emissions in the AFOLU sector

The main measures included in iBUR were introductory provisions such as reducing the number of livestock, supporting exports, and improving livestock health. The implementation of these measures for 2015-2020 is shown below in Table 6.6.

Table 6.6 Implementation of policies and measures included in iBUR and TNC to reduce GHG emissions in the animal husbandry sector

No	Policies and measures	Targets reported in iBUR. (In 2020)	Implementation
1	Adjust herd composition and numbers based on	To have 36,475.6 thousand head of livestock by 2021. By 2021, compared to 2008, the share of camels will	In 2021, there was 67,068.49 thousand head of livestock.

	the assessment of pasture capacity and conditions to improve livestock profitability (Mongolian Livestock National Program, 2010)	increase by 0.3%, horses by 3.1%, cattle by 8.0%, sheep by 2.7%, and goats will reduce by 14.1%.	In 2021, the share of livestock particularly camels 0.67%, horses 6.42%, cattle 7.49%, sheep 46.16% and goats 39.29%. Compared to 2008, the ratio of camels increased by 0.06%, horses increased by 1.37%, cattle increased by 1.67%, sheep increased by 3.74% and goats decreased by 6.85% as of 2021 (NSO, 2022).
	Adjust the number, type, and composition of livestock based on assessment of pasture carrying capacity and status (State Policy on Food and Agriculture, 2015)	To increase the share of cattle in the total herd from 6.7% in 2014 to 8.0% in 2020. Increase industrially processed meat from 16.8 thousand tonnes to 100 thousand tonnes.	The share of cattle in the total herd is 7.75 %, and industrially prepared meat has reached 26.8 thousand tonnes as of 2021.
2	Increase the number of raw materials for export and improve the health and profitability of animals.	Establishing a suitable relationship between traditional and intensive livestock husbandry.	The National Program “Supporting the Development of Intensified Animal Husbandry” was approved by Resolution No. 400 of the Government in 2018 (GoM, 2018d). Despite the Government policy in this area, the significant progress hasn’t been made except cattle breeding (number of cattle for industrial meat and milk production by 2021 increased by 60%-100% since 2016). These data were gathered and computed from the website of the MOFALI (https://mofa.gov.mn/).
		Develop the production of veterinary drugs, disinfectants, and biotechnology based disinfectants, improve herd’s health.	As of 2020, 95.2% of veterinary drugs and biological preparations (vaccines, diagnostics) are produced domestically (GoM, 2020).
		Forming an appropriate ratio for the number and type within herds, increasing the number of areas with animal disease-free status to at least 10% of the total area to meet the trade and quarantine requirements certified by the World Organization for Animal Health (WOAH).	In 2018, The Government of Mongolia approved The National Livestock Health program (GoM, 2018b). Within the framework of the Law on Animal and Animal Health, the General Department of Veterinary Medicine, the Veterinary Departments in 21 provinces and capitals, and the Veterinary Departments in 331 districts have been established and are transitioning to a vertical system. According to order No. A/84 and A/85 of the head of the General Authority for Veterinary Services (GAVS), the territory is divided into three zones, and measures are being implemented to prevent and fight highly contagious foot and mouth diseases and small animal scurvy, and improve the animal health. In 2020, Mongolia submitted to WOAH a request to obtain a foot-and-mouth disease free status for the

			provinces of the western region of Mongolia. Law on Animal Health and "Procedures for reporting the absence of infectious diseases and peacefulness by country, region, and territory" approved by Order No. A/40 of 2019 of the MOFALI, by Order No. A/256 of 2019 of the Head of the GAVS, cattle herds of Darkhan-Uul and Selenge provinces were declared as "Cattle Tuberculosis and Bovine Leukosis free and peaceful zone", respectively, ensuring healthy livestock from the following types of diseases: - dairy cattle are free of leukosis, 98.1% - sheep and goats are free of brucellosis, 99.2%
		Bring animals and animal-derived products to the markets of neighbouring countries and increase the number of purebred cattle to 100,000.	In 2014, there were 72,504 meat and dairy cattle, and in 2020, there were 126,223, which is 26.2% higher than expected. (MOFALI, 2020b). The number of purebred cattle reached 193.7 thousand head as of 2021 (NSO, 2022).

Introductory provisions of the agricultural sector Included in iBUR and TNC were abandoning the traditional technology of overturning soil and protecting against soil erosion. Table 6.7 shows the implementation of these measures for 2015-2020.

Table 6.7 Implementation of policies and measures included in iBUR and TNC to reduce GHG emissions in the arable land

No	Policies and measures	Targets reported in iBUR (in 2020)	Implementation
1	Reject the outdated technology of overturning soil	Increase the nutrient quality of the soil in the fields used for cultivation and reduce erosion and damage by reaching 70% by the introduction of zero-till technology in grain production areas; increase the irrigated agricultural area to 65.0 thousand hectares by introducing efficient and advanced irrigation technology; increase the supply of elite seeds of indigenous varieties up to 75%, respectively.	In grain production, reduced and zero-till technology has been investigated and introduced to 360,000 hectares, and in 2020, 196,000 hectares of fallow have been developed using advanced technology. 45% of the total fallow land is processed with zero-till technology. Harvesting is 100% straw mulching, and 70% of grain threshing is done with gas threshers. In 2019, 54,089.83 hectares of land were engaged in irrigated agriculture.
2	Establishing a protective forest strip to protect the soil from erosion and degradation	Expansion of irrigated agriculture based on water conservation and soil protection technologies adapted to drought conditions.	The Government is taking measures to provide discounts for the use of straw mulch to protect agricultural soil from wind erosion, fencing of agricultural fields, construction of forest strips, and introduction of irrigation equipment with low water consumption.

			By 2020, 342,000 hectares of arable land were covered by 10,400 km of fences, and there are 340 km of forest strips for protecting 6,200 hectares of arable land. This means that 1/3 of the total cultivated area is fenced and protected (MOFALI, 2020b).
3	Bring agricultural land fully into economic turnover and use it efficiently.	In 2020, the crop rotation area will increase up to 960 hectares and the wheat yield up to 17.3 centner per hectare.	The crop rotation area reached 896.9 thousand hectares in 2020 (91% implementation) and the wheat yield per hectare is 12.6 centner (NSO, 2021).

Included in the iBUR and TNC of the forest sector were the main provisions such as reducing deforestation, increasing the number of forested areas through restoration and afforestation, and creating sustainable management, and the implementation of the goals set for 2015-2020 for these measures is shown in the following table (Table 6.8).

Table 6.8 Implementation of policies and measures included in iBUR improving the removal of GHGs in the forest sector

No	Policies and measures	Targets reported in iBUR (in 2020)	Implementation
1	Reject the outdated technology of overturning soil	Increase the nutrient quality of the soil in the fields used for cultivation and reduce erosion and damage by reaching 70% by the introduction of zero-till technology in grain production areas; increase the irrigated agricultural area to 65.0 thousand hectares by introducing efficient and advanced irrigation technology; increase the supply of elite seeds of indigenous varieties up to 75%, respectively.	In grain production, reduced and zero-till technology has been investigated and introduced to 360,000 hectares, and in 2020, 196,000 hectares of fallow have been developed using advanced technology. 45% of the total fallow land is processed with zero-till technology. Harvesting is 100% straw mulching, and 70% of grain threshing is done with gas threshers. In 2019, 54,089.83 hectares of land were engaged in irrigated agriculture.
2	Establishing a protective forest strip to protect the soil from erosion and degradation	Expansion of irrigated agriculture based on water conservation and soil protection technologies adapted to drought conditions.	The Government is taking measures to provide discounts for the use of straw mulch to protect agricultural soil from wind erosion, fencing of agricultural fields, construction of forest strips, and introduction of irrigation equipment with low water consumption. By 2020, 342,000 hectares of arable land were covered by 10,400 km of fences, and there are 340 km of forest strips for protecting 6,200 hectares of arable land. This means that 1/3 of the total cultivated area is fenced and protected (MOFALI, 2020b).
3	Bring agricultural land fully into economic turnover and use it efficiently.	In 2020, the crop rotation area will increase up to 960 hectares and the wheat yield up to 17.3 centner per hectare.	The crop rotation area reached 896.9 thousand hectares in 2020 (91% implementation) and the wheat yield per hectare is 12.6 centner (NSO, 2021).

6.4 Policy and measures to reduce the GHG emissions in the waste sector

Population growth, urbanization, and industrialization led to the increase in waste and the change of components of the waste; the average volume of waste increased by 500 thousand tonnes per year in Mongolia. Based on data from the national GHG inventory, methane emissions from solid waste disposal centres account for more than 45% of the waste sector. Emissions of methane (CH_4) and nitrous oxide (N_2O) from solid waste and domestic wastewater have continuously increased yearly along with population growth. However, methane emissions from industry wastewater fluctuate depending on the food production and the economic situation of the year (MEGD, 2014).

The objectives and activities in the waste sector have been directly and indirectly included in laws, legal documents, long-term government policy, and medium and short-term programs. Although the indicators for the implementation, realization, and calculation of the results of the objectives and activities are not clear, and the financial, human resources, roles, and responsibilities related to their implementation are not detailed, it is not easy to calculate their implementation and results (MET, 2018). Mongolia's primary legal and policy documents and related reforms of programs to reduce GHG emissions in the waste sector are displayed in Table 6.9.

Table 6.9 Update on policies and programs to reduce GHG emissions from the waste sector

Legal documents	Policy documents	Related programs and measures
- Law on Waste (PoM, 2017b) - Law on Hygiene (PoM, 2017a) - *Law on Water (PoM, 2012a) - *Law on Water Contamination Fees (PoM, 2012b) - *Law on the City and Settlement Area's Water and Sewerage (PoM, 2011b) - *Law on hazardous and toxic chemicals (PoM, 2006) - *Law on the Import, Export and Cross-border Transport of Hazardous Waste (PoM, 2000)	- *Vision-2050 Long-term Development Policy and Annexes (PoM, 2020c) - Mongolia's five-year development guidelines for 2021-2025 (PoM, 2020b). - Nationally Determined Contributions (NDC, 2019) - Green Development Policy (PoM, 2014) - Mongolia Sustainable Development Vision 2030 (PoM, 2016a)	- Action Plan for implementation of Nationally Determined Contributions (NCC, 2021) - *The Action Plan to Make Ulaanbaatar a Green City (Ulaanbaatar City Administration, 2019) - *The Water Supply Project (Millennium challenge account, 2018) - National program to reduce air and Environmental Pollution 2017-2025 (GoM, 2017a) - Action Plan for the implementation of the Green Development Policy 2016-2030 (GoM, 2016, Resolution No. 35) - *Ulaanbaatar Waste Management Improvement Strategy and Action Plan for 2017-2030 (Ulaanbaatar City Administration, 2017) - Mongolian National Waste Management Improvement Strategy and Action Plan for 2014-2022 (GoM, 2014) - *National Program on Persistent Organic Pollutants for 2014-2040 (GoM, 2014) - National Action Program on Climate Change, 2011-2020 (PoM, 2011a). - *National Water Program for 2010-2021 (PoM, 2010)

**Newly approved and amended documents after iBUR and TNC submission*

Note: Some policy documents in this table were annulled by decision of Parliament resolution No 89, Nov 12th 2021, Government of Mongolia, Resolution No 314, Oct 13th 2021.

In the waste sector of the Initial Biennial Update Report on Greenhouse Gas Emissions and Removals related to the increase in liquid waste estimates, the "Law on Hygiene" (2017), "Water Law" (2012), "Water Law contamination Fees", (2012), " Law on the City and Settlement area's Water and Sewerage", (2011) and "Law on hazardous and toxic chemicals", (2006) were added.

Regarding the solid waste sector, the "Law on Waste" was newly approved in 2017. This Law aims to prevent and reduce the negative impact of waste on human health and the environment. In addition, to put waste into economic circulation to save natural resources, improve public education about waste, reduce, sort, collect, transport, store, reuse, recycle, recover, dispose of, and export waste, and regulate relations related to the prohibition of cross-border transport and import of hazardous waste. “National Program to Improve Waste management” and other related policies and programs included:

Solid Waste

- To reduce and save the consumption of natural resources and raw materials, to reduce waste by increasing production efficiency, and to support the introduction of advanced zero-waste technology,
- To introduce a recycling system for product containers and packaging by manufacturers,
- Support activities that create value-added products such as waste recycling, energy generation, fertilizer, and road and construction material production.

Liquid Waste

- Supporting any activities and initiatives for the treatment and reuse of wastewater within the laws and regulations.
- Conserving water, expanding wastewater treatment plants and facilities, and increasing the number of people provided with newly built and standard sanitary facilities,
- Renovating of non-standard sanitary facilities of households, processing excrement and sludge into compost, extracting gas fuel, and putting it into economic turnover,
- Step-by-step implementation of measures to limit the use of groundwater for industrial purposes and the introduction of graywater use.

6.4.1 Implementation of policies and measures in the waste sector

The main measures taken to reduce GHG within the framework of the waste sector are divided into four main groups: waste reduction, reuse, recycling, and reduction of waste disposal in nature. The implementation situation of the goals set for 2020 for these measures is shown in Table 6.10.

Table 6.10 Implementation of measures and policy reported in iBUR to reduce GHG emissions in the waste sector

No	Policies and measures	The target reported in iBUR (in 2020)	Implementation
1	Reducing waste	The ISO 14000 standard for the environmental management system will be introduced from 1 in 2013 to 4 in 2014-2017 in phase I, and to 20 in 2018-2022 in phase II (GoM, 2014).	At the meeting of the 2019 Technical Committee of the Environmental Management System, the draft of 5 standards of the ISO 14000 package was discussed and approved (GoM, 2021b).
		From 2014, the number of enterprises and organizations that supported and approved the introduction of the MNS ISO 14001 set of environmental management standards will increase as follows: - 2 times in 2016-2020 in phase I - 5 times in 2021-2025 in phase II, - 10 times in 2026-2030 in Phase III (PoM, 2016a).	In 2017-2020, a total of 13 organizations (Tsetsuh LLC, Ag LLC, Darkhan-Uul province ASUIS branch School of Medicine, Eurokhan LLC, Khaanzaa Services LLC, Alliance Mineral LLC, APU LLC, Energy Resource LLC, MSS Property LLC, Eco Wool LLC, Janson Construction LLC, Active Adventure Tours Mongolia LLC, and Moncrem LLC) introduced and certified the MNS ISO 14001 environmental management system in their operations (MASM, 2020). The number of ISO 14001-certified organizations registered with the Department of Standardization and Metrology increased by 1 in 2019, totaling to 4 (100% implementation) (MASM, 2020).
2	Reusing waste	Establishment of plants for solid waste separation, complete treatment and recycling ([Phase I 2011-2016; Phase 2017-2021], PoM, 2011a).	In 2021, there were 40 waste recycling plants and more than 160 sorting points in Mongolia, with more than 1500 employees (MOFALI website, 2021). As a result of the implementation of the project to introduce waste sorting at the source, there were 376 sorting points throughout the Ulaanbaatar city. The amount of sorted waste was 7.8 thousand tonnes in 2018, 16.9 thousand tonnes in 2019, and 25.7 thousand tonnes in 2020 and these sorted waste were included in the recycling process (GoM, 2021b).
3	Recycling waste	Increase processing and recycling of waste, and increase value-added products as follows: Green Development Policy (PoM, 2014) - 20% in 2014-2020 in phase I, - 40% in 2021-2030 in phase II. Sustainable Development Vision of Mongolia (PoM, 2016a) - 20% in 2016-2020 in phase I, - 30% in 2021-2025 in phase II, - 40% in 2026-2030 in phase III.	According to the results of Mongolia's "Solid Waste Account" (2019), 8.7% or 250.6 thousand tonnes of waste was recycled and reused out of 2.9 million tonnes of waste generated in 2019 (NSO, 2021). As of 2020, there are 28 waste recycling plants in Ulaanbaatar city, of which ten are actively operating for plastic waste processing, 2 for cardboard paper processing, 2 for waste tire processing, 1 for waste engine oil processing, 2 for waste bone processing, and 1 for alloy processing. Furthermore, these companies are generating value-added products (GoM, 2021b).

			In 2020, 160,000 tonnes of garbage were recycled in the Ulaanbaatar city (MOUBC 2021).
4	Others	Provide 40% of the population with improved sanitation facilities, as follows: - 20% in 2016-2020 in phase I - 30% in 2021-2025 in phase II, - 40% in 2026-2030 phase III (PoM, 2016a).	According to the Mongolian population and housing census (2020), approximately 29.66% of households were connected to centralized aerobic wastewater treatment plants. The 49.24% of households use latrines, 20.46% of households lack wastewater disposal points and only 0.64% use septic tanks (NSO, 2021b). In 2018-2019, around 400 sewage repellent improved pit latrines were installed and used in the centre of the Arkhangai and Uvurkhangai provinces (GoM, 2021b). According to the study of pit latrines in the Ger quarter of Ulaanbaatar city, of 133.1 thousand pit latrines registered, 11.8 thousand pit latrines meet the document requirements of the standards MNS5924: 2015 and UCS 0704B: 2020 (MOUBC, 2021).

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CHAPTER 7. GREENHOUSE GASE EMISSION PROJECTIONS

7.1 Impact assessment of the measures to reduce GHG emissions

Figure 7.1 summarizes the key policies and measures taken in previous assessments and updated documents to determine the present and future measures to reduce GHG emissions in Mongolia.

	Year	2010	2015	2020	2025	2030	2040	2050
Total	Baseline scenario (BAU), Mt CO_2e	20.9	29.3	36.1	51.9	61.4	77.2	97.4
	Mitigation scenario, Mt CO_2e	20.9	29.3	36.1	43.3	46.5	56.8	70.7
	Total GHG emission reductions, Mt CO_2e	-	-	-	8.5	14.9	20.4	26.7
	Total GHG emission reductions, %	-	-	-	16.5	24.3	26.4	27.4

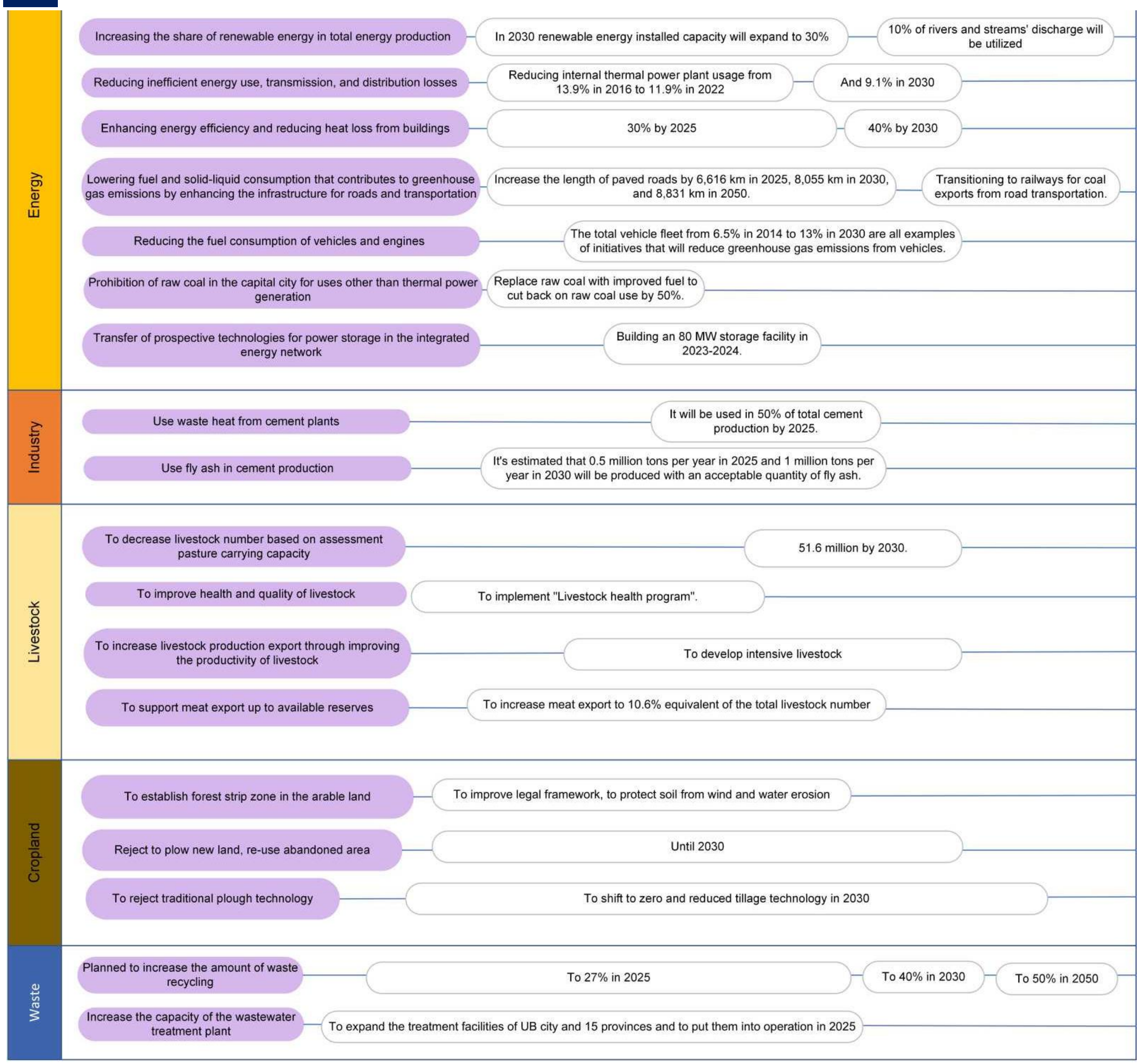

Figure 7.1 Policies and measures to reduce GHG emissions in Mongolia

The revised law on development policy, planning and its management of Mongolia established a system with 12 policies and planning at 5 levels. It included long term (30 years) development policy, 7 medium-term (10 years) different goals programs, 2 documents for 4-5-year development planning, 2 short-term documents including an action plan and the state budget. Based on this, the Parliament decided in November 2021 to cancel 17 policy documents that had been considered in the two-year complimentary first report, including the National Climate Change Program, the Green Development Policy, and the State's policy in some social and economic sectors.

The estimation for the future projection of GHG emissions and removals in Mongolia was based on population growth, accompanying economic developments, and their demands if no additional steps are taken (BAU) and mitigation scenario GHG emissions based on related policy measures at the national and sector-level using international guidelines, methodologies, and models. The results are shown in Figure 7.2.

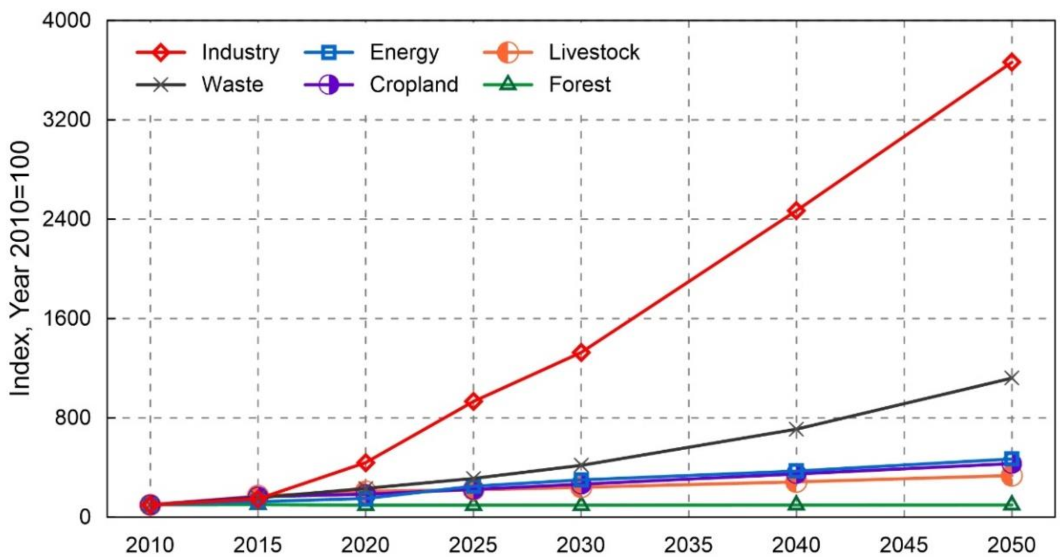

Figure 7.2 Future projections of GHG emissions and removals by sector

Future projections to 2030 and 2050, using 2010 as the base year and assuming no action is taken (BAU), show that emissions from the energy sector are expected to increase by 3.0 and 4.7 times, cement production in the industrial sector by 13.3 and 36.6 times, the livestock sector of 2.4 and 3.4 times, the cropland sector of 2.7 and 4.3 times, and waste sector 4.2 and 11.2 times, while the carbon sink potential of forests will rise by 14.0% and 31.0%, respectively.

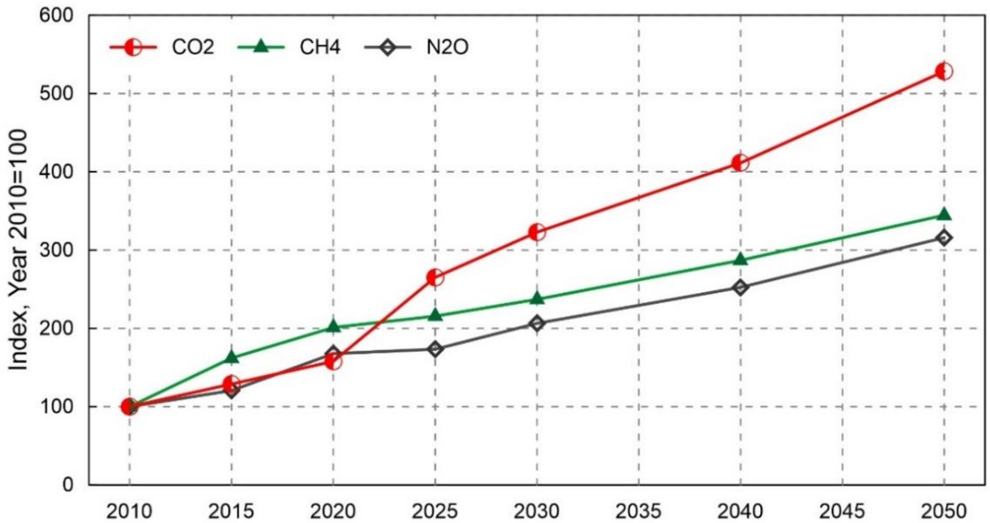

Figure 7.3 Future projections of GHG emissions by gas

Carbon dioxide (CO_2) emissions will rise by 3.2 and 5.3 times, methane (CH_4) emissions by 2.4 and 3.5 times, and nitrous oxide (N_2O) emissions by 2.1 and 3.2 times in 2030 and 2050 compared to the base year 2010, respectively (Figure 7.3).

If the measures outlined in the policies, plans and programs for sectors that emit GHG emissions are completely implemented, the total GHG emissions could be reduced by 24.3%, 26.4%, and 27.4% in 2030, 2040, and 2050, respectively, according the mitigation scenario (without LULUCF) (Figure 7.1).

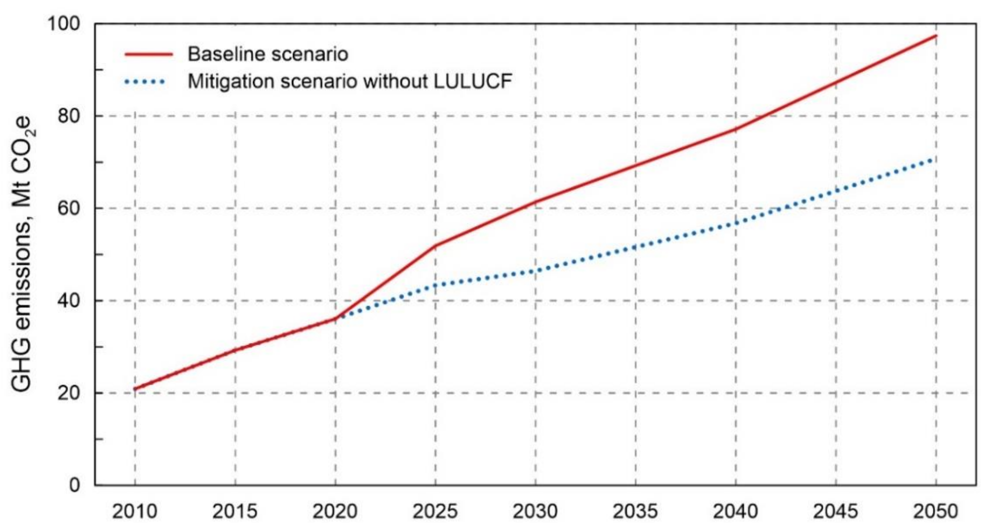

Figure 7.4 Comparison of the baseline and mitigation scenarios of GHG emissions of Mongolia

Figure 7.4 demonstrated the scenarios of GHG emissions without LULUCF, when all mitigation measures considered by national policy documents are fully implemented, compared with the baseline scenario for Mongolia.

Table 7.1 Total GHG mitigation potential including LULUCF, Mt CO_2e

	2010	2015	2020	2025	2030	2040	2050
GHG baseline scenario (including forest removals)	-7.3	0.5	9.0	24.7	34.1	49.6	69.6
GHG mitigation scenario (including increased forest removals)	-7.3	0.5	9.0	13.8	14.4	22.3	33.9
Total GHG mitigation potential (including forest removals)	-	-	-	11.0	19.7	27.3	35.7
Total GHG mitigation potential (including forest removals), %	*-*	*-*	*-*	*44.3*	*57.8*	*55.0*	*51.3*

7.2 Sectorial baseline scenario and potential mitigation options for reducing GHG emissions

7.2.1 Energy sector

The Energy sector shares 50% of total GHG emissions related to energy production and consumption using solid and liquid fuels. Energy production in 2020 used 7.5 million tonnes of raw coal and 1.4 million tonnes of imported oil products, which is 1.2 and 1.5 times more than in 2010. Mongolia has a wealth of renewable energy sources, including geothermal, wind, solar power, and coal (PoM, 2005; PoM, 2007).

According to the "Nationally Determined Contribution" statement, the energy sector will be responsible for 66.7% of the overall reduction in GHG emissions in 2030, which is estimated to be 16.9 million t CO_2e.

Increasing the use of renewable energy and increasing the efficiency of energy production and consumption are the two primary strategies outlined in the development documents for reducing GHG emissions in the sector. However, they may also be categorized by the energy sector as follows:

- *Increasing the share of renewable energy in total energy production:* In 2030, renewable energy installed capacity will expand to 30%, and 10% of rivers and streams' discharge will be utilized for energy production and other purposes (PoM, 2016; PoM, 2020a etc.),
- *Reducing inefficient energy use, transmission, and distribution losses:* Reducing internal thermal power plant usage from 13.9% in 2016 to 11.9% in 2022 and 9.1% in 2030 through the renewal of energy production and industrial technologies would also reduce power transmission and distribution losses from 15.7% in 2016 to 13.7% in 2022 (GoM, 2011; PoM, 2015; GoM, 2017),
- *Transfer of prospective technologies for power storage in the integrated energy network:* Building an 80 MW storage facility in 2023–2024 (PoM, 2020b),
- *Prohibition of raw coal in the capital city for uses other than thermal power generation:* Replace raw coal with improved fuel to cut back on raw coal use by 50% (PoM, 2017b),
- *Enhancing energy efficiency and reducing heat loss from buildings:* Reduce building heat loss by 30% by 2025 and 40% by 2030 by using locally sourced green technology, energy-efficient

solutions, and advanced standards, including energy audits and green building assessment systems (PoM, 2014; PoM, 2015). Using geothermal energy to increase the heat supply to the soum, the provincial capital, and the surrounding districts, as well as the effectiveness of the heating boilers (NDC, 2019),

- *Lowering fuel and solid-liquid consumption that contributes to GHG emissions by enhancing the infrastructure for roads and transportation:* Increase the length of paved roads by 6,616 km in 2025, 8,055 km in 2030, and 8,831 km in 2050. Reduce the usage of coal and liquid fuel by switching passenger railways to electric heating and transitioning to railways for coal exports from road transportation (PoM, 2016; NDC, 2019; PoM, 2020a),
- *Increase the use of gas-powered and low-fuel vehicles:* Improvements to the environmental tax and payment system, conversion of liquid fuel-using vehicles to liquefied gas vehicles, and an increase in the proportion of low-fuel-consumption vehicles in the total vehicle fleet from 6.5% in 2014 to 13% in 2030 are all examples of initiatives that will reduce GHG emissions from vehicles and engines (PoM, 2008; INDC, 2015; PoM, 2016). Vehicles with a gas engine will rise from 1.7% in 2016 to 2.3% in 2022, while those with a duo-drive system will rise from 11.6% in 2016 to 21% in 2022 (PoM, 2016, GoM, 2017).

The LEAP (Heaps C.G, 2022) model input data must be carefully planned to estimate future energy sector GHG emissions. The model needs data on social and economic variables, associated future energy requirements, and present and foreseeable capacity, output, and efficiency of energy generation. The projection of all input data will consider past, present, and future objectives as reflected in the nation's policies, programs, and plans. However, depending on the socioeconomic circumstances of the base year, the calculation of the future scenario of GHG emissions differs significantly. The base year used in this study was 2010, but actual social and economic data from earlier years and up to 2020 were integrated and computed; therefore, it is anticipated that a considerably more accurate scenario.

The most significant factors influencing energy generation and long-term energy planning are the population, the number of households, household income, gross domestic product (GDP), and their future variations. These data were gathered and computed from the website of the International Energy Agency (IEA, 2020), the National Statistics Committee of Mongolia (NSO, 2021), the Energy Statistics Bulletin published by the Energy Regulatory Commission (ERC, 2021), and other sources. The National Statistics Committee's website was used to compute population growth scenarios, and an appendix of the "Vision-2050" policy document was used to calculate GDP at the 2018 rate (Table 7.2).

Table 7.2 Baseline scenario of socio-economic indicators of Mongolia

Indicators	2010	2015	2020	2025	2030	2040	2050
Population number, million people	2.739	3.004	3.357	3.641	3.922	4.552	5.283
GDP, billion USD	7.2	11.8	13.3	25.0	32.6	54.6	77.6
Household number, 1000 household	742.3	859.1	908.7	978.9	1054.6	1223.9	1420.4
Household income, USD	2604	3843	3914	6875	8299	12,004	14,682

Sources: NSO (www.1212.mn), Vision-2050 of Mongolia

The challenge of estimating GHG emissions from future energy requirements is a crucial next step that needs data from the energy-using industries. The installation and installed energy capacity, efficiency-coefficient, and energy output data are relevant to satisfying that demand and will be incorporated into the model after this has been done. The capacity of thermal power plants presently operational and may be set up in the near future is displayed in Table 7.3. This is the most crucial detail in the baseline scenario since it explains the vast majority of GHG emissions from the energy sector.

Table 7.3 Information about thermal power plants, both existing and to be constructed in the future

No	Name	Installed capacity, MW	Commissioning year	Power source	Measures, description	Annual energy output in GWh
1	CHP2	24	It has been functional since 1961	Coal	No upgrades or additions are anticipated	The installed capacity of thermal power plants was 905.7 MW, 4,256 GWh in 2010, 1,078.7 MW, 5,323.5 GWh in 2015, and 1,278.4 MW, 6,493.4 GWh in 2021.
2	CHP3	198	It has been functional since 1968	Coal	Expansion of 12 MW in 2021	
3	CHP4	772	It has been functional since 1983	Coal	Expansion of 89 MW in 2020	
4	Darkhan CHP	83	It has been functional since 1965	Coal	Expansion of 35 MW in 2019	
5	Erdenet CHP	71	It has been functional since 1987	Coal	Expansion of 12 MW in 2021	
6	CHP of the Erdenet plant	53	It has been functional since 2011	Coal	Expansion of 48 MW in 2017	
7	Choibalsan CHP	36	It has been functional since 2007	Coal	Expansion of 50 MW in 2023	
8	Dalanzadgad CHP	9	It has been functional since 2000	Coal	Expansion of 6 MW in 2015 to 9 MW in 2018	
9	Ukhaa khudag CHP	18	It has been functional since 2011	Coal	It began delivering to the central energy system in 2019	
10	Diesel station	14.4	Existing	Diesel	It will continue to decline.	
11	CHP5	450	From 2025	Coal	To support the infrastructure of CHP3	Total 2030 Capacity: 2,968.7 MW, 14,164.3 GWh, including 1,690.0 MW of new capacity.
12	Baganuur CHP	700	From 2026	Coal	2,160,000 million kWh per year	
13	Oyutolgoi/Tavantolgoi CHP	450	From 2025	Coal	2021-2025	
14	Amgalan TPP	50	From 2023	Coal		

Sources: ERC, 2021a; GoM, 2018; MoE: https://www.energy.gov.mn/; NSO: https://www.1212.mn/; ERC: https://erc.gov.mn/; NDC, 2019; National Dispatching center: https://ndc.energy.mn/; Second thermal power plant: http://www.tpp2.mn; Third thermal power plant: http://tes3.energy.mn; Fourth thermal power plant: http://tpp4.mn; Erdenet thermal power plant: http://erdpp.energy.mn; Darkhan thermal power plant: http://dpp.energy.mn.

The capacity, output, and efficiency-coefficient data for currently installed coal-fired and renewable energy producers make up the next section of the baseline scenario. It was gathered from the sources mentioned above and placed into the program. A basic scenario was designed utilizing mathematical and statistical approaches by adding data from several energy consumption sectors and the energy production information mentioned above. The information on the heat output of coal mines and the coefficient of GHG emissions is taken from Tables 7.3 in the report "Development of a National Methodology for Determining GHG Emissions in the Energy Sector" by B. Namkhainyam et al. (2021), which the Energy Regulatory Commission (ERC) commissioned. The LEAP model is used to compute the overall GHG emissions from the energy sector, considering all mentioned above. The results are displayed in Figure 7.5.

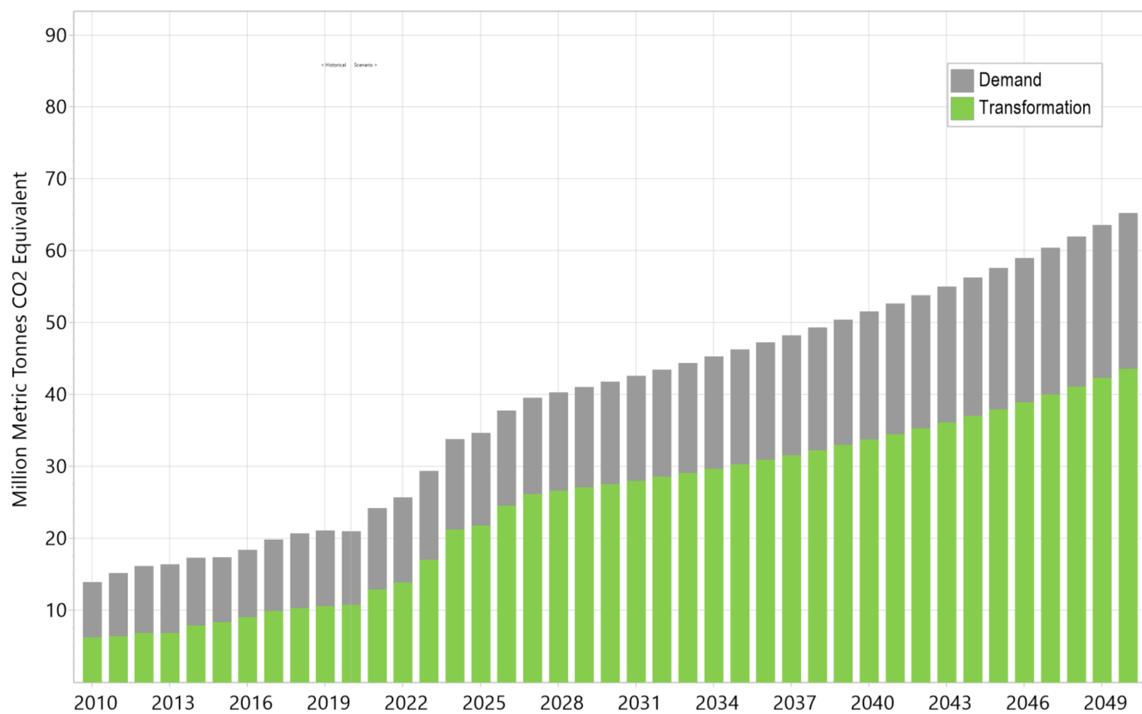

Figure 7.5 Baseline scenarios using the LEAP model for GHG emissions from the energy sector

In 2020, this sector will emit 21.0 Mt CO_2e GHGs, as shown in Figure 7.5. The amount will rise to 34.7, 41.8, 51.6, and 65.2 Mt CO_2e in 2025, 2030, 2040, and 2050, respectively.

The policy and program's actions were broken down into two main categories to calculate the reduction of GHG emissions from the energy sector: "Improving energy efficiency" and "Expanding the usage of renewable energy and output."

Solar, wind, and hydro-power plants are the main targets of policies to expand renewable energy generation, as seen in Table 7.4.

Table 7.4 Information on implemented and upcoming renewable energy sources as of 2021

No	Name	Location	Installed capacity, MW	Commissioning year	Power Source	Measures, description, expenses, million USD	Annual energy output in GWh
Implemented Project							
1	Salkhit WPP	Sergelen soum, Tuv province	50	Currently operational (since 2013)	Wind	120.0	168.5
2	Durgun HPP	Durgun soum, Khovd province	12	Currently operational (since 2009)	Hydro	26.5	38.0
3	Taishir HPP	Taishir soum, Govi-Altay province	11	Currently operational (since 2008)	Hydro	20.0	37.0
4	Nar SPP	Khongor soum, Darkhan-Uul province	10	Currently operational (since 2017)	Solar	20.0	14.2
5	Shand WPP	Sainshand soum, Dornogobi province	55	Currently operational (since 2018)	Wind	110.0	200.0
6	Tsetsii WPP	Tsogttsetsii soum, Umnugobi province	50	Currently operational (since 2017)	Wind	118.0	201.8
7	Gobi SPP	Sainshand soum, Dornogobi province	30	Currently operational (since 2020)	Solar	70.0	52.0
8	Gegeen SPP	Zamiin-Uud soum, Dornogobi province	15	Currently operational (since 2018)	Solar	25.0	28.6
9	Sumber SPP	Sumber soum, Gobisumber province	10	Currently operational (since 2018)	Solar	17.3	17.1
10	Bukhug SPP	Sergelen soum, Tuv province	15	Currently operational (since 2019)	Solar	27.0	22.7
11	Monnaran SPP	Bayanchandmani soum, Tuv province	10	Currently operational (since 2017)	Solar	23.0	14.5
12	Tosontsengel HPP	Tosontsengel soum, Zavkhan province	0.37	Currently operational (since 2006)	Hydro	Small size	1.5
13	Bogd's River HPP	Aldarkhaan soum, Zavkhan province	2	Currently operational (since 1997)	Hydro	Small size	2.9

No	Name	Location	Installed capacity, MW	Commissioning year	Power Source	Measures, description, expenses, million USD	Annual energy output in GWh
Planned to be implemented (within the next four years)							
14	Eg river	Khutag-Undur soum, Bulgan province	315	2022-2023	Hydro	827	606.0
15	Wind Farm Choir	Sumber soum, Gobisumber province	50.4	2023-2025	Wind		154.5
16	AB Solar Wind	Dalanjargalan soum, Dornogobi province	100	2023-2025	Wind		306.6
17	"Cleantech"LLC	Khanbogd soum, Umnugobi province	102	From 2025	Wind		312.7
18	"Mosheaecoenergy" LLC	Sergelen soum, Tuv province	50	2022-2025	Solar		73.6
19	"Luxtum" LLC	Sergelen soum, Tuv province	9	2022-2025	Solar		14.2
20	"Solar power Mongolia" LLC	Zuunmod soum, Tuv province	30	2022-2025	Solar		48.6
21	"Sun steppe" LLC	Bayandelger soum, Tuv province	50	2022-2025	Solar		76.7
22	"Sun road trade."	Sumber soum, Govi-Sumber province	30	2023-2025	Solar		48.6
23	"Uni Solar" LLC	Khongor soum, Darkhan-Uul province	30	2023-2025	Solar		48.6
24	"DSTSTS"LLC	Erdene soum, Dornogobi province	20	2023-2025	Solar		32.4
25	"Newcom Solar Energy "LLC	Saintsagaan soum, Dundgobi province	24	2023-2025	Solar		38.9
26	Power storage Station	Songinokhairkhan district, Ulaanbaatar city	80	2023-2024	Accumulator	114.0	200.0
27	Aldarkhaan SPP	Aldarkhaan soum, Zavkhan province	5	2022-2023	Solar	195.0	9.0
28	Erdeneburen HPP	Erdeneburen soum, Khovd province	90	2023	Hydro		
There was 23.37 MW, 79.4 GWh of installed renewable energy plants in 2010, 75.37 MW, 247.9 GWh in 2015, and 270.37 MW, 803.2 GWh in 2020.				2022-2025 will see the installation of 895.4 MW and 1970.4 GWh, resulting in a total installed capacity of 1165.77 MW and a 2773.6 GWh production capacity in 2025.			

Sources: ERC, 2021; GoM, 2018; MoE: https://www.energy.gov.mn/; NSO: https://www.1212.mn/; ERC: https://erc.gov.mn/; NDC, 2019, National Dispatching Center: https://ndc.energy.mn/.

Based on the information above, planned for inclusion in plans and programs, Table 7.5 displays the share of renewable energy in the overall energy output. The objectives outlined in the policy programs can be accomplished from this perspective if all scheduled projects are completed on time. The relevant policy and action provisions are no longer effective due to the sectoral policy documents being modified under the planning of the Vision 2050 long-term policy document. However, in accordance with the condition that the proportion of renewable energy in total production would reach 30% in 2030, sustaining the share of renewable energy production in 2030 has been adopted to achieve policy consistency between 2030 and 2050.

Table 7.5 Share of renewable energy in total electricity production

Indicators	2010	2015	2020	2025	2030	2040	2050
Total energy production, GWh	4,312.8	5,541.7	7,145.0	10,169.9	13,122.6	14,762.9	16,403.3
By existing and planning to be implemented renewable energy projects, GWh	79.4	247.9	803.2	2,773.6	4,142.4	4,665.1	5,183.4
Share of renewable energy production,%	1.8	4.5	11.2	27.3	31.6	31.6	31.6
GHG emission reduction, Mt CO_2e	-	-	-	2.1	3.1	3.5	3.9

By adopting steps to gradually increase the share of renewable energy generation in total energy production, as shown in Table 7.5 and Figure 7.6, the quantity of GHG emissions will be decreased by 2.1 Mt CO_2e, 3.1 Mt CO_2e, 3.5 Mt CO_2e, and 3.9 Mt CO_2e in 2025, 2030, 2040, and 2050, respectively.

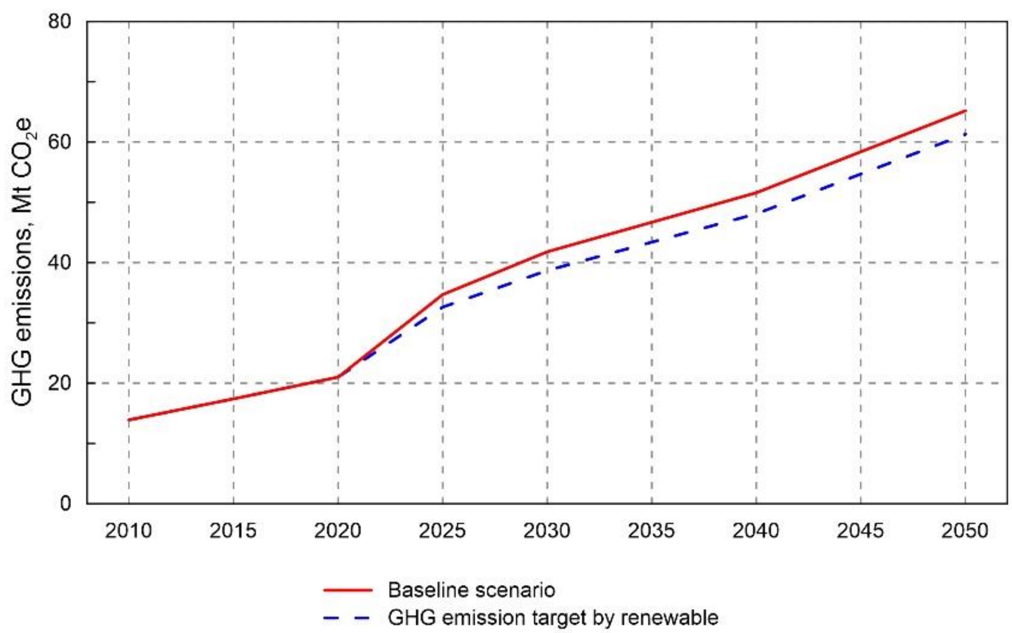

Figure 7.6 A scenario for reducing GHG emissions in the energy sector by increasing renewable energy

Alternatively, in the section on enhancing energy efficiency, the power transmission included in the Mongolian construction NAMA implemented in 2016 and 2020, NAMA Energy Efficient Lighting (2015), NAMA Urban Passenger Transport Ulaanbaatar (2016), and other policies and programs, calculations by previous researchers including reducing on distribution losses and internal consumption of stations, increasing the use of efficient household lighting (reducing the use of incandescent lamps), reducing heat loss in buildings and homes, and increasing the number of gas and electric vehicles that consume less fuel.

To prepare scenarios, calculations were done using the numbers in Table 7.6. According to the above sources, insulating buildings and homes can reduce energy use by up to 30%. If improved fuel is used for purposes other than thermal power plants in the capital city, raw coal consumption can be cut by 50%. Moreover, if full LED lights are used, the annual energy consumption for lighting can be reduced by 73.6% (UNFCCC 2016a). On the other hand, the internal demand of stations and losses associated with power transmission and distribution have been converted into GHG emissions by deducting the policy and program's goal amount from the potential value in the future.

Table 7.6 Calculation of scenario for reducing GHG emissions by improving energy efficiency

Indicators		2010	2015	2020	2025	2030	2040	2050
Reduction of losses during the transmission and distribution of energy	Percentage of total reserve electricity (reduction rate),%	13.5	14.2	10.8	9.3 (4.1)	7.8 (6.1)	5.3 (6.5)	3.5 (6.8)
	Reduction, Mt CO_2e	-	-	-	0.3	0.6	0.7	0.8
Reduction of heat distribution losses	Heat dissipation percentage (reduction rate),%	2.4	3.6	2.1	1.9 (2.3)	1.6 (4.1)	1.3 (4.2)	0.9 (4.3)
	Reduction, Mt CO_2e	-	-	-	0.8	1.4	1.9	2.1
Reduction of the internal demand for plants	Percentage of electricity produced,%	15.6	14.1	11.2	11.2 (2.2)	9.1 (4.1)	6.7 (5.4)	3.5 (7.7)
	Reduction, Mt CO_2e	-	-	-	0.8	2.0	3.0	4.7
Use of improved fuels in the capital city for purposes other than thermal power plants	Reduction of raw coal consumption by 50%, thousand. household	204	197	228	259	204	197	228
	Reduction, Mt CO_2e	-	-	-	0.6	0.6	0.7	0.7
Insulation of old buildings and apartments	Number of apartments,%	-	20	50	70	90	90	100
	Reduction, million t CO_2e	-	-	-	1.1	1.3	1.3	1.3
The proportion of city homes using LED lighting	City households,%	-	50	60	75	90	100	100
	Reduction, Mt CO_2e	-	-	-	0.1	0.1	0.1	0.1
	The share of hybrid, gas, and electric transport,%	-	6.5	8.7	10.9	13.0	17.4	21.8

Share of vehicles with low fuel consumption in the total number of vehicles,%	Reduction, Mt CO_2e	-	-	-	0.1	0.2	0.3	0.4
Total GHG emission reductions, Mt CO_2e		-	-	-	3.8	6.2	8.0	10.1

Sources: ERC, 2021a; GoM, 2018; MoE: https://www.energy.gov.mn/; NSO: https://www.1212.mn/; ERC, 2021; NDC, 2019: ERC: https://erc.gov.mn/, National Dispatching Center: https://ndc.energy.mn/.

Increasing energy efficiency will cut the sector's GHG emissions by 3.8 Mt CO_2e, 6.2 Mt CO_2e, 8.0 Mt CO_2e, and 10.1 Mt CO_2e in 2025, 2030, 2040, and 2050, respectively, if all the projects and policies mentioned above are implemented.

Table 7.7 Estimation of the scenario for reducing GHG emissions in the energy sector

	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU)	13.9	17.4	21.0	34.7	41.8	51.6	65.2
Mitigation scenario	13.9	17.4	21.0	28.8	32.5	40.1	51.2
Total GHG emission reductions	-	-	-	5.9	9.3	11.5	14.0
-Use of renewable energy	-	-	-	2.1	3.1	3.5	3.9
-Energy efficiency improvement scenario	-	-	-	3.8	6.2	8.0	10.1
Total GHG emission reductions, %	-	-	-	17.0	22.2	22.3	21.5

The sector's overall GHG emission reductions by scenario estimates are shown in Table 7.7. and Figure 7.7. It will be able to cut the overall GHG emissions from the energy sector by 5.9 Mt CO_2e, 9.3 Mt CO_2e, 11.5 Mt CO_2e, and 14.0 Mt CO_2e in 2025, 2030, 2040, and 2050 if all the stated projects and actions are implemented.

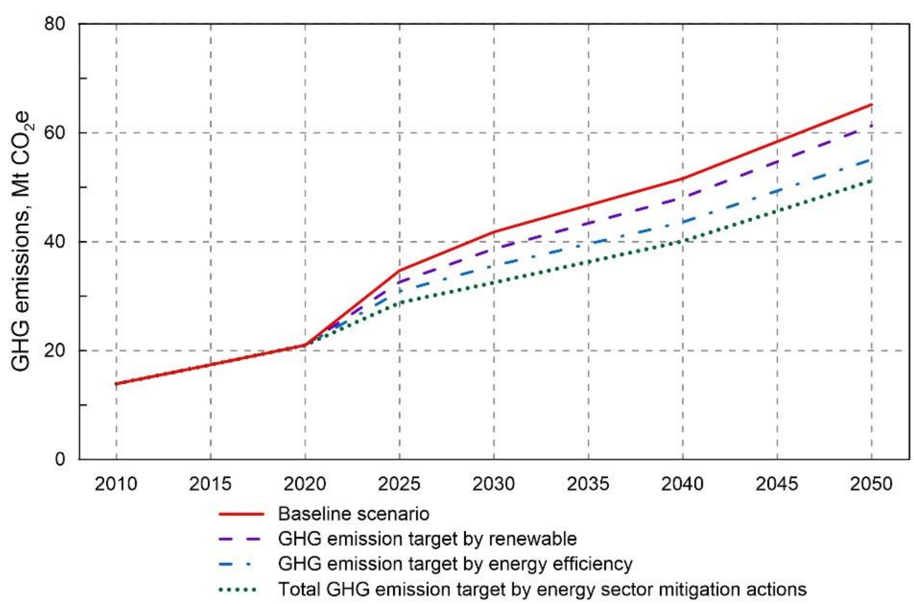

Figure 7.7 Comparison of the baseline and mitigation scenarios for GHG emissions in the energy sector

7.2.2 Industry sector

GHG emissions from the Industrial sector are mainly emitted from cement, lime and metal productions and the use of refrigeration and air conditioning equipment in Mongolia. Although, GHG emissions from the sector have been increasing due to some social and economic factors such as population and the construction industry's growth since 2010, this sector contribute less than 3% of the national total GHG emissions.

In the future, according to "Vision-2050," "State Industry Policy," "State Oil Policy," "State Mineral Resources Policy," "Law on the Promotion of Production," "Investment Program of Mongolia 2018-2021" and other documents, the government planned to implement large projects such as an oil refinery, copper smelter, synthetic natural gas from coal, and steel complex. Long-term emissions of GHGs from industrial processes and product use are predicted to increase dramatically.

According to NDC (2019), industry sector study indicated more than ten national and sector level policy documents which are implemented in Mongolia and all of them have been analysed, including the government's policy on the industry, high-tech industry, mineral resources use related business etc.,

Since the NDC submission in 2019, the following policy documents have been freshly adopted, which would affect GHG emissions by industry and product use as follows.

1. National Program for Heavy Industry Development (GoM, 2019)

The primary material is on the heavy industry goals included in the government's 2016-2020 action plan, which was accepted as an action plan and contained targets affecting GHG emissions. It includes:

- Building a ferrous metallurgy complex with infrastructure in the Orkhon and Darkhan-Selenge areas,
- Building a coal-chemical plant on the Tavantolgoi deposit,
- Building a coal gasification plant based on the Nyalga-Choir district's coal reserves,
- In the Dornogobi province, a factory for processing oil and generating goods such as gasoline and diesel fuel is being built.

2. Mongolia's long-term development policy, "Vision-2050" (PoM, 2020a)

   According to this long-term policy, the Mongolia's economy will grow at a 6.0% annual rate, along with the major topics identified Mongolia's long-term social and economic development orientations targeted such as mining deposit will be operational, and the following high-tech heavy industry complexes will be constructed until 2030.

3. Mongolian Government Action Plan for 2020-2024 (GoM, 2020)

According to this document following plants will be developed and built:

- Ferrous metallurgy (coke, cast iron, direct reduced iron) in Darkhan-Uul, Orkhon, and Dornogobi provinces,
- A precious metal refining plant ,
- An oil refinery plant, based on domestic raw materials,.

4. Mongolian Development Guidelines for 2021-2025 (PoM, 2020b)

According to this five-year direction documents for Mongolia's growth in line with the legislation on development policy, planning, and management, a list of measures to be executed, criteria for monitoring and evaluating implementation, and investment plans. To support export of the most dominant of mineral resources such as of coal, copper concentrate, iron ore, and crude oil, heavy industries such as coal-chemical, copper concentrate, and metallurgy should be immediately started and put into operation.

The following measures concerning GHG emissions in the industrial and production sectors are included in Mongolia's long-term development policy document "Vision-2050," passed by Resolution No. 52 of 2020 of the Parliament of Mongolia (Tables 7.8 and 7.9).

Table 7.8 Provisions relating to GHG emission reductions in the industry sector

Objective	Target	Effects on GHG emissions
Objective 4.2. Leading economic sectors will be developed, and an export-oriented economy will be established.	Appendix 2-4.2.14 The mining deposit will be used, and the following high-tech heavy industry complexes will be established and erected. Including: - Copper concentrate processing plant, - Petrochemical, coke-chemical, and metallurgical industries, - Coal washing plant, - Coal-chemical, coal-energy, methane gas production, technology park, - Steel industry, - Feldspar concentrator.	GHG emissions from industrial operations and energy consumption will significantly increase.
Objective6.4. Develop a low-carbon, productive, and inclusive green economy, and contribute to global efforts to mitigate climate change.	- Increase the capacity to adapt to and endure climate change and mitigate potential risks. - Develop and build the national green finance system, which will be built on public-private partnerships, and we will employ international financial methods to finance environmentally friendly green projects and activities. - Climate change mitigation measures will be adopted, and the difference between GHG emissions and removals will be zero.	There will be progress in designing, financing, and executing GHG emission reduction and adaptation initiatives. It is necessary to define the steps to be done to close the gap between GHG emissions and removals.

Table 7.9 Mitigation measures of "Vision-2050" monitoring and assessment criteria and achievement levels for industry sector

No	Assessment criteria	Baseline level (2015)	Level of achievement			Description of the assessment criteria
			2025	2030	2050	
1	Share of the manufacturing sector in gross domestic product	10.9	12	14.6	27.4	Economic sector development is expressed as a percentage of GDP
2	Percentage of domestic supply of major gasoline brands and types in compliance with the Euro 5 standard	8.0	70	100	100	Import, consumption volume, and proportion of total fuel, 2015 baseline

Source: PoM, 2020a

The key industrial projects described in the recently accepted policy papers are identical to those used in the NDC (2019) industry sector report, and no new major projects have been added i.e. no changes have occurred in the baseline level of GHG emissions.

Regarding policy texts, the most central aim of "Vision-2050" is to reduce the national gap in GHG emissions and removals by 2050. However, the sector's GHG emissions will multiply several times due to the planned deployment of a considerable number of heavy industry projects.

According to the "Vision-2050" policy document, the gross domestic product will be 23.9 billion USD in 2025 and will increase almost 10 times up to 209 billion USD in 2050. It is also predicted that the manufacturing sector will account for 12% of the gross domestic product in 2025, 14.6% in 2030, and 27.4% in 2050 (Table 7.9), which will lead to substantial increase in GHGs emissions.

The goal of minimizing the gap between GHG emissions and removals by 2050 can be met and achieved by implementing measures such as underground storage of carbon dioxide emitted by heavy industry, developing industries with the low emission technology and increasing the application of renewable energy. Once such a target has been established, it is vital to build a strategy for achieving it, as well as outline the actions to reduce GHG emissions until 2050.

Table 7.10 shows outlines the measures included in the NDC (2019) to reduce GHG emissions from industrial processes.

Table 7.10 Measures to reduce GHG emissions for industrial process

No	Measures	Description
1	Utilization of waste heat from cement plants	Waste heat-generating technology from cement plants will be implemented in 50% of the whole cement sector by 2025, based on researches done in 2019
2	Use of fly ash in cement manufacturing	The demand for raw materials should be reduced by incorporating fly ash from power plants into clinker mills. Due to the scarcity of fly ash, it is expected that 0.5 million tonnes per year will be generated until 2025 and 1 million tonnes per year until 2030 from various brands of cement that contains 25-35% fly ash.

3	Utilization of methane gas emitted from coal mine	Methane gas emitted during coal mining and transportation accounts for the most GHG emissions in the industrial process and product consumption sectors. According to the NDC 2019, only a small portion of this, or underground mining tailings methane will be used. It is based on the premise that Mongolia now has no underground coal mines and/or plan to be built a new one by 2025.
4	Conditional measures: underground storage of carbon dioxide	Due to scientific and budgetary limitations, this strategy was regarded as a "conditional option" for reducing GHG emissions from heavy, chemical-industrial operations. Starting in 2028, 50% of carbon dioxide emissions from coal gasification facilities are expected to be stored underground, which is not included in the industry's baseline assumption.

Source: NDC, 2019

On July 6, 2021, the National Committee for Climate adopted the strategy for implementing measures 1–3 in the NDC (2019) in Table 7.10. The implementation plan's execution duration and the stakeholders' duties are shown in Table 7.11.

Table 7.11 Implementation duration and duty of stakeholders

Measures	Implementation duration	Implementer	Co-Implementer
Utilization of waste heat from cement plants	2020-2025	Ministry of Energy, Ministry of Mining and Heavy Industry	Ministry of Finance, Energy Regulatory Commission, Ministry of Urban Development and Construction, Ministry of Environment and Tourism
Utilization of fly ash in cement manufacturing	2020-2025	Ministry of Energy, Ministry of Urban Development and Construction	Mongolian Association of Construction Materials Manufacturers, Ministry of Environment and Tourism, Thermal power plant, Ministry of Mining and Heavy Industry, Cement plants
Utilization of methane gas emitted from coal mine	From 2025	Ministry of Mining and Heavy Industry	Ministry of Mining and Heavy Industry, Ministry of Energy

Source: NCC, 2021

This report discusses the following ways to reduce GHG emissions based on the characteristics of the sources of GHG emissions in the industrial process and product consumption sectors, as well as current technological breakthroughs. It includes:

- Utilizing waste heat from cement plants,
- Utilizing fly ash in cement manufacturing.

1) *Utilizing waste heat from cement plants*

Aside from the use of dry technology in the cement industry, the utilization of waste heat is the next method for reducing GHG emissions. It is feasible to utilize waste heat generated from the high heated components during the cement manufacturing process, for example, the part exiting the furnace, the clinker cooling part, and the preheating part, and generate power using a steam turbine or organic oil turbine technology. Under various conditions, the potential power generation rate ranges from 7 to 20 kWh/t cement and high-temperature gas from dry technology furnaces can be further used to generate energy. The investment to generate power from waste heat is 2-4 USD per tonnes with annual operating expenses of 0.2-0.3 USD per tonnes (EPA, 2010).

Because Mongolia's cement companies have all transitioned to dry technology, there is a technological potential for using waste heat. Assuming that the technology mentioned above is used for 50% of cement production, it is conceivable to create 27 million kWh of energy by 2050, reducing GHG emissions from coal and power consumption in the cement industry by 28.2 thous. t CO_2e.

2) *Utilizing fly ash in cement manufacturing*

Using fly ash from power plants during clinker grinding decreases the requirement for raw materials in the cement industry, lowering GHG emissions. Because fly ash may constitute up to 25-35% of the weight of cement, the energy required to create one tonne of cement can be decreased by 200 MJ -500 MJ, GHG emissions can be reduced by 0.045 t CO_2e -0.127 t CO_2e (NDC, 2019), and the investment required is around 0.75 USD per tonnes of cement. If the average value of this standard or 0.086 t CO_2e cement will reduce GHG emissions, on the other hand, considering the limited resources of powdered coal, it is estimated that 0.5 million tonnes per year in 2025 and 1 million tonnes per year in 2030 will be produced with an acceptable quantity of fly ash. As a result, GHG emissions may be decreased by 43.0 thous. t CO_2e in 2025, 86.0 thous. t CO_2e in 2030, 172.0 thous.t CO_2e in 2040, and 258.0 thous. t CO_2e in 2050.

Figure 7.8 shows the baseline scenario of GHG emissions from cement and lime industries as computed by the LEAP model.

Table 7.12 Reduction of GHG emissions from industrial processes and product use

Measures	2010	2015	2020	2025	2030	2040	2050
Baseline scenario, thous.t CO_2e	222.9	327.9	980.7	2077.3	2956.9	5503.2	8165.2
GHG emission reduction scenario, thous.t CO_2e	222.9	327.9	980.7	2024.6	2857.5	5310.4	7879.0
Utilizing waste heat from cement plants, thous.t CO_2e	-	-	-	9.7	13.4	20.8	28.2
Utilizing fly ash in cement manufacturing, thous.t CO_2e	-	-	-	43.0	86.0	172.0	258.0
Total GHG emission reduction, thous.t CO_2e	-	-	-	52.7	99.4	192.8	286.2
Total reduced GHG,%	-	-	-	2.5	3.4	3.5	3.5

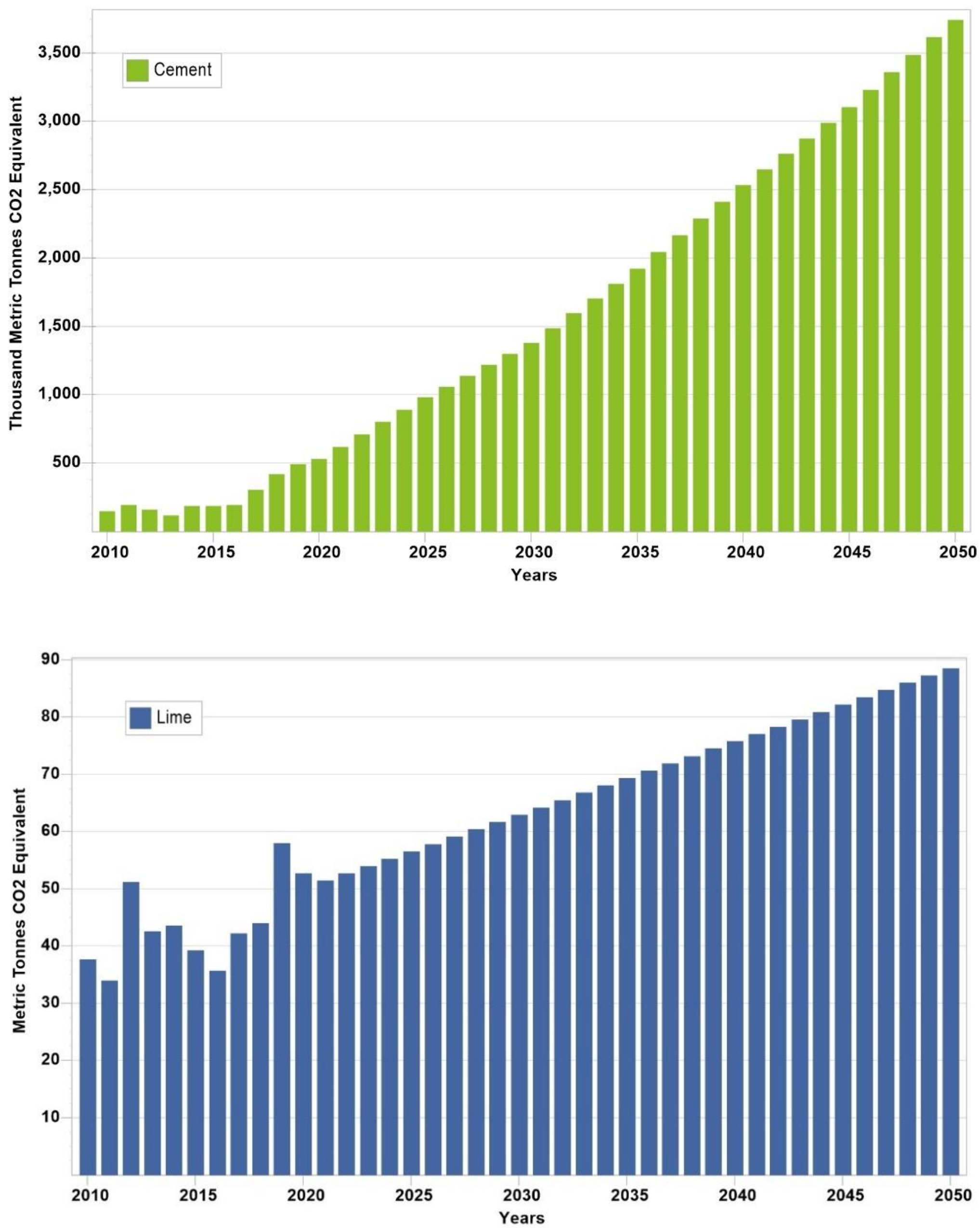

Figure 7.8 The baseline scenario for GHG emissions from the cement and lime industries (LEAP model)

By implementing the actions outlined above in the industrial sector, GHG emissions in 2025, 2030, 2040, and 2050 will be 52.7 thous. t CO_2e, 99.4 thous. t CO_2e, 192.8 thous. t CO_2e, and 286.2 thous. t CO_2e or 2.5, 3.4, 3.5, and 3.5% reduced compared to the baseline scenario (Table 7.12, Figure 7.9).

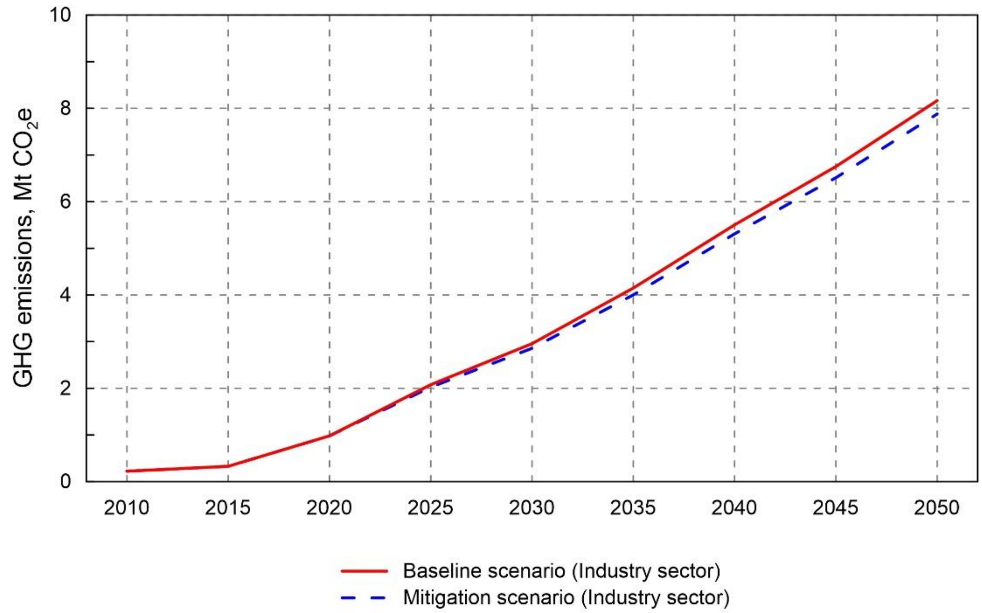

Figure 7.9 Comparison of the baseline and mitigation scenarios of GHG emission in the industrial sector

7.2.3 Agriculture, Forestry and Other Land Use (AFOLU)

Different models, such as the LEAP model for the baseline scenario of the livestock sector, the COMAP model for land use change and forest and the EX-ACT model for Forest sink, estimated the emissions for the baseline and mitigation scenario. EX-ACT is an FAO model for evaluating individual projects, programs, and actions to reduce GHG emissions (https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/en/). It is based on the IPCC's GHG Estimation Manual. This model is used in the AFOLU sector to estimate how much GHG will be removed or eliminated due to the activity's implementation. The EX-ACT model was used to forecast the future outcomes of the "Billion Tree" national campaign. When determining the number of trees to be planted per hectare, the 2008 Joint order by the Minister of Finance and Minister of Environment on the "Standard Price of Planted Forests and Trees to be purchased from Citizens, Communities, Enterprises, and Organizations" the maximum number of trees to be planted is 2500 per hectare, with a total area of 400,000 ha, and only above-ground biomass carbon sink is considered. In the estimation, the above-ground biomass of 1 ha is 55 t/ha, and carbon is 26.8 t/ha values are used (Mongolia's Forest Reference Level submission to the UNFCCC 2018).

The COMAP model was developed to quantify CO_2 emissions (https://unfccc.int/resource/cd_roms/na1/mitigation/Module_5/Module_5_2/b_COMAP/Manuals/COMAP)Manual.pdf) from land use changes and was used to predict forest and cropland absorption concerning crop yields.

The NDC, Vision - 2050, the Mongolian Government's 2020-2024 action program, and sector-specific programs and plans are the national documents that reflect the essential efforts to reduce GHG emissions. The policies in the above documents for the AFOLU sector are summarized in Tables 7.13, 7.14, and 7.15.

Table 7.13 Provisions in Vision-2050 related to the reduction of GHG emissions in the AFOLU sector

Objective	Sector	Implementation duration	Measures/specific objectives	Expected outcomes
Name: Vision-2050 Type: Policy of Mongolia Objective: Leading economic sectors will be developed, and an export-oriented economy will be established.				
A legislative and regulatory framework will be established to stimulate investment in the processing of livestock and animal-derived raw materials, as well as the manufacture of final products	Livestock	2020-2050	Increase agricultural processing and livestock exports	The number of livestock will drop, while the herder's revenue will rise
Maintaining environmentally sustainable and organic livestock while preserving traditional nomadic culture, as well as diversifying intense agricultural production		2021-2030	Intensification of resource utilization and economic circulation of agricultural production, shifting from quantity to quality	Will have livestock suitable for the ecology and pasture capacity
To protect livestock health and to achieve the sanitary and hygienic requirements of animal-derived raw products	Livestock		Increase the number of food products exported by stepping up efforts to protect livestock health and improve livestock quality and production	Increase the number of livestock-related raw products export
Define the legislation that controls relations involving the use, improvement, and protection of pastureland			Develop an integrated pasture management system to decrease pasture degradation and desertification	The capacity of pastures will increase
Improve crop rotation area usage, supply domestic demands with the major crop varieties, and expand production of other profitable crops	Agriculture	2021-2030	Abandon old crop-ploughing and crop-processing technologies in favour of innovative agrotechnical and irrigation technologies; do not plough new land; instead, recycle arable land and use the soil	To conserve and increase soil fertility, fully implement zero and reduced technologies in agricultural production
A forest ecosystem has been developed by implementing	Forestry	2021-2050	Prevent deforestation and expand forest coverage by	In 2019, forest covered area

sustainable management of forest conservation and restoration			promoting afforestation, forest growth, restoration, and forest preservation	was 7.9%; by 2025, 2030, and 2050 this amount will rise to 8.7%, 9%, and 10%, respectively
Becoming to provide a healthy and safe living environment for its citizens, preserve ecological balance, and become a city with a pleasant living environment, low GHG emissions, and green technology	Forestry	2021-2030	Develop an ecosystem in the forest that is resistant to the effects of urban climate change, use sustainable management to keep the forest protected, and eventually adopt a payment system for ecosystem services	Building new and updated dirt strips in Ulaanbaatar to prevent forest fires

Table 7.14 Provisions in NDC (2019) related to the reduction of GHG emissions from the AFOLU sector

Objective	Sector	Implementation duration	Measures/specific objective	Expected outcomes
Name: Objectives for Nationally Determined Contributions (NDC) to the implementation of the Paris Agreement Type: Policy of Mongolia Objective: Determination of main objectives and measures for reducing GHG emissions in Mongolia's key economic sectors				
Increase livestock productivity and limit the number of livestock	Livestock	2021-2030	Limiting and reducing the rise in the number of livestock, establishing an acceptable ratio of the number and type of livestock consistent with the carrying capacity of pastures, and developing intensive animal husbandry further	To reduce livestock numbers by 5% per year from 2015 levels under pasture capacity and to have 51.2 million practical livestock in 2033
			Improving the livestock manure and dung management	GHGs released from livestock manure and dung will decrease
Increase soil fertility and reduce land degradation			Implementation of measures aimed at protecting pastures and soil	If the Pasture Law is passed and enforced, the number of animals will be reduced by 6% yearly.
Increase forest carbon sink	Forestry	2021-2030	-The average forest fire area will be decreased by 35% in 2025 and 70% in 2030. - The spread of harmful insects and diseases will be decreased by half by 2025	-The forest area affected by the fire will decrease to 84.3 thousand ha/year in 2025 and 38.9 thousand ha/year in 2030. -Once hazardous insect populations are totally under control, the amount of forest area being destroyed each year by

			and entirely controlled by 2030.	these pests will drop to 4.9 thousand ha in 2025 and 0.0 thous. ha in 2030.

Table 7.15 Provisions included in the Government of Mongolia's 2020–2024 action plan for reducing GHG emissions in the AFOLU sector

Objective	Sector	Implementation duration	Measures/specific objective	Expected outcomes
Name: Government of Mongolia's 2020–2024 action plan Type: Plan Objective: The government of Mongolia's 2020–2024 action plan aims to promote regional and local development, environmental governance, and economic and social advancement				
To assist the growth of the intensive livestock sector by increasing animal pasture resources, enhancing livestock quality and productivity, shifting livestock numbers to quality, and adopting "Mongolian Livestock-II" measures.	Livestock	2020-2024	Based on agricultural regions, intensive dairy cattle farming will be established. Deep wells and water storage facilities will be constructed to enhance pasture utilization, and pasture reserves and hayfields will be expanded.	The pasture and livestock quality will increase.
Create law and legal framework for the utilization, protection, and preservation of grasslands and decrease pasture deterioration and desertification.	Land use	2020-2024	Combat rodents and pests that damage pasture crops in a way that is less harmful to the environment.	Grassland crops will recover, and their absorbing capacity will enhance.
Agricultural raw materials processing facilities will be built regionally to produce and export value-added goods, increasing herder and citizen income.	Livestock		Support in the production of value-added goods for export.	Meat and meat products export amount (thousand tonnes): 59 thousand tonnes in 2019, 70 thousand tonnes in 2021, 90 thousand tonnes in 2022, 120 thousand tonnes in 2023, and 150 thousand tonnes in 2024
Fight infectious and highly contagious diseases, provide a calm zone free of highly contagious diseases, and create opportunities for livestock raw materials and products export.	Livestock		Empower veterinarians and increase the quality of veterinary services. It prevents livestock and animal infectious diseases.	The number of animal and zoonotic infectious disease foci and cases will decrease.

Enhance the productivity of the livestock processing factory, construct an environmentally friendly complex, and increase agricultural commodities and product exports.	Livestock		Introduction of advanced technologies and innovations to improve the productivity of the manufacturing industry, The "Darkhan leather complex" production and technology park, as well as the "Shine Khovd" manufacturing and technology park, will be intensified.	Amount of meat reserves (thousand tonnes): 11 thousand tonnes in 2019, 20 thousand tonnes in 2021, 20 thousand tonnes in 2022, 20 thousand tonnes in 2023, and 20 thousand tonnes in 2024.
This will make it easier for national small and medium-sized businesses to carry out specific work for large factories like Oyutolgoi and Erdenet.			It will establish a process for delivering quality goods and products to significant national development projects, government agencies, and large corporations and implement the "National Supply" program.	
To ensure stable agricultural output growth, expand the ability to export and process products, and increase the industry's productivity and competitiveness by improving crop rotation and feed production by executing the “Atar IV” campaign.			-Agricultural production intensification through technological innovation -Increase soil fertility and unit yield -Expand the amount of irrigated land -Improve sea buckthorn competitiveness, increase exports, test various fruits, and berry crops and varieties, develop growing techniques and technologies	Supply of vegetables: 2019-40% 2021-55% 2022-60% 2023-70% 2024-80% Supply of potatoes and wheat in 2019-2024 will be 100%.
Environmental protection, appropriate use of natural resources, the introduction of innovative methods and technologies, reduction of pollution and deterioration of the environment, and establishment of conditions	Forestry	2020-2024	Forest coverage will be extended to 8.6%, and a legislative and regulatory framework will be established to provide monetary incentives to residents and businesses that contribute to green	Forest coverage as a percentage of total area: 2019 7.9%, 2021-8.0%, 2022-8.2%, 2023-8.4%, 2024-8.6%

for residents to live in a healthy environment			development by planting trees.	
	Land use	2020-2024	Mining-related land damage will be rehabilitated.	8,000 hectares of mining-damaged land that has been abandoned for many years will be rehabilitated.

Analysing the preceding policy documents:

Livestock sector

- Determine the maximum quantity, type, and structure of livestock that is compatible with natural ecology and pastureland capacity,
- Increase the number of agricultural goods that are processed and the number of livestock products that are exported,
- To step up efforts to protect livestock health and improve livestock quality and production.

Agricultural sector

- Abandon conventional agricultural ploughing and processing procedures in favour of new agrotechnical and irrigation systems,
- Do not plough new land; instead, reuse abandoned land,
- Full implementation of zero and reduced technology in cropland
- Promoting the use of ecologically friendly fertilizers, as well as preserving and enhancing soil fertility,
- It will apply environmentally friendly plant protection methods and offer suitable techniques to combat the spread of diseases, weeds, dangerous insects, and rodents.

Forestry

- Preventing deforestation through encouraging afforestation, forest extension, restoration, and forest preservation measures, increasing forest coverage from 9% of the total land in 2030 to 10.5% in 2050, and enhancing carbon sink,
- Reducing average forest fire area by 35% in 2025 and 70% in 2030,
- To entirely limit the spread of pests and diseases in forests by 2030,
- It also includes expanding green space in metropolitan areas.

7.2.3.1 GHG emission reductions in the livestock sector

"Vision-2050", "Nationally Determined Contribution" (2020), "Mongolia's Sustainable Development Concept-2030" (2016), and "Mongolia's 2020-2024 Government Action Plan" are policy measures to reduce GHG emissions from the livestock sector. To address problems in the livestock sector at a certain level, as well as to ensure the coherence of approved programs, and to contribute to the "Action Plan for the Implementation of the Global Sustainable Livestock Program," the Ministry of Food, Agriculture, and Light Industry launched the "Mongolian Livestock Program on Sustainable Economic Development Plan," which was approved by Order No. A-105 in June 2018 and would be implemented between 2018 and 2020. The key steps included in the above policy plans are to reduce livestock heads and numbers and to optimize pasture capacity. The primary cause of grassland deterioration is livestock overpopulation. The NSO researched Mongolia's current grazing capacity and herd structure in 2018. According to the study, the acceptable number and heads of livestock were 51.6 million, which is 22.0% or 14.6 million higher than the number of livestock recorded in 2017 (NSO, 2018). The carrying capacity of the pasture has been exceeded by all animals except camels, as seen in the graph below.

According to Figure 7.10, all animals, except camels, exceed the grazing capacity. The improper loss of livestock is a factor that inevitably influences the change in the number of animals. The NSO study estimates the unusual loss of large animals as animals that perished for causes other than unexpected danger, natural catastrophes, illnesses, eaten by wild animals, or other factors.

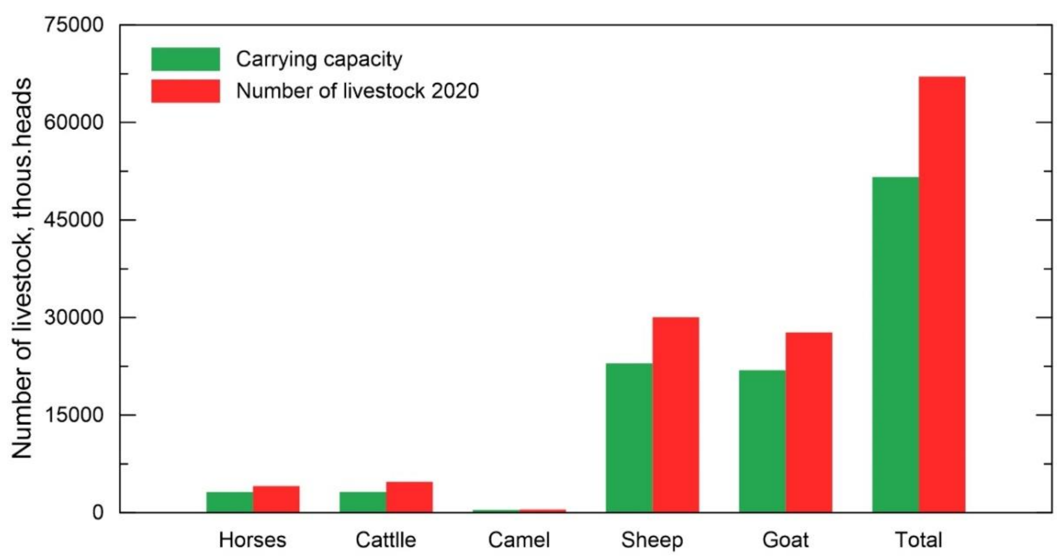

Figure 7.10 The number of suitable livestock for grazing capacity in Mongolia

The Dzud in 2010 resulted in the highest loss of livestock, amounting to 10.3 million animals or 35% of large livestock. This drop has been rather consistent in recent years, averaging 1.9% over the past 10 years (2011-2020) and 4.6% on average during the past 50 years (1971 to 2020). The production of animal meat and the export of raw materials (wool, skin and leather materials) are two other important factors that affect changes in the number of livestock in Mongolia. For example, 4 million skins and leathers were exported in 2000, however, this was followed by a sharp decline in exports.

Between 2017 and 2019, our nation exported the most meat production; in 2018, 39,300 tonnes of meat were exported overseas. Since the Covid 19, meat exports have been declined in recent years. According to statistical analysis, 10–12 million animals heads were provided from animal husbandry to food in the last five years. Compared to the overall number of animals, proportion of animals for food production accounted, sheep accounted for 23%, goats 21%, cattle 16%, horses 10%, and camels 7%.

The Mongolian government has been implementing policies to increase livestock fattening in animal husbandry; thus, at least 25% of sheep and goats, no more than 15% of cattle and horses, and no more than 3% of camels are being prepared for food production in 2017-2018. Considering the above policy, meat, and export reserves in 2017-2018 accounted for 3,412.4 thous. heads of sheep or 61.4 thous. tonnes of meat, 3,132.9 thous. goats or 47.0 thous. tonnes of meat, 214.2 thous. tonnes of cattle or 27.9 million tonnes of meat and 291.0 thous. horse or 43.6 thous. tonnes of meat (Table 7.16). Therefore, the number and amount of meat exports, including 27.9 thous. tonnes of beef and 43.6 thous. tonnes of horse meat, were determined at a meeting of the Government's National Food Safety Council on November 29, 2017, and the export volume of sheep and goat meat was decided separately without imposing limitations.

The number and amount of meat exports, including 27.9 thousand tonnes of beef and 43,6 thousand tonnes of horse meat, were determined at a meeting of the Government's National Food Safety Council on November 29, 2017, and the export volume of sheep and goat meat was decided separately without imposing limits.

Table 7.16 Meat export reserve

Meat export reserve in 2018			
Livestock	1000 head	1000 tonnes	Weight per animal (kg)
Sheep	3,412.4	61.4	17.8
Goat	3,132.9	47	15.0
Cattle	214.2	27.9	130.2
Horse	291	43.6	149.8

Table 7.17 shows food consumption and export reserve estimated based on data provided in Table 7.16, if the number of animals used for food and export is set at 1000.

Table 7.17 Food consumption and export reserve

Livestock	Livestock number in 2018 (1000 heads)	Percentage of livestock in food consumption	Percentage of livestock in food consumption (1000 heads)	Export reserve (1000 heads)	Share of export reserves	Total food consumption and export reserves (1000 heads)	Total food consumption and export reserves (%)
Horse	3,940.1	10.0	394.0	291.0	7.4	685.0	17.4
Cattle	4,380.9	16.0	700.9	214.2	4.9	915.1	20.9
Camel	459.7	7.0	32.2	0.0	0.0	32.2	7.0
Sheep	30,554.8	23.0	7,027.6	3,412.0	11.2	10,439.6	34.2
Goat	27,124.7	21.0	5,696.2	3,132.9	11.5	8,829.1	32.5
Total	66,460.2	20.8	13,850.9	7,050.1	10.6	20,901.0	31.4

To predict the pattern number of livestock head changes in the future, the following scenarios were considered (Figure 4-11):

1. From 1990 to 2020, pattern via linear regression of changes in the number of livestock (BAU1),
2. Average annual growth rate (2.48%) from 1970 to 2020 (BAU2),
3. Based on the NDC's average (0.5%) annual growth (BAU) scenario.

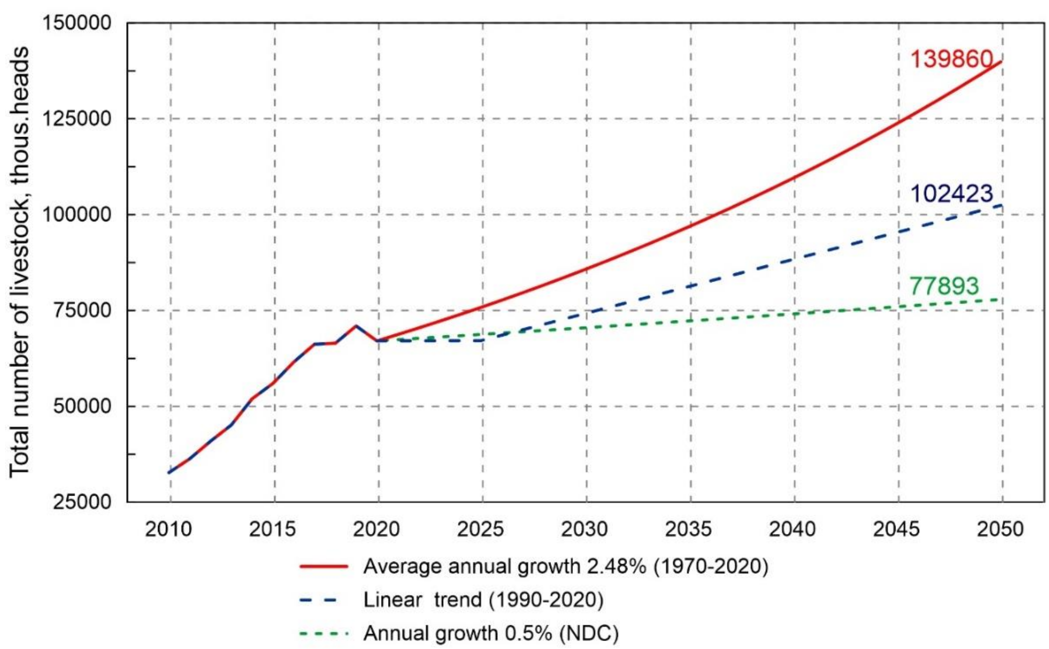

Figure 7.11 The future growth trend for livestock number

The baseline scenario was built into the LEAP model based on the average of the above three scenarios (Figures 7.12 and 7.13, and Table 7.18).

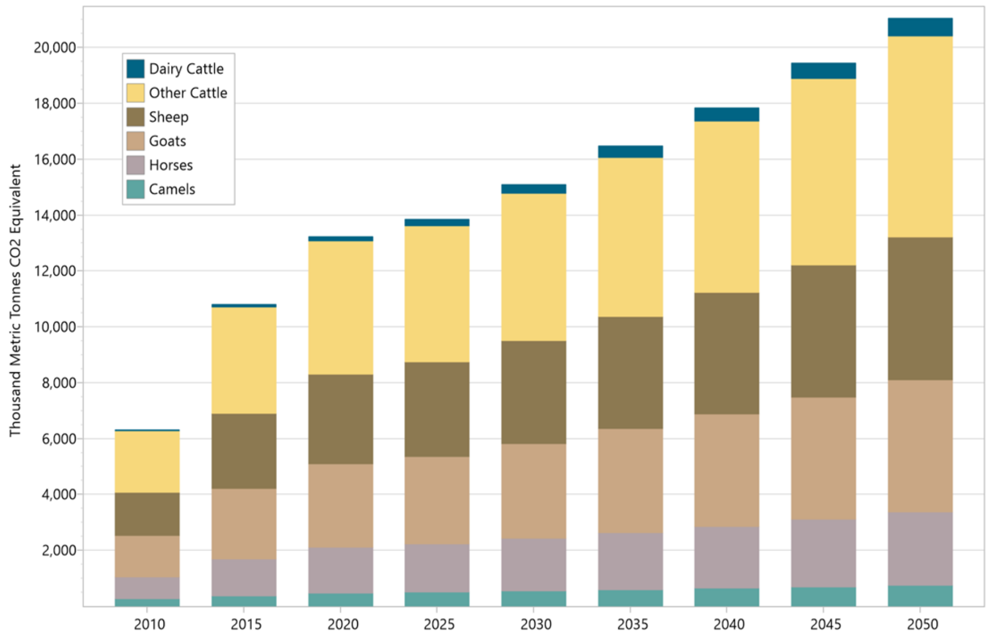

Figure 7.12 Baseline scenario of GHG emissions from livestock by animal type (LEAP)

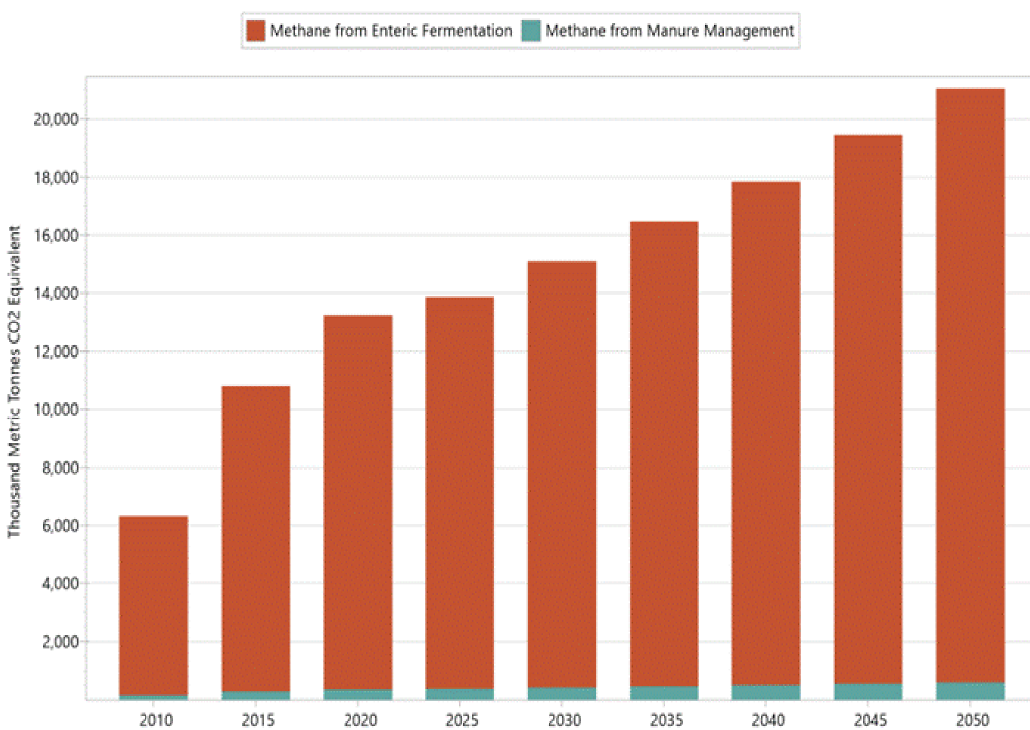

Figure 7.13 Baseline scenario of GHG emissions from livestock by source (LEAP)

Table 7.18 Baseline scenario of GHG emissions from livestock by animal type (1000 t CO_2e)

	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU) of GHG emissions from total number of livestock	6,273.1	10,702.4	13,075.1	13,847.7	15,091.3	17,848.8	21,047.4
Dairy cattle	34.4	99.3	155.9	242.6	323.4	438.1	572.0
Cattle (other)	2,181.9	3,776.0	4,713.5	4,867.8	5,260.0	6,178.8	7,244.0
Sheep	1,542.8	2,647.1	3,180.3	3,386.4	3,685.0	4,353.2	5,128.1
Goat	1,482.0	2,508.8	2,939.5	3,130.0	3,406.0	4,023.6	4,739.9
Horse	765.8	1,309.1	1,621.8	1,726.9	1,879.2	2,220.0	2,615.1
Cattle	266.3	362.1	464.0	494.1	537.7	635.2	748.2

As a result, the primary goal of minimizing GHG emissions from livestock is to restrict the quantity of livestock and develop an optimum herding structure ratio to adjust to pasture capacity.

According to the Ministry of Food, Agriculture, and Light Industry statistics for the last five years, assuming 10-12 million livestock are utilized for food, 18-21 million are accessible for food consumption and export. About 20% of total livestock is used for food, while about 10% can be exported.

The following options are considered in the computation of feasible strategies for GHG emission reductions based on the data presented above such as:

1. Setting the top limit for the quantity, type, and structure of livestock in accordance with natural ecology and grazing capacity (Vision-2050),
2. Reducing the number of livestock to 51.6 million following the optimum herding structure ratio under pasture carrying capacity (Report on determining the number of livestock by the carrying capacity and conditions of the pastures, NSO, 2018),
3. Supporting the meat export and deliver it to the potential reserves.

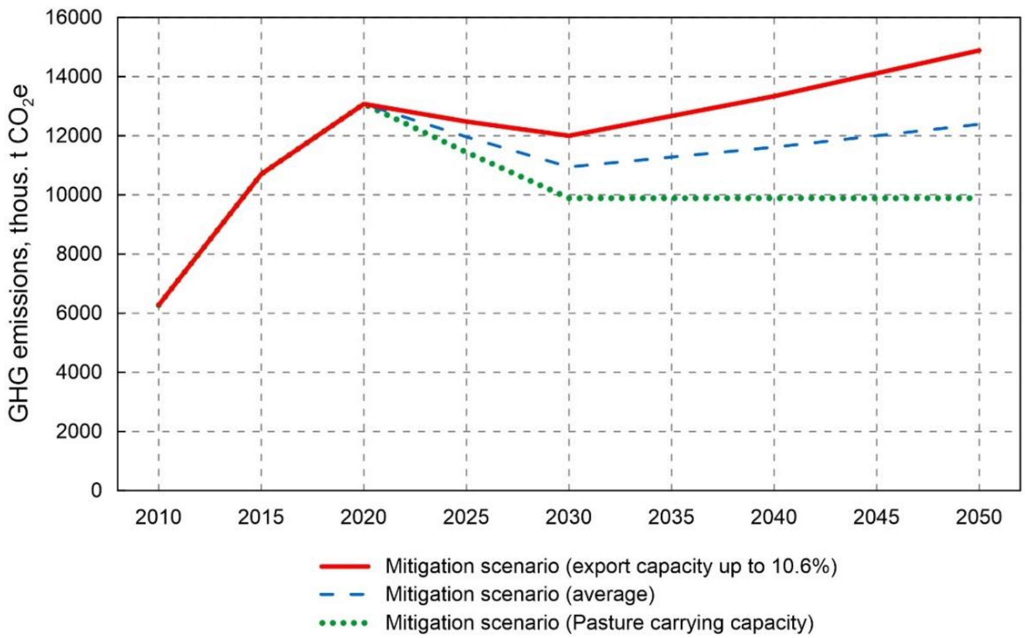

Figure 7.14 Mitigation scenario for measures to support export capacity and pasture carrying capacity in livestock sector

In Table 7.19 shown the GHG mitigation potential in livestock sector by 2050. GHG emission reductions from livestock sector are predicted by 17.4%, 34.5%, 44.6%, and 53.0% in 2025, 2030, 2040, and 2050, respectively, compared to the baseline scenario.

Table 7.19 Total GHG mitigation potential in livestock sector, thous. t CO_2e

	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU)	6,273.1	10,702.4	13,075.1	13,847.7	15,091.3	17,848.8	21,047.4
Mitigation scenario	6,273.1	10,702.4	13,075.1	11,442.9	9,890.0	9,890.0	9,890.0
Total GHG emission reductions	-	-	-	2,404.8	5,201.3	7,958.8	11,157.4
Total GHG emission reductions, %	-	-	-	17.4	34.5	44.6	53.0

7.2.3.2 GHG emission reductions in the agriculture land

Changes in soil conditions influence GHG emissions from agricultural activities. “Vision-2050” “Sustainable Development Concept of Mongolia-2030”, and the Government’s food and agriculture policies included the measures potential to reduce GHG emissions from the agricultural sector. Regarding to the above mentioned policies, the following decisions were made from 2016 to 2020 as follows:

- Government resolution No. 476 of 2019 on the Introduction of the “Atar-IV” campaign for the sustainable development of agriculture,
- Government resolution No. 131 of 2018 on the Introduction of certain “Agricultural areas”,
- Government resolution No. 278 of 2017 on approving the “National Vegetable Program”,

- Approval of the program by Government resolution No. 223 of 2017/ "Fruit and Vegetable National Program",
- The Government Resolution No. 212 of 2016 on launching a "National Campaign Approval".

The key agricultural legislation updated after 2015 is the Law on Agriculture, enacted in 2016. The legislation is noteworthy in that it explicitly addresses the challenges of assessing soil physical and chemical qualities, preserving it, and promoting soil fertility. The actions of soil conservation and enhancement are expressed in Article 25 of Chapter 4 of the Law "Protection of Agricultural Land Soil"as follows:

- Utilizing zero-tillage and reduced-tillage techniques for soil cultivation during crop production,
- Fencing agriculture land,
- Planting a forest strip,
- Cover the agricultural field with straw mulch.

The indicators for figuring out the agrochemical and physical properties of the soil are also described in details, and the local administrative body in charge of agriculture will determine those properties every five years using the landowner's funds. The local governor was given the authority to withdraw the certificate of ownership and usage if restoring the soil quality was not completed and causing soil degradation. Given the current condition of agriculture, the quantity of cultivated land is increasing each year while the amount of abandoned land decreasing. The primary ways to minimize GHG emissions from agricultural production are not to plough additional new areas and rather to utilize better technologies.

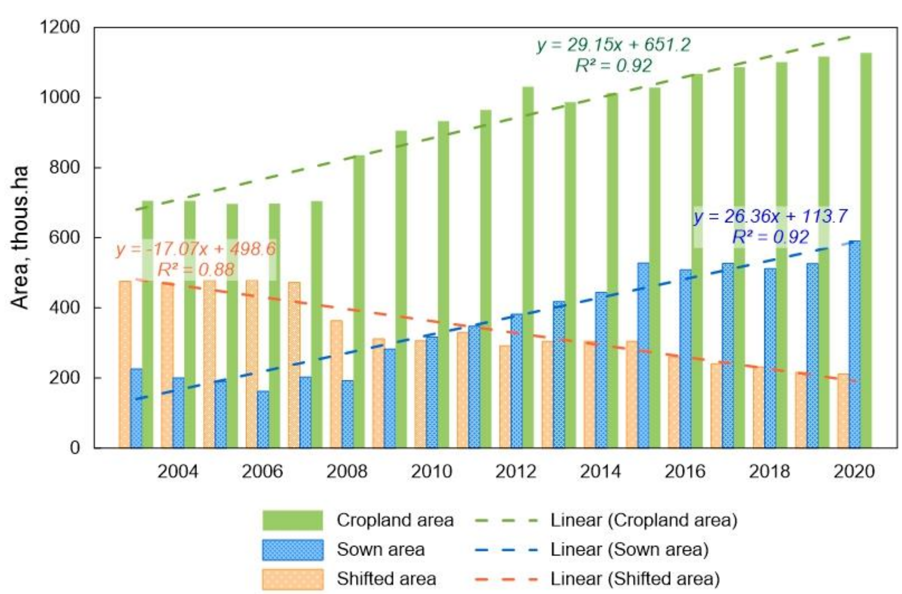

Figure 7.15 Changes in the Cropland area in Mongolia

As seen in Figure 4-15 the amount of cultivated land and arable land area is steadily growing and based on this trend the baseline scenario for GHG emissions from agriculture land was estimated. However, estimating the emission reductions, it considered the “Vision-2050” program’s provisions for 2022-2030, which specifies that only abandoned land would be cultivated, and no new land would be ploughed. The key measures in cropland sector as follows:

- Eliminate traditional agricultural ploughing and processing technologies in favour of advanced agrotechnical and water-saving irrigation techniques, refrain from ploughing new land, and only recycle previously cultivated land (PoM, 2021),
- Step by step shift to zero and reduced tillage technology in agriculture land,
- Protection of agricultural land soils.

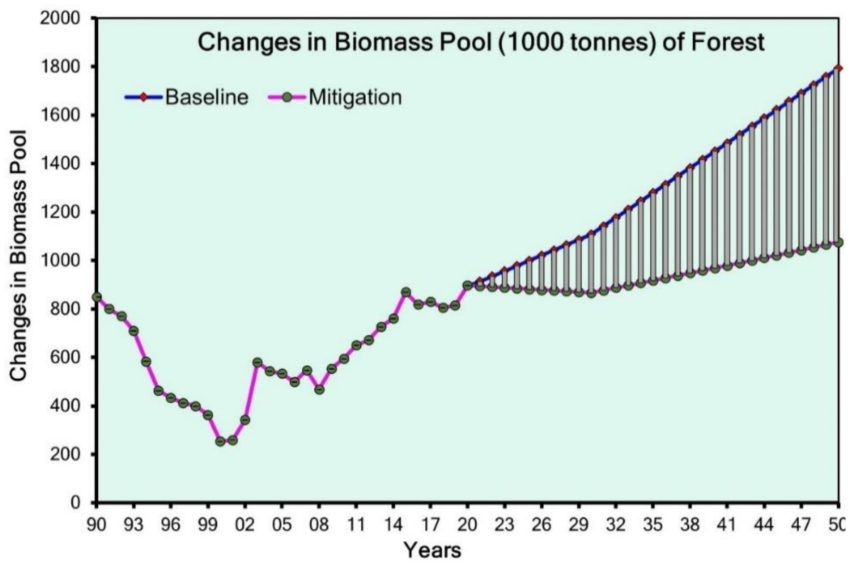

Figure 7.16 Changes in biomass pool of cultivated cropland (COMAP)

The COMAP model was used to determine the biomass change of total cropland, and the yield per hectare was projected to be 13 tonnes/ha for the average wheat production from 2015 to 2020. Figure 7.16 shows the extent to which emissions will continue to rise in the MoD's baseline scenario, i.e., if no action is taken (BAU), and if the above-mentioned key measures in the agricultural sector are implemented.

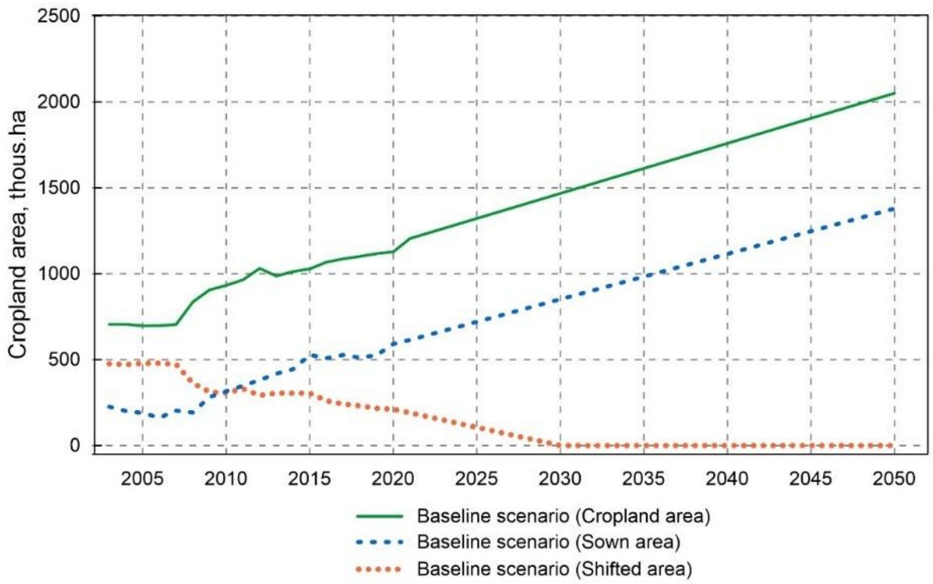

Figure 7.17 Baselne scenario of arable farming of Mongolia

According to Figure 4-18, it is estimated that in the baseline scenario, in case no action is taken, the amount of cropland and the sown area will continue to grow linearly, but there will be no shifted land or zero shifted land from 2030.

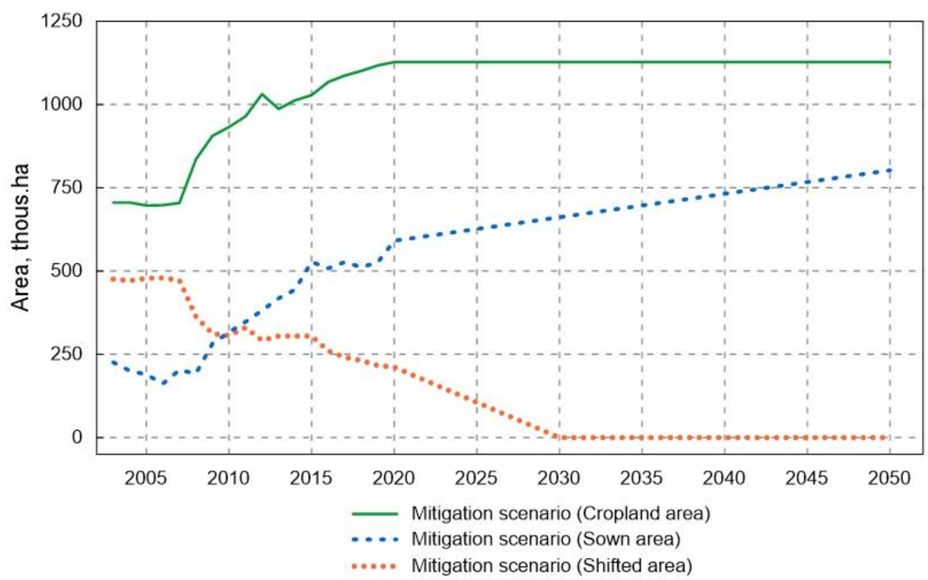

Figure 7.18 Mitigation scenario of arable land of Mongolia

Figure 7.18 and Table7.20 shows the extent of the reduction of cropland, sown and fallow areas if the measures are fully implemented.

Table 7.20 Changes in cropland area, thous ha

Cropland area scenarios	2010	2015	2020	2025	2030	2040	2050
Cropland area (baseline)	932.4	1,028.2	1,127.5	1,321.9	1,467.6	1,759.2	2,050.8
Cropland area (mitigation)	932.4	1,028.2	1,127.5	1,127.5	1,127.5	1,127.5	1,127.5
Sown area (baseline)	316.4	527.7	591.2	720.1	851.9	1,115.5	1,379.1
Sown area (mitigation)	316.4	527.7	591.2	626.4	661.7	732.2	802.7
Fallow (baseline)	309.4	195.5	324.8	496.0	615.8	643.7	671.7
Fallow (mitigation)	309.4	195.5	324.8	395.3	465.8	395.3	324.8
Shifted (abandoned) area (baseline)	306.6	305.0	211.5	105.8	0.0	0.0	0.0
Shifted (abandoned) area (mitigation)	306.6	305.0	211.5	105.8	0.0	0.0	0.0

Figure 7.19 and 7.20 are shows the baseline and mitigation scenarios in cropland and sown area of Mongolia, respectively, taking into account the mitigation actions.

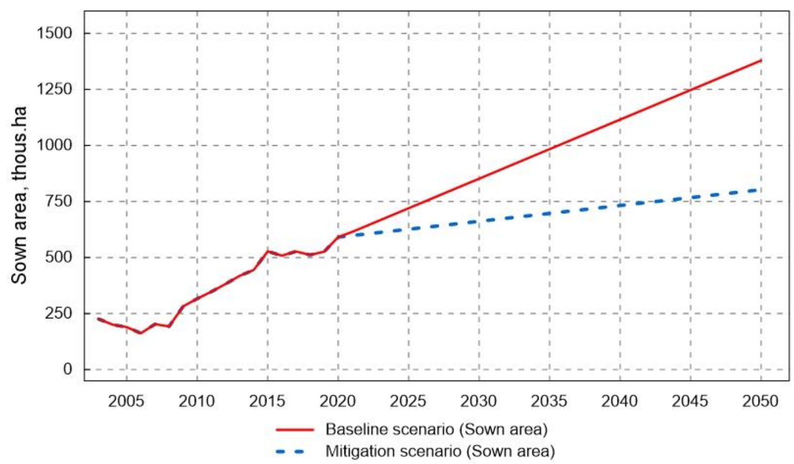

Figure 7.19 Baseline and mitigation scenarios of sown area in Mongolia

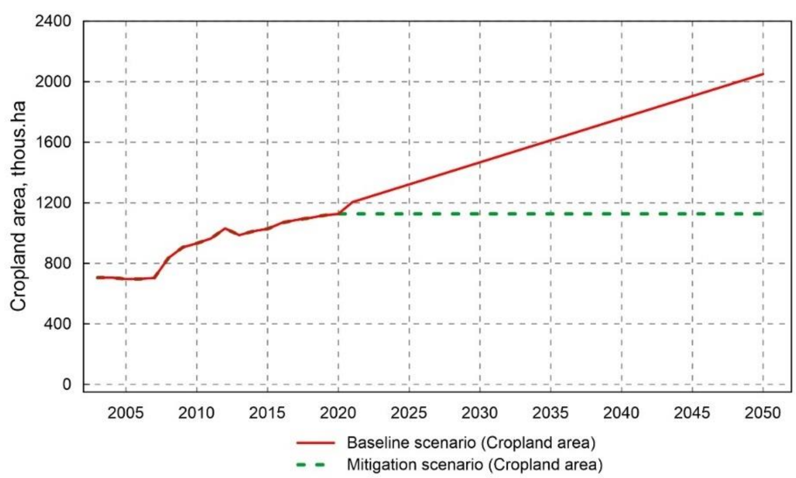

Figure 7.20 Baseline and mitigation scenarios of cropland area in Mongolia

Results from total GHG mitigation potential in cropland demonstrated in Table 7.23. The quantity of CO_2 emitted from the soil of the sown area is expected to drop by 13.0%, 22.3%, 34.4%, and 41.8% compared to the baseline scenario in 2025, 2030, 2040, and 2050, respectively.

Table 7.21 Total mitigation potential in cropland, thous. t CO_2e

	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU)	406.4	677.8	759.3	924.9	1094.2	1,432.9	1,771.5
Mitigation scenario	406.4	677.8	759.3	804.6	849.9	940.5	1,031.0
Total GHG emission reduction	-	-	-	120.3	244.3	492.4	740.5
Total GHG emission reductions, %	-	-	-	13.0	22.3	34.4	41.8

7.2.3.3 Contribution of the forest sector to GHG removals

Forests in Mongolia are divided into two main categories. In the northern part of the mountain-steppe region, forest covers with the dominance of coniferous forest, while in the south, there are Saxaul forests. Forests constitute a significant removal environment of GHGs, and forest cover is being depleted and degraded due to anthropogenic influences, forest fires, pest and insect impacts and grassland degradation (MET, 2018).

The forest resource of Mongolia is estimated to be 14.2 million ha of land, and forests cover 12.1 million ha, 133 thous. ha of cut-down forests, 719.2 thous. ha of reserve land for reforestation and 62.3 thous. ha of forest nurseries for statistics as of 2020. Annually, 955.3 thous. m3 of wood was logged for different purposes (MET, 2022).

The forests of Mongolia are highly vulnerable to drought, fire and forest pests and have a low productivity. Moreover, due to their slow growth rate, the forest cover quickly loses ecological balance and has poor regeneration capacity. Therefore, sustainable forest management is necessary to prevent forest protection and degradation.

“Multipurpose National Forest Inventory” have conducted in 2014-2016 in Mongolia and also the “UN-REDD National Program of Mongolia” was implemented in 2016-2019. Within the framework of the “UN-REDD National Program of Mongolia” implementation, the “Forest Reference Level Report” was developed and submitted to the Secretariat of the UN-REDD.

The “State policy on Forests” was approved in 2015 to maintain the balance of the forest ecosystem in Mongolia, ceasing the depletion and degradation of forests; and increasing the area covered by forests through forest restoration and afforestation; and creating the sustainable forest management aimed at the appropriate use.

The national strategic action plan on “Reduction of GHG emissions due to Forest Depletion and Degradation (REDD+)” was approved by order of the Minister of Environment and Tourism on September 25, 2019. In addition, many other policies and measures related to the forest have been included in different national policies and programs such as "Vision-2050" and "Green Development Policy".

On September 22, 2021, the President of Mongolia, while participating in the 76th session of the United Nations General Assembly, announced that “Mongolia has planned to grow a billion trees by 2030 (GoM, 2021a)” then, the implementation measures of this program were approved as a “Billion trees” national campaign.

If the “Billion Trees” national campaign is fully implemented by 2030, the total removal of CO2 is expected to be 16 million tonnes, and it has a potential to remove more than 2 million tonnes CO2 per year.

The main purpose of forest policies and programs in Mongolia is to reduce GHG emissions caused by deforestation and increase forest capacity to store GHG. Those are:

1. Reduction of GHG emissions from forested lands by preventing the degradation and deforestation:

- Prevent forest from fire and reduce the its risk,
- Prevent and control harmful insects,
- Improve management measures to combat illegal logging.

2. To increase carbon sink capacity of forest by implementing sustainable forest management with proper forest restoration techniques:

- Support the natural regeneration of forests,
- Increase the reforestation,

Main goals to be included in the policy documents such as:

- As reflected in “Vision-2050”, the area covered by forests will increase up to 10.5% by 2050,
- Within the “Billion Trees” national campaign, it is planned to plant one billion trees by 2030,
- GHG emission reductions due to forest degradation is reflected in the national strategy and action plan of the UN REDD+ (MET, 2019),
- Carbon released from forested area reduced from 3,551,439 t CO_2e per year to 2,649,844 t CO_2e per year by 2025,
- Forest carbon sink will be increased from 74,055 t CO_2e per year to 99,973 t CO_2e per year (MET, 2018),
- According to the policy decisions the area covered by forests will increase up to 9% in 2030 and 10.5% in 2050 (the area covered by forests will increase by 2 million ha),
- Planting a billion trees by supporting the regeneration capacity of natural forests for afforestation between 2022 and 2030,

- The afforested area will be increased from 8,000 ha to 15,000 ha in 2025, while the regenerated area will be increased from 2,000 ha will be to 80,000 ha,
- Reduce the forest area degraded by fire from 130,000 ha per year (MET, 2018) to 103,000 ha per year by 2025,
- Reduce the area degraded by insects and pests from 10,000 ha per year (MET, 2018) to 5,900 ha per year in 2025,
- Reduce the amount of illegally logged wood from 550 m³ (MET, 2018) to 300 m³ in 2025.

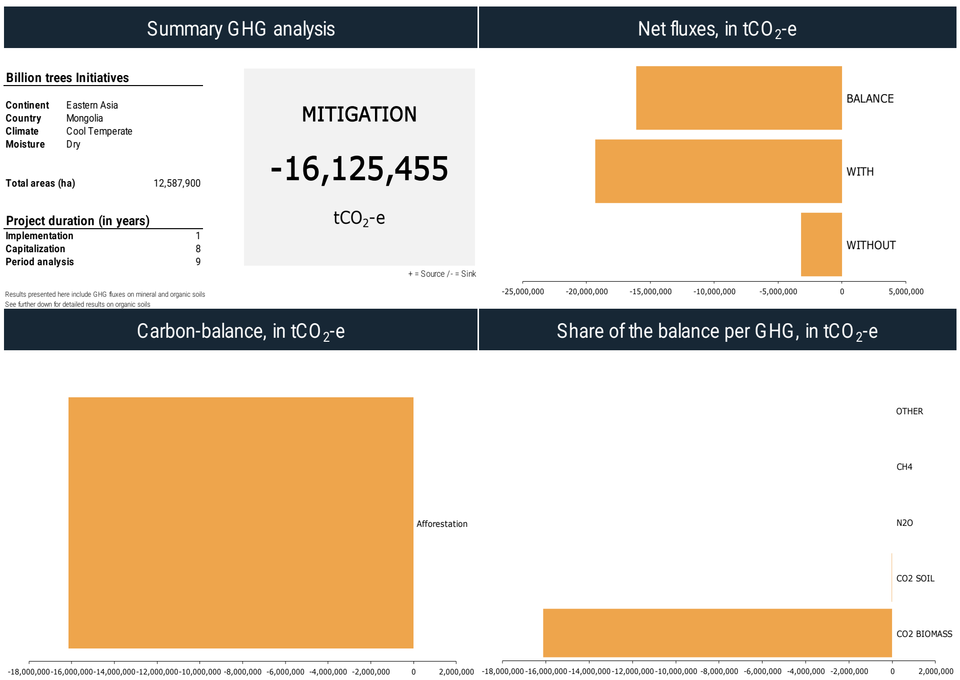

Figure 7.21 Estimation of the results of the "Billion Tree" national campaign using the EX-ACT tools

DETAILED RESULTS

Project name	Billion trees Initiatives						
Continent	Eastern Asia	Project duration (in years)		Total area (ha)	12,587,900	Global warming potential	
Country	Mongolia	Implementation	1	Mineral soil	12,587,900	CO_2	1
Climate	Cool Temperate	Capitalization	8	Organic soil	0	CH_4	34
Moisture	Dry	Period analysis	9	Waterbodies	0	N_2O	298

GROSS FLUXES (In tCO_2-e over the whole period analysis) — SHARE PER GHG OF THE BALANCE (In tCO_2-e over the whole period analysis) — AVERAGE ANNUAL EMISSIONS (In tCO_2-e/yr)

PROJECT COMPONENTS		WITHOUT	WITH	BALANCE	CO_2 BIOMASS	CO_2 SOIL	N_2O	CH_4	ALL NON-AFOLU EMISSIONS*	WITHOUT	WITH	BALANCE
Land use changes	Deforestation	0	0	0	0	0	0	0		0	0	0
	Afforestation	-3,180,746	-19,306,201	-16,125,455	-16,125,413	-42	0	0		-353,416	-2,145,133	-1,791,717
	Other land-use	0	0	0	0	0	0	0		0	0	0
Cropland	Annual	0	0	0	0	0	0	0		0	0	0
	Perennial	0	0	0	0	0	0	0		0	0	0
	Flooded rice	0	0	0	0	0	0	0		0	0	0
Grasslands & Livestock	Grasslands	0	0	0	0	0	0	0		0	0	0
	Livestock	0	0	0			0	0		0	0	0
Forest mngt.		0	0	0	0	0	0	0		0	0	0
Inland wetlands		0	0	0	0	0	0	0		0	0	0
Coastal wetlands		0	0	0	0	0	0	0	0	0	0	0
Inputs & Invest.		0	0	0		0	0		0	0	0	0
Total emissions, tCO_2-e		**-3,180,746**	**-19,306,201**	**-16,125,455**	**-16,125,413**	**-42**	**0**	**0**	**0**	**-353,416**	**-2,145,133**	**-1,791,717**
Total emissions, tCO_2-e/ha		**-0.3**	**-1.5**	**-1.3**	**-1.3**	**0.0**	**0.0**	**0.0**	**0.0**			
Total emissions, tCO_2-e/ha/yr		**0.0**	**-0.2**	**-0.1**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**			

+ = Source / - = Sink

Results presented here include GHG fluxes on mineral and organic soils

See further down for detailed results on organic soils

* Includes fisheries, acquaculture and inputs & investments that are not included in the AFOLU definition.

Uncertainty level	tCO2-e/yr	Percent
Without	-353,416	20%
With	-2,145,133	20%
Balance	-1,791,717	20%

Figure 7.22 Outputs of the EX-ACT for "Billion Trees" national campaign

GHG emission reduction due to forest degradation is reflected in the national strategy and action plan for REDD+ (MET, 2019).

- Reducing the carbon released from forests from 3,551,439 t CO_2 e per year to 2,649,844 t CO_2e per year by 2025.
- Forest carbon sink will be increased from 74,055 t CO_2e per year ("Forest Baseline Level Report", 2018) to 99,973 t CO_2e per year.

If we summarize the above policy decisions, the area covered by forests will increase to 9% in 2030 and 10.5% in 2050 (the area covered by forests will increase by 2 million ha).

- Planting a billion trees by supporting the regeneration capacity of natural forests for afforestation between 2022 and 2030,
- The afforested area will increase from 8000 to 15000 hectares in 2025 while the regenerated area from 2000 hectares will be increased to 80000 hectares,
- Reduce the forest area degraded by fire from 130,000 ha/year to 103,000 ha/year by 2025 ("Forest Baseline Level Report", 2018),
- Reduce the area degraded by insect pests from 10,000 ha/year ("Forest Baseline Level Report", 2018) to 5,900 ha/year in 2025.

Reduce the amount of illegally logged wood from 550 m^3 ("Forest Baseline Level Report", 2018) to 300 m^3 in 2025.

The COMAP model was used to determine the baseline (BAU) and mitigation scenario for the reduction of GHG and the following outputs have been produced (Table 7.22 and Figure 7.23).

- Planting 1 billion trees by 2022-2030 within the framework of the "Billion Trees" national movement
- According to the "Vision 2050" policy document, it is estimated that by 2030, the area covered by forests will reach 9% or 2 million hectares, and by 2050 it will increase by 10.5% or 3.8 million hectares.

Table 7.22 Change of biomass of forest (1000 tonnes of biomass per 1000 hectare)

COMAP model	2010	2020	2025	2030	2040	2050
BAU (biomass pool)	962,021	970,028	972,226	976,825	986,261	996,021
Mitigation (biomass pool)	962,021	976,352	1,059,354	1,148,784	1,236,030	1,324,093
BAU (forested area)	12,011	12,109	12,134	12,188	12,296	12,204
Mitigation (forested area)	12,011	12,109	13,209	14,329	15,399	16,469
Change of biomass,%	0.0	0.0	9.0	17.6	25.3	32.9
Area covered by forest,%	0.0	0.0	8.9	17.6	25.2	34.9
Growth, compared to 2010,%	0.0	0.8	10.0	19.3	28.2	37.1

According to Figure 7.23, in the base scenario, if no measures are taken regarding forests, the biomass of the area covered by forests will increase by 6,797-9,760 thousand tonnes every 10 years until 2050, while by implementing measures to increase forest absorption, the biomass will drastically increase by 88,063-172,432 thousand tonnes in the above period.

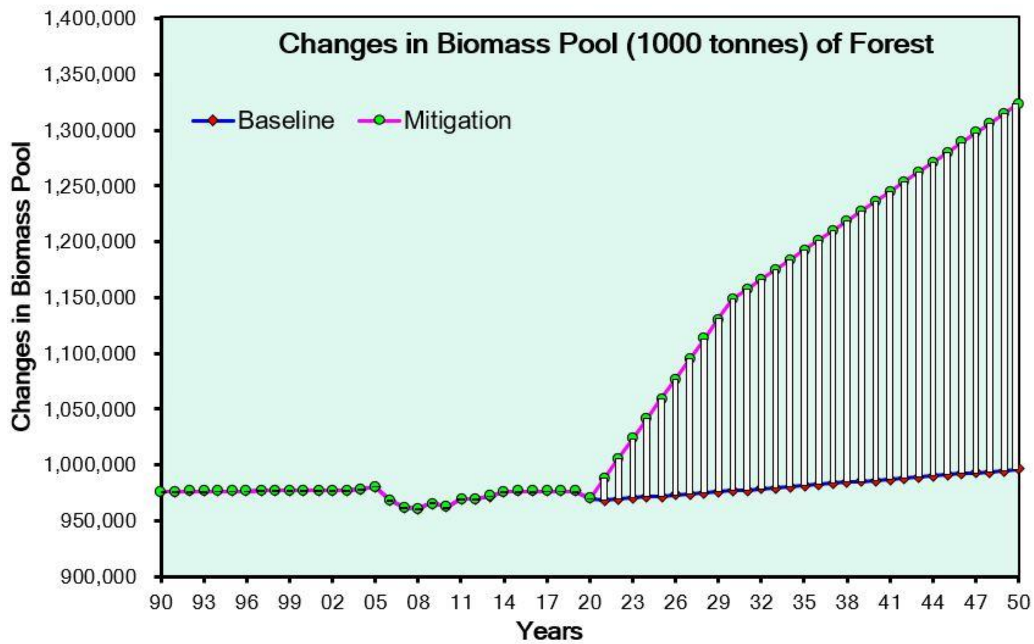

Figure 7.23 Change of biomass of forest covered area estimated by COMAP model

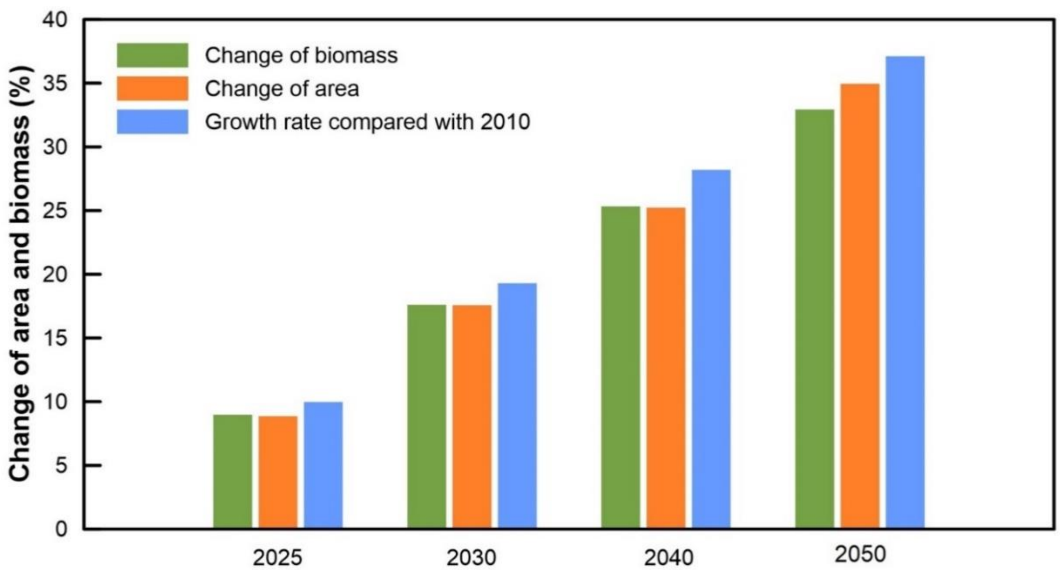

Figure 7.24 Change of forest area and biomass in Mongolia

According to the future projection estimated by the COMAP model, the area covered by forest will increase by 9% in 2025, 17% in 2030, 25.3% in 2040 and 35.0% in 2050, compared to the baseline scenario (Figure 7.24).

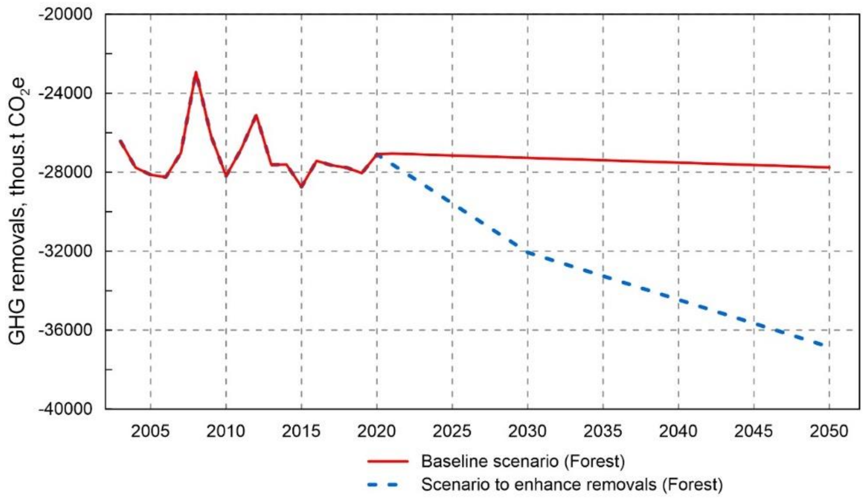

Figure 7.25 GHG removals by forested areas in Mongolia

If the forest management measures planned by policies are implemented successfully, the sink or removal of forests is expected to increase by 8.9%, 17.6%, 25.2% and 32.8% in 2025, 2030, 2040 and 2050, respectively, compared to the baseline scenario (Figure 7.25 and Table 7.23).

Table 7.23 GHG removals by forested areas in Mongolia

Removals by forested areas	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU)	-28,188.4	-28,736.7	-27,096.9	-27,152.8	-27,273.5	-27,515.1	-27,756.7
Scenario to enhance removals	-28,188.4	-28,736.7	-27,096.9	-29,580.8	-32,064.7	-34,459.1	-36,853.5
Enhancement of forest removals	-	-	-	2428.0	4,791.1	6,944.0	9,096.8
Enhancement of forest removals, %	-	-	-	8.9	17.6	25.2	32.8

7.2.4 Waste sector

The baseline scenario of GHG emissions (methane and nitrogen oxide) from the waste sector in Mongolia considered the following three sources: a) methane generated from solid waste collection points, b) methane and nitrogen oxides generated during the treatment and discharge of household wastewater, and finally, c) methane gas emissions generated during the treatment and discharge of industrial wastewater.

According to the methodology of the Intergovernmental Panel on Climate Change in 2006 (the 2006 IPCC GLs), the baseline scenario of the GHG emissions was calculated using the half-decomposition method based on the amount of degradable organic compounds.

The amount of methane that can be generated from the centralized points of urban waste is estimated to increase annually by 6% considering following parameters: the population growth and waste generated per capita with the Gross Domestic Product (GDP) growth.

When determining the future trend of GHG released from household wastewater, considered the population growth trend and the characteristics of wastewater treatment and disposal technologies of households in Ulaanbaatar city and the centres of provinces, villages, soums and rural areas.

In addition, the trend of methane gas emissions from industrial wastewater was calculated based on statistical data on products containing degradable organic compounds in industrial wastewater from 1990-2020. The total GHG emissions from the waste sector were calculated by LEAP model considering all above mentioned sources. The results are demonstrated in Figure 7.26.

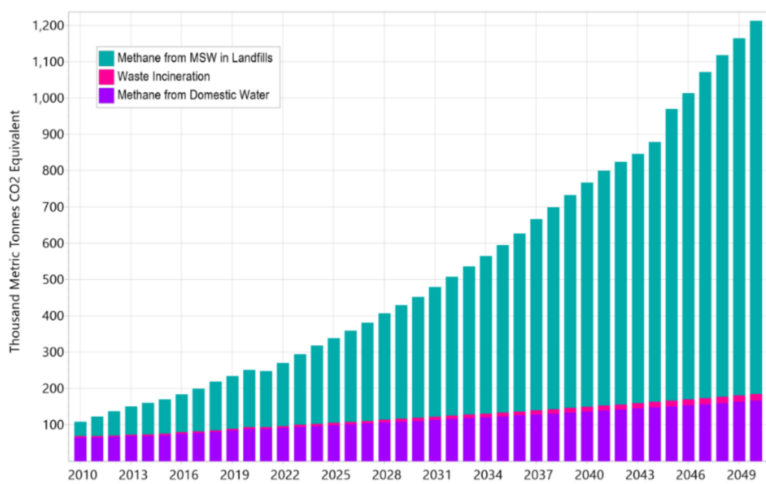

Figure 7.26 Baseline scenario for GHG emissions from the waste sector using the LEAP model

After the determination of the baseline scenario of the GHG emissions, GHG emission reductions have been estimated by considering the impact of measures such as increasing the capacity of sanitation facilities, separating and sorting, and recycling waste which are included in the laws, regulations, long-term and medium-term development policy documents, and action programs of Mongolia at the national level.

According to Mongolia's long-term policy document, "Vision-2050" (PoM, 2020) and policy documents such as "New Revival Policy" (PoM, 2021), which aims to create the primary conditions for its implementation and promptly solve the limiting factors of development, planned to increase the amount of waste recycling to 27% in 2025, to 40% in 2030, and to 50% in 2050.

Similarly, potential options for reducing the GHG generated from the centralized points of waste and the treatment of household wastewater were based on the objectives to expand the treatment facilities of UB city and 15 provinces and to put them into operation by 2025, which were included in the implementation of NDC action plan.

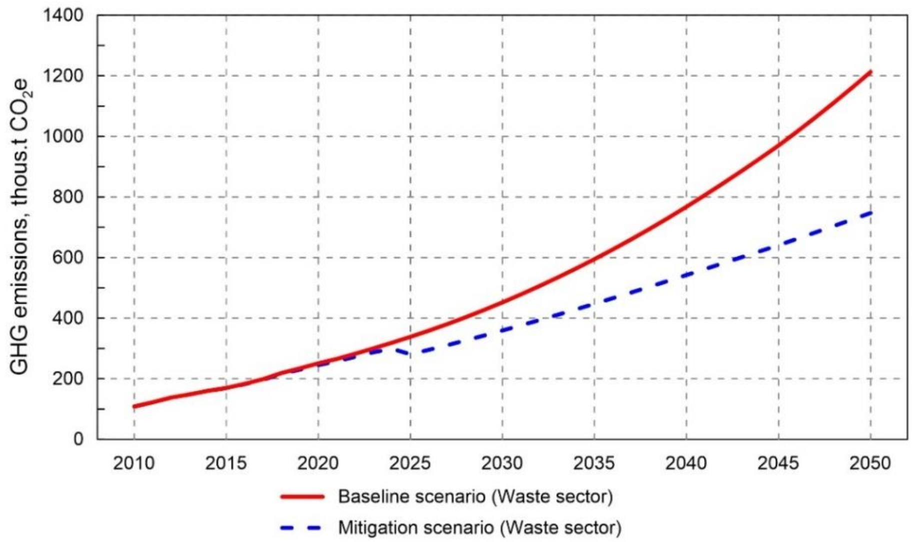

Figure 7.27 Comparison of the baseline and mitigation scenarios of GHG emission in the waste sector

Table 7.24 Total GHG mitigation potential in the waste sector, thous. t CO_2e

	2010	2015	2020	2025	2030	2040	2050
Baseline scenario (BAU)	108.3	169.5	250.9	338.3	452.0	767.7	1,212.5
Mitigation scenario	108.3	169.5	250.9	280.7	359.2	542.4	747.1
The total GHG emission reduction	-	-	-	57.6	92.8	225.3	465.5
- Reducing the amount of waste to be buried and landfills by encouraging waste recycling factories	-	-	-	19.7	48.0	165.8	388.8
- Increasing the capacity of sewage treatment facilities by expanding and putting them into operation in the capital city and 16 provinces	-	-	-	37.8	44.8	59.5	76.6
Total reduction of the GHG emission,%	-	-	-	17.0	20.5	29.4	38.4

7.3 Ranking measures reducing GHG emissions and increasing GHG removals and analysis of cost-benefit

7.3.1 Ranking measures reducing GHG emissions and increasing GHG removals

Considering all the possible policies and measures taken in the field of reduction of GHG emissions in Mongolia, it is expected to reduce GHG emissions by 8.5 Mt CO_2e, 14.9 Mt CO_2e, 20.4 Mt CO_2e, and 26.6 Mt CO_2e 2025, 2030, 2040 and 2050, respectively, by each emission sectors, based on the baseline scenario. Considering the removals by forests, it is possible to reduce by 10.6 Mt CO_2e, 19.4 Mt CO_2e, 26.8 Mt CO_2e, and 35.2 Mt CO_2 e in the mentioned years (Table 7.25).

Table 7.25 Total GHG projected mitigation potentials by implementing of policies and measures by 2050

			2025	2030	2040	2050
		Total emission reductions, Mt CO_2e				
		Total emission reductions Mt CO_2e	**8.535**	**14.938**	**20.369**	**26.650**
1	Energy		5.900	9.300	11.500	14.000
	1.1	*Use of renewable energy*	*2.100*	*3.100*	*3.500*	*3.900*
	1.2	*Energy efficiency improvement scenario*	*3.800*	*6.200*	*8.000*	*10.100*
2	Industrial Processes and Product Use		0.053	0.099	0.193	0.286
	2.1	*Utilizing waste heat from cement plants*	*0.010*	*0.013*	*0.021*	*0.028*
	2.2	*Utilizing fly ash in cement manufacturing*	*0.043*	*0.086*	*0.172*	*0.258*
3	Agriculture		2.525	5.446	8.451	11.898
	3.1	*Reducing the number of livestock to the optimum herding structure ratio under pasture carrying capacity*	*2.405*	*5.201*	*7.959*	*11.157*
	3.2	*Improving management of arable land*	*0.120*	*0.244*	*0.492*	*0.741*
4	Waste		0.058	0.093	0.225	0.466
	4.1	*Reducing the amount of waste to be buried and landfills by encouraging waste recycling factories*	*0.020*	*0.048*	*0.166*	*0.389*
	4.2	*Increasing the capacity of sewage treatment facilities by expanding and putting them into operation in the capital city and 16 provinces*	*0.038*	*0.045*	*0.059*	*0.077*
		Total emission reductions/removals Mt CO_2e				
		Total GHG emissions accounting removals from forest	**10.642**	**19.356**	**26.835**	**35.156**
5	Enhancement of forest removal		2.428	4.791	6.944	9.097
	5.1	*Expansion of forest covered area*	*2.428*	*4.791*	*6.944*	*9.097*

Ranking the share of emission sectors in the total GHG emission reductions without removals by forest in 2030 and 2050, 64% and 54% for the energy sector, 35% and 43% for the agriculture sector, 1% and 1% for the industry sector, and 1% and 2% for the waste sector, respectively (Figure 7.28). However, forest removals account for 33% and 35% of the reduction of total GHG emissions in 2030 and 2050, respectively.

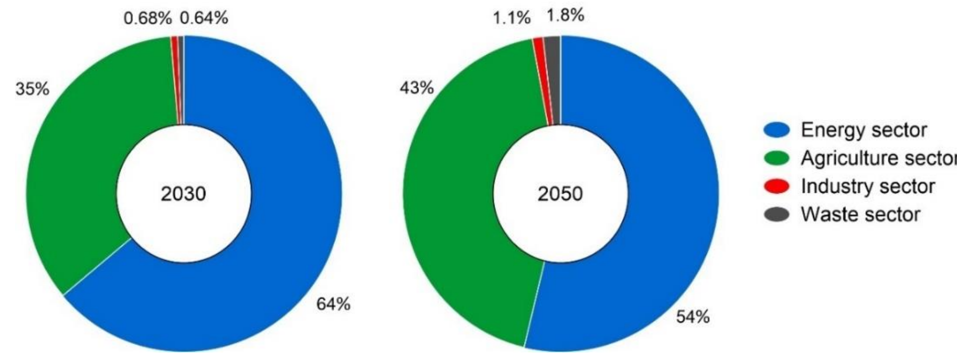

Figure 7.28 Shares of mitigation measures in the total GHG emission reductions by sector in 2030 and 2050

Figure 7.29 shows the shares of mitigation measures in the total reduction of GHG in 2030 and 2050. In the above years, the measures with the most significant influence on the reduction of GHG are improving energy efficiency (43%, 39%), adjusting the livestock heads to the carrying capacity of pastures (33%, 41%), and increasing renewable energy (21%, 15%), and other measures accounted for 3-6% of the total reduction (cropland management is about 2-3%).

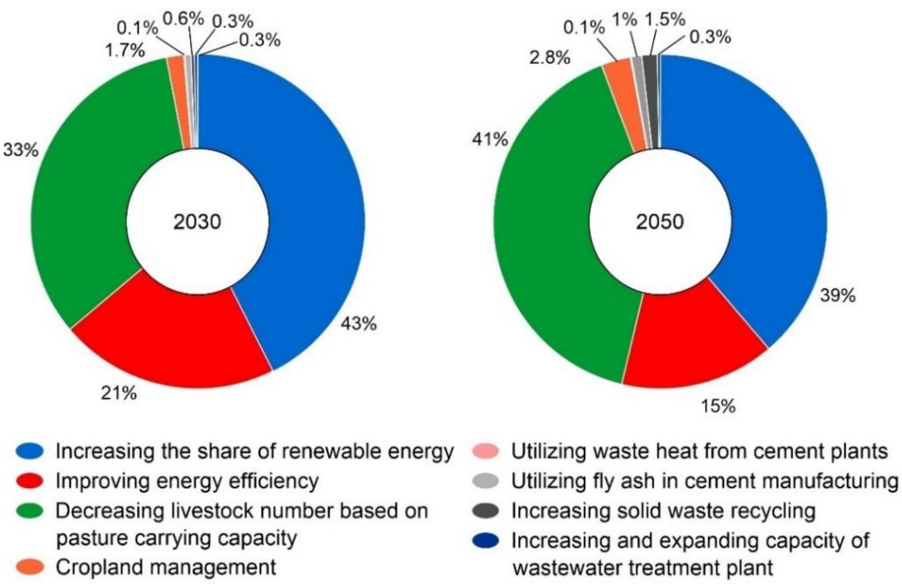

Figure 7.29 Shares of mitigation measures in the total GHG emission reductions in 2030 and 2050

7.3.2 Cost-benefit analysis of mitigation measures

To assess the cost-effectiveness of projects and measures for reducing GHG emissions in Mongolia, analysis and estimations have been done for NAMA projects implemented in the construction sector and for each renewable project represented from hydro, wind and solar energy sectors. Also, the relationship between the Net Present Value (NPV) of cost and GHG abatement for projects being implemented and planned to be implemented in the field of renewable energy has been analyzed by applying the Marginal Abatement Cost Curve (MACC) model.

The MACC model was developed by the Greensense organization of the Western Australian Local Government Association /WALGA/ in 2014. It calculates the reduced GHG amount's relation to the relative costs during the implementation and operations of the GHG reduction projects. Such estimation provides an assessment of the effectiveness of the projects by comparison concerning greenhouse gas reduction amount and cost and expenses.

The main documents of the projects were used in the calculation, and the total cost of the project, the amount of GHG was planned to be reduced per year, and the project duration was calculated from the year of planning and implementation of the projects until 2030.

The price of energy or the price of 1 kWh of energy of the current year is taken from the statistical data and converted into the dollar exchange rate of the current year.

Figure 7.29 shows the cost-benefit calculation of the construction NAMA and some renewable energy, such as the Sumber Soum solar plant, Sainshand Wind Park, and Erdeneburen Hydroelectric Power Plant project until 2030, using the above model. As shown in the figure, the GHG reductions of the nationally adapted (NAMA) activities in the construction sector are small but cost-effective. Also, the GHG emission reduction from solar power generators (Sumber 10 MW) was low, and the cost was high. However, it can be seen from the figure that although wind (Sainshand 55 MW) and hydropower (Erdeneburen 90 MW) projects are expensive, they significantly reduce GHG emissions.

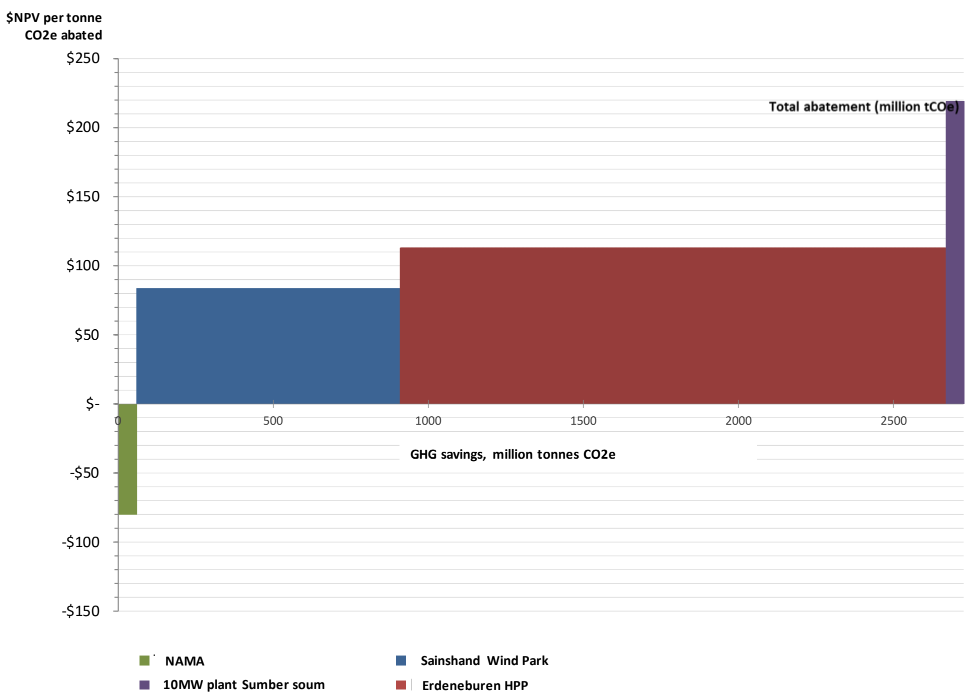

Figure 7.30 Cost-benefit analysis of construction NAMA and some renewable energy projects in 2030 (MACC tool)

Table 7.26 and Figure 7.29 show the cost-benefit analysis of the measures to reduce GHG emissions by expanding mentioned above energy sources by including the data on the implemented and planned renewable energy sources in Mongolia from Table 2.3 of section 2.2.1 of this report into the "MACC tool" model.

Table 7.26 Cost-benefit analysis of renewable projects to be implemented in Mongolia by 2030

Mitigation measures and projects	Start Year	End Year	Net Present Value ($NPV)	Total Abatement (t CO_2e)	Net Annual Emissions (kg CO_2e)	MAC ($NPV per t CO_2e)
Total WPP	2023	2030	$ 15,031,275.68	6429.69	-1,071,247,700.00	$ (2.34)
Energy storage	2023	2030	$ (59,981,507.97)	956.73	-159,400,000.00	$ 62.69
Total SPP	2023	2030	$ (231,531,099.26)	2581.73	-430,140,900.00	$ 89.68
Total HPP	2023	2030	$ (879,213,194.23)	5008.47	-834,459,000.00	$ 175.55

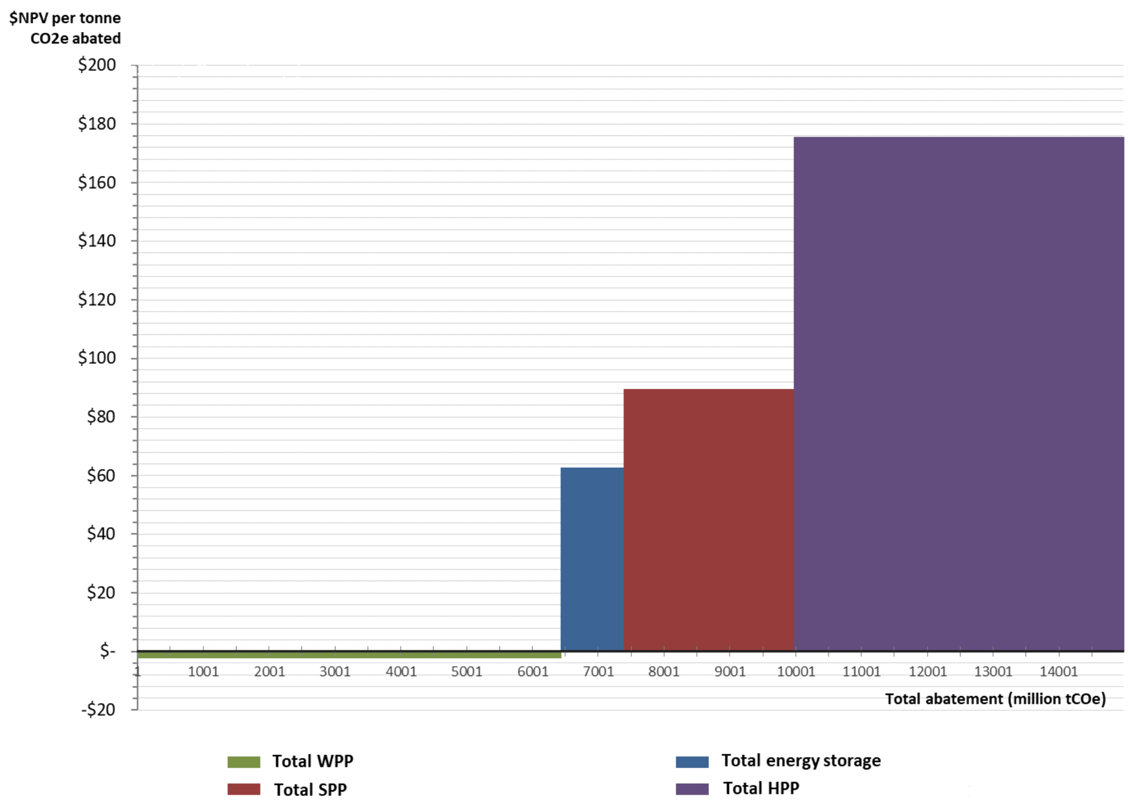

Figure 7.31 Cost-benefit analysis of all feasible renewable energy projects in Mongolia by 2030 (MACC tool)

According to the model output results, the wind power source is cost-effective, and the amount of reduction in GHG is relatively higher than other power sources. For hydropower plants, the cost and the amount of reduction are high. However, the cost-benefit ratio for solar sources and energy storage projects is average (Figure 7.30).

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CHAPTER 8. TECHNOLOGY RELATED ISSUES FOR MITIGATION AND ADAPTATION

8.1 GHG reduction in energy and other related sectors development policy in Mongolia

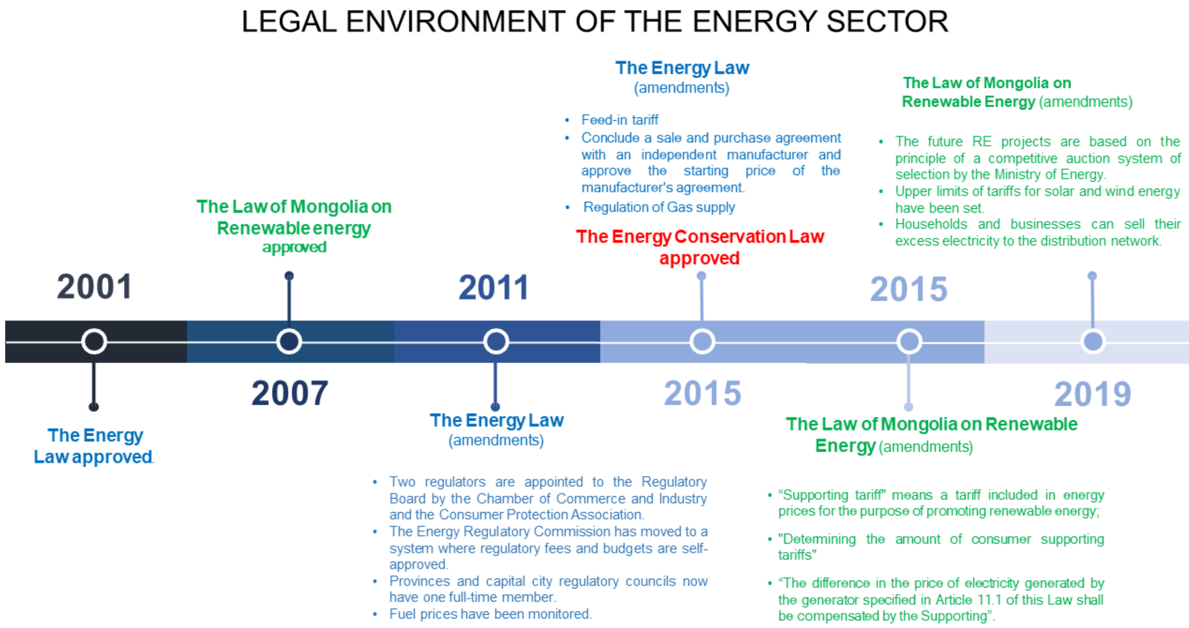
The energy sector is the biggest contributor to GHG emissions with non-renewable resources taking up the majority (MET, 2018). The energy sector made full use of the total installed capacity of the system during the heavy winter load of 2021- 2022, and operated in emergency mode without backup equipment. The successful implementation of the CHP-4 turbo generator modernization project and the expansion of the Darkhan CHP and the expansion of Erdenet CHPs by 35 MW played an important role in overcoming the heavy winter load of 2021-2022 (Figure 8.1).

Source: Ministry of Energy

Figure 8.1 Age of thermal plants (35-60 years)

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 and reducing electricity transmissions losses are subject for continued discussions and some options for solution were reflected in different policy documents (Figure 8.2).

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.



Source: ERC

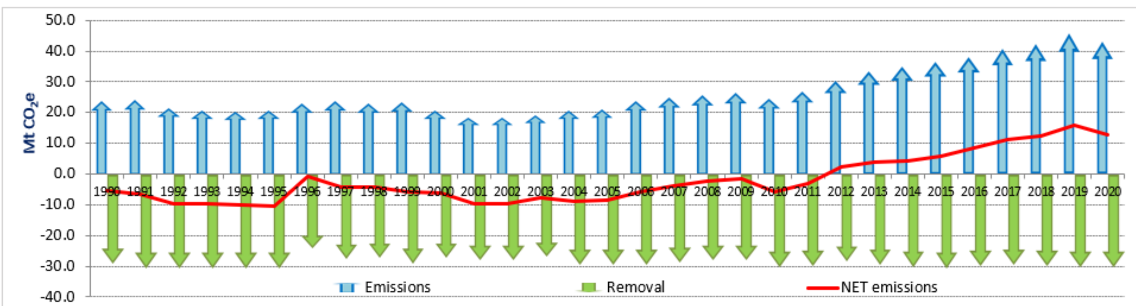
Figure 8.2 Legal Environment of the Energy Sector

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 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. GHG emissions from industries are increasing due to the development of mining and quarrying. Measures are being taken such as, for instance, the introduction to dry-processing technology to produce cement in order to decrease GHG emissions (Batjargal, Otgontsetseg 2022).

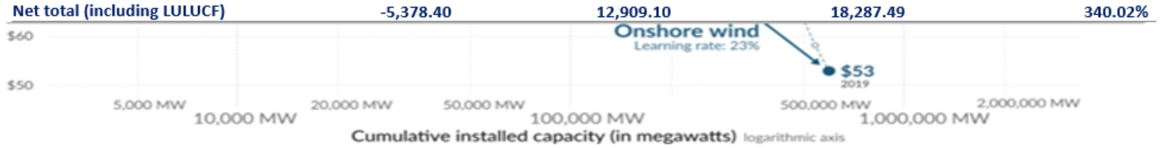
In terms of the livestock sector, technologies related to grassland protection such as the implementation of sustainable grassland management will decrease the trend of pasture degradation. One of the main ways to decrease emissions is to limit the increase in the total number of livestock by introducing alternative way of income generation for local communities and by using modern technology to produce value added products including those for international market.

In Mongolia, waste is managed poorly, mostly waste-disposal open dumps are common practices for today. Instead of this, the introduction of technologies which might help to generate energy using methane from solid waste treatment or by burning the wastes is a more efficient way to manage with it. On the other hand, solid waste collection and sorting are key issues because of scattered location of human settlements and mobility of lifestyle in rural areas. In this regard in respect of waste management there is a need to develop complex approaches based on maximum recycling principles restoring traditional practices and exploring modern technology.

Mongolia put forward ambitious goal in its long term development policy (POM, 2021) to reach in the future a GHG neutrality pursuing low carbon development model. Recently completed national inventory on GHG and BUR have demonstrated that this target is in generally feasible (Figure 8.3), if Mongolia can manage to conserve its grassland intact reducing overgrazing and to prevent deforestation due to forest fire, insect invasion and other negative factor including illegal cutting. This trend was based on assessment made for the Mongolia's initial biennial update report (iBUR, 2017). At present this trend was extended and update for the BUR 2 (see chapter 2). But GHG reduction in energy sector in the near future is not much optimistic due to some reason like an issue related to planned hydropower plants. At the same time an optimism is raising in aspect of removal of GHG. Recently announced "One billion tree" nationwide campaign, initiated by the President U.Khurelsukh will substantially contribute to the removal of GHG from the atmosphere, making "net zero" dream more feasible (see chapter 1).



Sector	Emissions and removals, (Gg CO_2eq.)		Change from 1990	Change from 1990
	1990	2020	(Gg CO_2eq.)	(%)
Energy	12,086.55	19,292.48	7,205.92	59.62%
IPPU	284.98	1,147.75	862.77	302.75%
Agriculture	11,221.64	22,390.57	11,168.93	99.53%
Waste	55.62	250.82	195.20	350.95%
Total (excluding LULUCF)	**23,648.79**	**43,081.62**	**19,432.82**	**82.17%**
LULUCF	-29,027.19	-30,172.52	-1,145.33	3.95%
Net total (including LULUCF)	**-5,378.40**	**12,909.10**	**18,287.49**	**340.02%**



Source: BURII, 2023

Figure 8.3 Mongolia's total and net GHG emissions and removals, 1990-2020 (Mt CO_2e)

Project rationale and background: It is expected that temperatures increases caused by anthropogenic global warming in some parts of Asia could range between 4 to 6 degrees centigrade, causing disruptive biophysical processes, including extreme weather events. These new temperature extremes affect human health, crop productivity and losses. Mongolia is already experiencing annual mean air temperature increases by 2.24°C during the last 80 years, which is about triple the global average. Annual precipitation has decreased around 10% with seemingly erratic seasonal rainfall patterns, and with these changes predicted to intensify over time.

To address these challenges, the Government of Mongolia (GoM) has adopted national and sectoral policies and strategies such as the National Action Program on Climate Change (NAPCC) (2011-2021), the Green Development Policy (2014-2030) and the Sustainable Development Vision 2030 (2016). The fundamental development policy document called Long Term Development Vision-2050 approved by the Parliament in 2020 gives some light how this country can move forward to climate neutrality. The GoM updated its Nationally Determined Contribution (NDC) with a higher mitigation target of reducing greenhouse gas emissions by 22.7% by 2030 to contribute to the Paris Agreement. The NDC sets out adaptation needs and priorities considering country-specific vulnerabilities and climate risks for key socio-economic and natural resource management sectors. The national adaptation plan (NAP) details adaptation activities, considering co-benefits between mitigation and adaptation actions, as well as nature-based solutions, in order to ensure efficient and effective response measures to climate change.

The Ministry of Environment and Tourism (MET) is responsible for the coordination and implementation of the NDC. In May 2020, the Climate Change Research and Cooperation Center (CCRCC) was established to serve as a Think Tank for the implementation of state policies and decisions on climate change issued by the Parliament, the GoM and the state administrative bodies in charge of climate change. The CCRCC coordinates closely with line ministries and institutions through the National Climate Committee (NCC) and sits under MET. The NCC manages nationwide climate change-related activities, coordinates sectoral integration, evaluates projects and program implementation and provides technical supervision and guidelines to stakeholders. The NCC also develops the national strategy and policy for climate change and supervises the NAPCC implementation status of other agencies.

Mongolia has been actively cooperating with international and bilateral climate finance mechanisms to finance projects while leveraging private sector funds through the Green Climate Fund (GCF) and Mongolia-Japan Joint Crediting Mechanism. In 2017, the Mongolian commercial bank XacBank became the nationally accredited entity of the GCF and since then has implemented three full funded and two readiness projects. In partnership with other international organizations Mongolia has secured different GCF funds for climate change mitigation and capacity building projects.

Despite on-going efforts by the GoM, capacity gaps remain at the local, rural and non-governmental levels to fully embed climate change into policy measures and community response, and to fully implement the activities set out in the NDC. Coordination and streamlining between key stakeholders engaging rural, remote and vulnerable communities as well as civil society organizations (CSOs) and other agencies responsible for climate change action will be essential.

The recent and even current social and economy development situation is worsening due to Covid19 pandemic impact. Actually, energy demand was decreasing due to economic slowdown, but NDC target in energy sector is becoming problematic not only in term of GHG reduction, but also in electricity and heat production and supply issues. In this regard the government has developed New recovery policy both for increase of electricity and heat production while not much increasing GHG emission. Some of measures reflected in this recovery document (Tavinbekh, 2022) are listed below (Figure 8.4)):

- New energy sources and transmission and distribution networks shall be established and their existing capacity shall be enhanced, and the reliability of energy production and supply shall be improved.
- Renewable energy facilities shall be developed in an appropriate ratio where the water facilities and stored resource stations shall be built for ensuring the reliability and stability of the integrated energy system.
- In certain phases, the energy sector shall be transferred into an independent financial and economic system.
- Actions shall be taken to ensure the preparation of the high voltage aerial transmission lines and substations for connecting to the renewable energy source and network within the Northeast Asian integrated energy grid.
- The construction of a natural gas pipeline from the Russian Federation to the People's Republic of China through the territory of Mongolia shall be boosted.

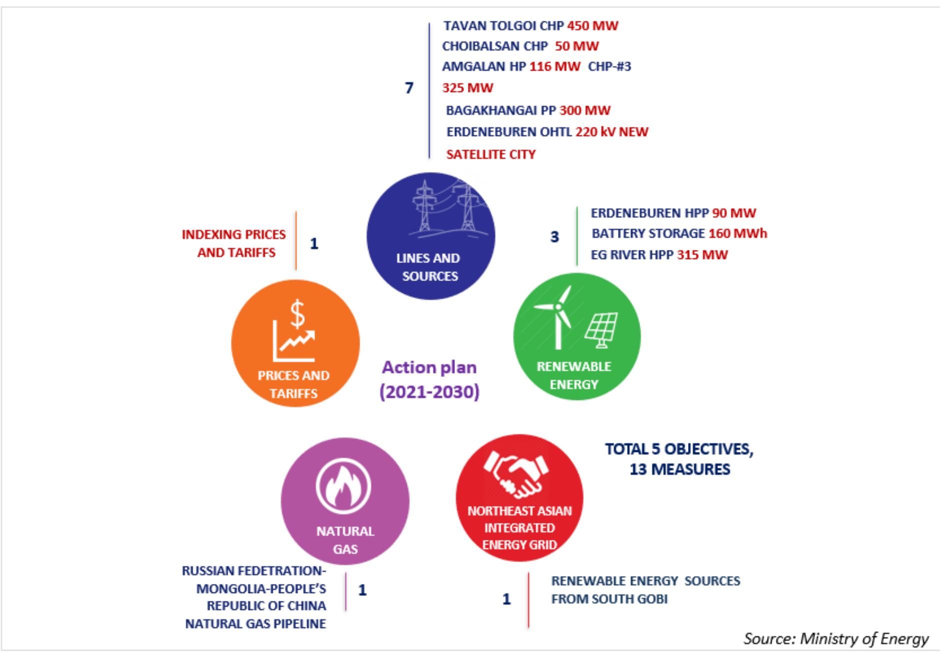


Figure 8.4 Energy recovery policy

Environmentally friendly development projects based on science and advanced technologies planned to be implemented are listed below:

Green-Hydrogen Energy Project

- Make a basic research on the development of hydrogen production and the use of hydrogen in energy supply.
- Protect the tax and legal environment for international investors
- Create a legal environment for use in energy and other sectors of the economy
- Step-by-step training of national personnel for the construction and operation of hydrogen plants and energy sources.

Nuclear Energy Project

The project will conduct a baseline study on the construction and operation of small-scale nuclear sources with technology above the III + nuclear reactor.

- Complete the feasibility study;
- Promoting international cooperation;
- Create a legal environment;
- Construction and operation of a nuclear reactor.

Russia-Mongolia-China Natural Gas Pipeline

- Mongolia's energy consumption will be calculated and the capacity, location infrastructure and logistics terminals of the facilities will be surveyed.
- The natural gas pipeline will pass through 6 provinces and 22 sums of Mongolia

Hydro Power Plant and OHTL substation

- Start the construction of Erdeneburen 90 MW HPP
- Build 220 kV Erdeneburen- Myangad-Uliastai overhead transmission line and substation.

Renewable Energy Enhancement Project in The Western Region /Solar 35 MW, Wind 15 MW/

The projects expected to reduce transmission and distribution network losses and imported electricity will be reduced by 40 MW. It will be supplied with green energy without carbon emissions.

- Khovd Myangad 10 MW SPP, /construction work 98%, World Bank/
- Uvs Umnugobi 10 MW Wind farm, /wind farm technical studies/
- Gobi-Altai, Yesun-Bulag 10 MW SPP, /at the stage of re-tendering/
- Gobi-Altai, Altai300 kW SPP /construction work 60%/
- Zavkhan, Uliastai 5 MW SPP with 3.6 MW battery storage /construction work 77%, JCM/ (Figure 8.5)

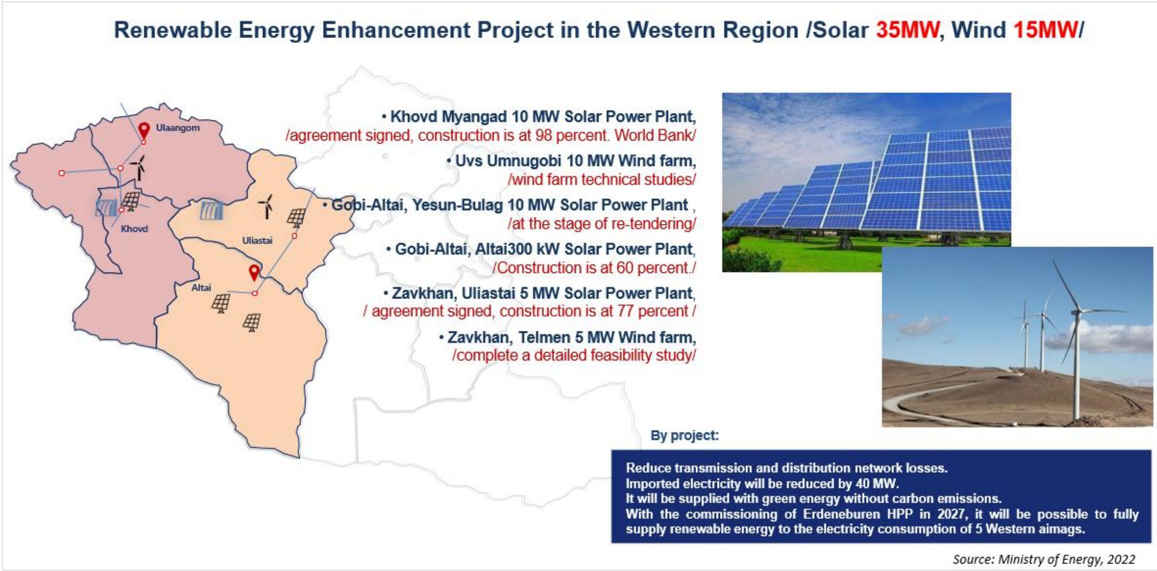


Figure 8.5 Western region RE development

8.2 Regularity mechanism to reduce GHG emission in energy sector

Mongolia's primary source of energy is coal and it is estimated that there are 173 billion tons of coal. Coal-fired thermal power plants accounted for a total of 96.1% of the total electricity supply in 2015, a total of 5,541.74 GWh of electricity (MET, 2018). 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 GHG emission reductions after implementation of renewable energy mitigation scenario are calculated by using LEAP model and results are shown in Table 8.1 and Figure 8.6.

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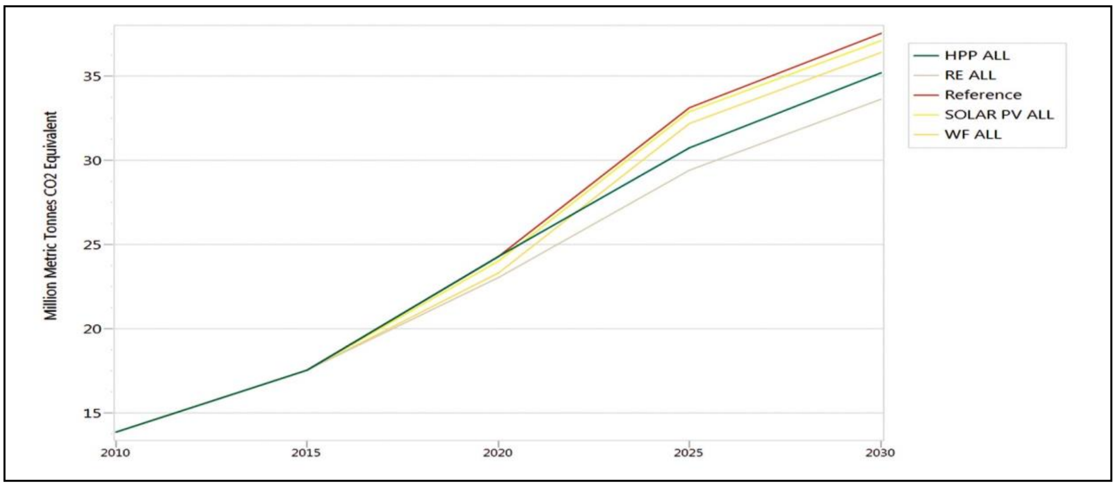
The GHG emission reductions after implementation of renewable energy mitigation scenario are calculated by using LEAP model and results are shown in Table 8.1 and Figure 8.6.

Table 8.1 Renewable energy mitigation scenario, 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	13,891.0	17,403.0	24,153.0	30,579.0	34,959.0
Solar PP	13,891.0	17,403.0	23,881.0	32,752.0	36,919.0
Wind PP	13,891.0	17,403.0	23,180.0	32,031.0	36,202.0
RE TOTAL	13,891.0	17,403.0	22,907.0	29,230.0	33,431.0

Source: iBUR, 2017

The Table 8.1 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 as mentioned above.



Source: iBUR, 2017

Figure 8.6 Renewable energy contribution to mitigation scenario, Gg CO_2e

Mongolia's Renewable Energy Law was approved in 2007 and revised 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 Law of Mongolia was approved by the Parliament on 26 November 2015 (Bolor-Erdene, 2018). This 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. 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.

8.3 Renewable energy in general energy development policy and trend

The production and consumption of energy in central region of Mongolia can illustrate the tendency of energy development in this country due to concentration of population and more intensified economic activities. In order to demonstrate this trend some data are given there. For instance, it was planned that by end of 2018 the total installed capacity of the Central region energy system (CRES) of Mongolia have to be reached 1,255.8 MW from which 87.2% or 1,095.8 MW will be thermal power plants and remaining 12.74% or 160 MW will be wind and solar power plants (Myagmarsuren, 2018).

The total demand, as well as installed capacity of CRES is growing year by year in the central region of the country (Table 8.2). At the same time the share of renewable energy is increasing. For instance, it was only 2.25% in 2014 when the Green Development Policy (GrDP) was approved by the Parliament with declared target that the share of renewable energy for the country would reach 20% by 2020 and 30% by 2030.

Table 8.2 Load demand of central region energy system

Year	The total load demand of CRES, million kWh	Growth, million kWh	Growth,%	Renewable energy generation, million kWh	Share of renewable energy
2013	5136.72			52.30	1.02%
2014	5451.37	314.65	6.13%	122.46	2.25%
2015	5512.26	60.89	1.12%	149.01	2.70%
2016	5650.51	138.25	2.51%	157.50	2.79%
2017	5965.42	314.91	5.57%	173.44	2.91%
2018	6196.8	231.38	3.88%	345.00	5.56%
2019	6384.57	187.77	3.03%	590.00	9.24%
2020	6635.08	250.51	3.92%	670.00	10.1%

Source: Ministry of Energy

8.3.1 Current challenges with renewable energy development in Mongolia

The Energy regulatory commission issued special license for construction of solar power PV plant to 29 entities with total installed capacity of 727 MW, wind farms to 5 entities with total installed capacity of 502.4 MW and other renewables such as biomass to 5 entities with total installed capacity of 299.4 MW (Bavuudorj, 2018).

In total 39 entities (Table 8.3) received special license for construction of renewable energy generation source with total capacity of 1,528.8 MW. Such kind of increased interest of the private sector to invest in renewable energy was happened thanks to the Renewable energy law, approved by the Parliament in 2015. On the other hand, the current capacity of the centralized energy supply grid of the country cannot tolerate this level of input from unstable energy sources as wind and solar energy plants.

Table 8.3 Special licenses issued for renewable energy power plant construction

#	Technology type	Number of special licenses issued	Capacity, MW
1	Wind farm	5	502.4
2	Solar power pant	29	727
3	Hydro power plant	3	217.4
4	Other	2	82

Source: ERC

During the winter peak load of 2018, the Central region energy system (CRES) of Mongolia had import reserve of 100 MW. At that time, the renewable energy sources with total installed capacity of 100 MW was operating. Since renewable energy is intermittent type of source and it is resulting in system instability with around 100 MW variation. Since there were operating 2 wind farms and 2 solar PV plants were causing 90-70 MW variation from scheduled generation during day time. The wind farms causing 80-60 MW variation from scheduled generation during evening peak load hours.

Another issue is related to power transmission capacity (Bavuudorj, 2018). For instance, the "Choir – Airag – Sainshand - Zamyn -Uud" 110kW overhead transmission line has one circuit with AC-150/24 type conductor and the "Airag – Sainshand - Zamyn - Uud" overhead transmission line has AC-120/19 type conductor. During summer time the transmittable capacity of the "Choir - Airag" 110 kV line is 60 MW, the "Airag – Sainshand -Zamyn-Uud" 110 kV line is 50 MW. The winter time transmittable capacity of the "Choir - Airag" 110 kV line is 80 MW. The load demand of the "Airag – Sainshand - Zamyn-Uud"area in summer time is 8 MW and winter time 18 MW. Assessment show that with the commissioning of Naranteeg 15 MW solar PV plant and Sainshand 55 MW wind farm the summer time transmittable capacity of the overhead lines is reaching maximum already in nowadays.

These circumstances were leading the Ministry of Energy and the Energy Regulatory Commission to revise the Renewable Energy Law making a certain amendment in respect of support tariff for renewable energy. If all energy generation sources with special licenses for construction will be in commercial operation then the renewable energy support tariff would reach 136.37 MNT/Kw hour which could cause significant problems in financial stability of the energy sector. In this regard, a talk on the need for change of law on renewable energy, particularly, on feed in tariff level was the hot topic for discussion among both producers of energy and its consumers.

For illustration of the past and current situation, attributed to the GHG estimation period, some examples of power purchase agreement and present level of support tariff are given in Table 8.4 and Table 8.5. The Figures 8.7 and 8.8 are demonstrating the level of support tariff and its dependence on renewable energy development trend.

Table 8.4 Power purchase agreement

#	Technology type	Number of PPA		Capacity, MW	Note
		NETC	NDC		
1	Wind PP	6	1	454.4	"Clean energy" LLC and "Clean Energy Asia" LLC with total installed capacity of 100MW are already started commercial operation
2	Solar PP	3	16	483	"Solar power international" LLC, "Everyday farm" LLC and Tenuun Gerel Construction LLC are started commercial operation
3	Hydro PP	-	2	124.6	Chargait HPP, Ulaanbaatar hydro pumped storage
4	Other	-	1	32	Waste processing power plant
Total		9	20	1,094	

Source: ERC

Table 8.5 Present level of support tariff for renewable energy

#	Technology type	Special license issued	Capacity, MW	Electricity sales, Million kWh	Support tariff for RE, MNT/kWh
1	Hydro PP	3	217.4	715.1	22.64
2	Wind PP	5	502.4	631.0	32.71
3	Biomass	1	32.0	60.0	3.19
4	Electricity storage	1	50.0	53.1	2.82
5	Solar PP	29	727.0	1,133.7	63.13
	Total	39	1,528.8	2,592.9	124.49
Present RE support tariff level, MNT/kWh					11.88
Support tariff level, MNT/kWh					136.37

Source: ERC

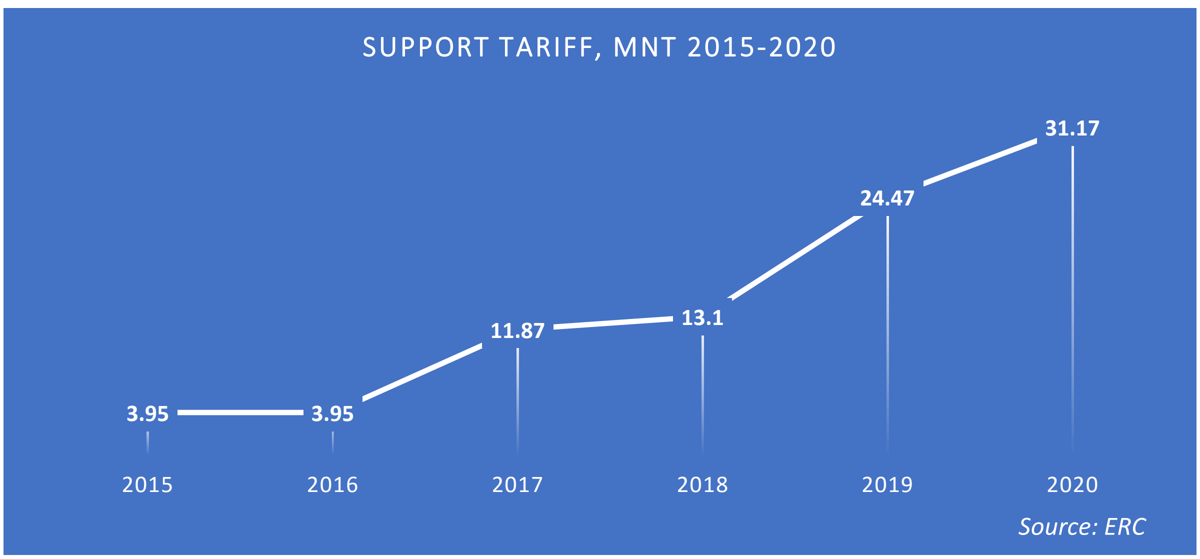


Figure 8.7 Support tariff for renewable energy

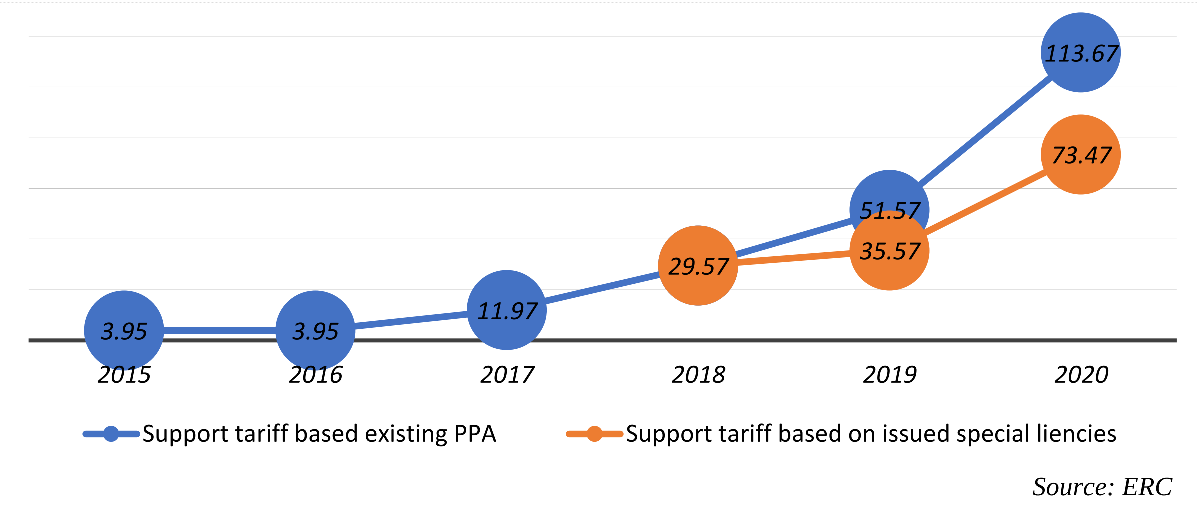


Figure 8.8 Support tariff for renewable energy for existing PPA and expected projects

8.4 Innovative technologies in energy sector for GHG reduction

Mongolia is rich in coal reserve, but dependent on other type of fuel imports. Because of GHG reduction needs at present Mongolia is making effort on promoting clean coal technology, developing own source of energy, and ecologically clean gas and liquid fuels.

Mongolia has large potential sources of renewable energy – especially wind, solar, and geothermal energy. But currently, the energy system has only 4.2% of renewable energy generation, and a potential to expand is significant (IRENA, 2023):

- The wind resource has been estimated at up to 1.1 TWe with an electricity output of 2,550 TWh/year.
- The solar potential has been estimated at 4,774 TWh/year based on 270-300 sunny days a year, with an average sunlight duration of 2,250-3,300 hours available in most territories. Mongolia's annual average solar energy is 1,400 kWh/m^2 per year, with a solar intensity of 4.3-4.7 kWh/m^2/day.
- The significant geothermal potential is characterized by hot springs in several parts of the country. Still, limited data are available in underground temperature maps and site measurements.
- Hydropower potential has been estimated to be 1.2-3.8 TWe.

The information in following subsection included the main results from the assessment, "Renewable energy solutions for heating systems in Mongolia", that was conducted by IRENA (2023), and some additional information from previous study of the Ministry of Energy.

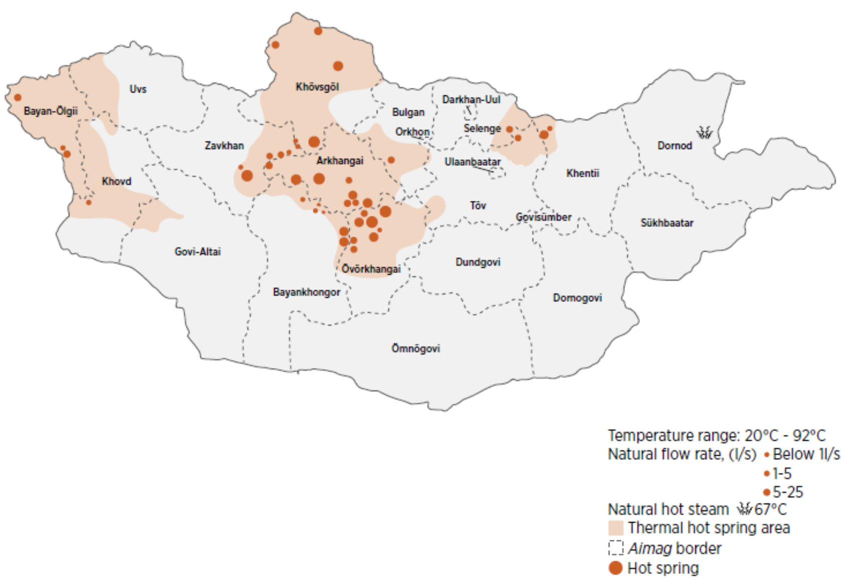
Geothermal

Geothermal energy is one of the potential heat sources for Mongolia. However, an assessment of deep geothermal resources at 1-3 km depth has not been comprehensively carried out, only hot springs are studied to some extend.

In Figure 8.9 demonstrated research results from the study by Tseesuren as of 2001. With regards to the geothermal potential estimates, limited data are available in the form of underground temperature maps and site measurements (Namkhainyam et al., 2019a). While this has not been comprehensively quantified, Mongolia has a significant geothermal potential characterised by the occurrence of hot springs in several parts of the country. Around 43 potential geothermal areas are already exploited for heating, bathing and medicinal purposes in the country.

Uvurkhangai, Tuv and Ulaanbaatar areas are being considered for geothermal district heating. These areas have hot springs with relatively high temperatures and flow rates, and some are already being used to heat buildings and greenhouses. The four hot springs closest to Ulaanbaatar are estimated to have heating potential of 2.7 MW (Figure 8.9).

Mongolia's geothermal resources are mainly distributed in Khentii, Khuvsgul and Mongol Altai platforms, and in the Dornod-Dariganga and Orkhon-Selenge regions. Most detailed studies on the geothermal potential in Mongolia have been done in the Khangai region of the country. The largest geothermal resource available is located in Shargaljuut soum of Bayankhongor province where can be built a binary-cycle geothermal plant with a capacity of 6 MW. The other location with geothermal potential is Arkhangai province, with the Tsenkher springs having a potential of around 2 MW. More in-depth investigation needs to be conducted in areas such as Tuv province near Ulaanbaatar (IRENA, 2023).



Source: Tseesuren, 2001

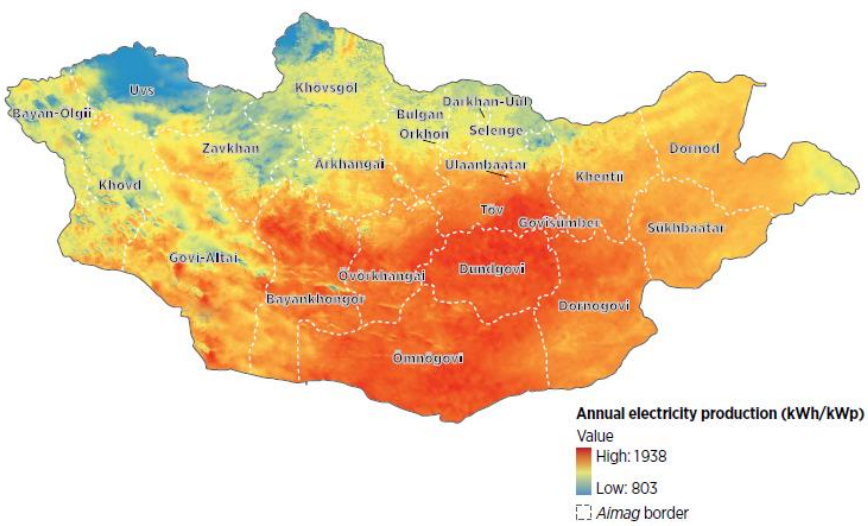
Figure 8.9 Map of geothermal hot springs in Mongolia

These geothermal sources can be used directly for district heating purposes, but an efficiency of geothermal plants depends on the relative temperatures of the geothermal resource and district heating system. The efficiency of different geothermal options, the district heating temperatures are 70-80°C, which makes geothermal sources more efficient than where the district heating temperatures are higher.

Solar potential

Solar thermal collectors

The technology to gather solar thermal energy for district heating purposes is typically divided into flat plate collectors (FPCs), evacuated tubular collectors (ETCs) and concentrated solar power (CSP). The most common type used in district heating is the FPC technology and will also be the focus of the following description. The purpose of solar collectors is to provide optimal conditions to absorb heat energy from the sun. The input to the solar collectors is solar radiation, which is highly dependent on weather conditions, seasonal variations and the location on earth. The closer to the equator, the more solar radiation is available. In Figure 8.10 the average solar irradiance for Mongolia is presented. Here, it is clear that the southern regions of Mongolia have a higher solar irradiance, but the other areas also have high potential.



Source: World Bank, 2020

Figure 8.10 Map of solar irradiance for Mongolia

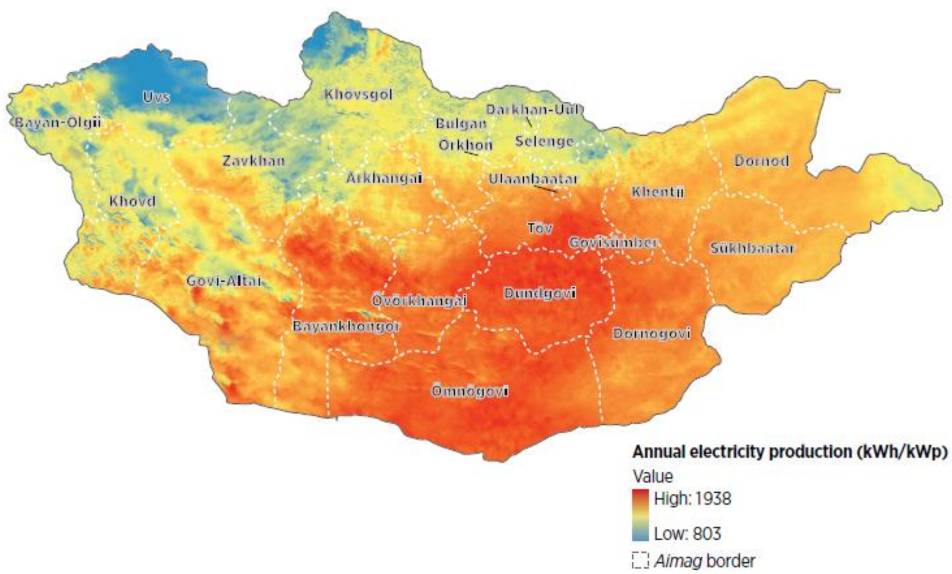
Notes: *kWh/m^2 = kilowatt hours per square metre; DNI = direct normal irradiationThe solar irradiance changes over the year, typically with a higher solar irradiance in the summer. The solar irradiance follows the length of the day, and thus there is always a significant difference between day and night and summer and winter months.*

In most district heating systems, solar collectors are designed to cover around 10-25% of annual heat demand. However, this varies and some examples show coverage of up to 40-45% of annual heat demand. The output of solar thermal collectors is hot water with varying performance over the year with limitation in winter months of Mongolia. In general, solar as a heat source should be considered for district heating systems with high fuel expenditure, as the main benefit of solar systems is that they replace part of those fuels in use (IRENA, 2023).

Solar photovoltaics (PV systems)

Mongolia has great potential for ground-mounted solar PV systems that can be connected to the main electricity grid; the electricity can further be used in heat pumps or electric heating either for district heating purposes or individual buildings. Figure 8.11 presents an estimated annual electricity production for solar PV in relation to a set installed capacity, whereby the potential is high especially in south and central regions of the country.

In Ulaanbaatar, the efficiency of the solar PV and solar thermal collectors reduced due to direct sunlight has been diminished by air pollution during winter, alternatively, the PV systems need to be placed outside the city and connected to the main electricity grid. In the Ulaanbaatar masterplan (Stryi-Hipp *et al.*, 2018) it is estimated that there is sufficient area for around 2 gigawatt peak (GWp) roof-mounted PV and 1.5 GWp ground-mounted PV.

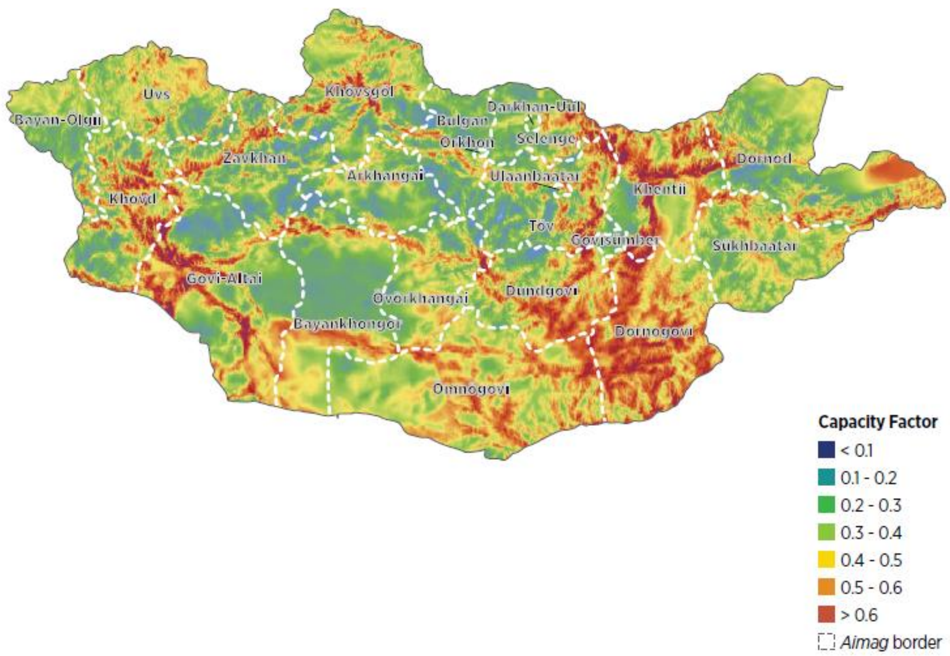


Note: kWp = kilowatt peak *Source: World Bank, 2020*

Figure 8.11 Map of solar PV potential showing annual electricity production per kWp

Wind potential

Mongolia is subject to a westerly wind flowing across its territory, and the western and central parts have a topographical advantage over the rest of the country. Many factors affect wind energy utilisation, the key aspects for Mongolia being ambient characteristics of the mid-latitude westerly wind flow and the progression of weather systems. Areas with a lower elevation have maximum wind potential, with a higher frequency of high wind speeds in the summer months starting from March. Figure 8.12 presents the estimated capacity factors for wind turbines in Mongolia. Capacity factors indicate the gap between the nominal and the estimated power production of a wind turbine; if the capacity factor is 1, it means the plant is producing all the time. Hence, the higher the capacity factor the better, and for onshore wind turbines, a capacity factor above 0.3 is considered reasonable, which means that Mongolia has good wind resources.



Source: Global Wind Atlas (n.d.).

Figure 8.12 Estimated capacity factor for wind turbines in Mongolia

While other parts of Mongolia have moderate potential for the development of wind farms, for the city of Ulaanbaatar it is assumed that just 1% of the land available can be utilised. This is due to existing wind speeds, availability of land for building wind farms and environmental concerns (IRENA, 2023).

Bioenergy

Mongolia bioenergy source is relativity limited and long lasting cold winter season is another reason as a barrier for extended use of natural bio-geophysical processes. Bioenergy generally consists of biomass (residues from wood industries, wood chips from forestry, straw and energy crops) and biogas. Traditional way of use of bioenergy as the animal dung for heating and cooking was not explored as an adequate example. Actually attempt to use bioenergy in more new ways was starting in Mongolia much early as of 1980th. But progress was insignificant mostly because of above mentioned and other circumstances. Until now, it is was feasible for small-scale operations. There is a hope that new and better technologies can help in its adoption on a large scale. Mongolia still needs to develop **bioenergy** sector in order: a) to utilize potential natural resources wisely, b) to increase agricultural productivity, c) to facilitate ecologically clean-living environment, d) to improve the livelihood of rural citizens e) to decrease greenhouse gas emissions.

Biomass

Mongolia has some types of biomass such as dried cow dung, pellets, horse-dung, "khurzun"-hardened dung and urine of sheep and goats, straw, forest shrubs and biomass waste of urban settlements.

All forms of dung belong to high-quality compact fuel. The thermal energy capacity of the different dung forms depends on seasons and regions, for example, cow dung is 10800-13300 kJ/kg, pellets is 8800-16700 kJ/kg, and "khurzun" is 12500-14600 kJ/kg. The 15.2 million hectares of Mongolian landscape is covered by forest, which makes the growing forest mass 1.2x109 $м^3$. Eighty percent of that consists of pine trees and the rest is leaf trees. Another potential renewable energy source is straw left in wheat fields. The thermal energy capacity of straw is 9000-10 000 kJ/kg.

In Gobi Desert area, widespread usage of saxaul (only tree-like plant grows in the Gobi desert) and shrubs is resulting in extinction of forests and green zones in desert area, consequently increasing sand movement/spread. Thus, using different types of dung for fuel and for generating biogas, will help saving the plants in Gobi Desert (Sarangerel, 2011).

Biogas and Biodiesel

Mongolia is facing following difficulties related to development of biogas technology due to harsh weather condition, additional expenses in general heating system, lack of biogas specialist, lack of wastewater management, and nomadic lifestyle.

In order to develop biogas and biodiesel technologies, it requires to create master plan and feasibility study of biomass resources and utility of biogas technology, to determine long-term objectives of biogas technology development, to realize more economically viable projects, to create legal environment, to increase government support for development of biogas technology, to advance Mongolian agriculture to new stage by new technology, to cooperate with international organizations and experienced specialists, to prepare future human resource/biogas specialists (Sarangerel, 2011).

Thermal storage

There are three main long-term storage technologies: pit thermal energy storage, borehole thermal energy storage and aquifer thermal energy storage.

Pit thermal energy storage (PTES) is typically used for seasonal storage in smaller district heating areas, often in combination with solar thermal collectors. PTES is basically a large water reservoir for storing thermal energy. The technology is relatively cheap as it is a hole in the ground using a waterproof membrane and covered by an insulating lid. PTES has a relatively large land area requirement compared to other types of storage. PTES varies in size from 50 000 m^3 to 500 000 m^3, which equals around 5 000-40 000 MWh for a full charging cycle. In the case of Mongolia, it is mainly steel tanks and PTES options that are relevant; however, it could also be relevant to examine whether abandoned mines close to cities could be used for storage, as seen in Spain for example.

Borehole thermal energy storage (BTES) comprises tubes in boreholes and are typically operated in combination with heat pumps. BTES storage uses the ground as a storage medium instead of the water used in PTES. In the Ulaanbaatar case study, BTES storage has not been included, but it could be an option in Mongolia (IRENA, 2023).

8.5 Technological issues related to adaptation

Most of talk on technology related to climate change was focused on mitigation, particularly, on the reduction of the GHG, rather than adaptation related measures.

Since UNFCCC COP in Cancun, discussions on the need to focus on adapting to climate change have been prevalent and some ideas on use of technology and new approaches were included in different reports on climate change. There is no any universal technology which can be suitable for all climate zone or for every country with different climate condition and livelihood options. Mongolia is one of those unique country with very specific circumstances, not only due to climate but also due to lifestyle, accommodated to the given natural condition as a life sustaining system.

In this report highlighted a certain technological issue, which could be more relevant to Mongolia, as a country, where significant portion of population is still practicing nomadic lifestyle. Pasture based livestock breeding, with seasonal mobility as an adapting action to changeable weather condition is only way to minimize a negative impact of seasonal change, while gaining some positive outputs, using favorite condition of each season. Rainfed crop production is very sensitive to climate change and even traditional irrigated crop production could be diminished significantly due to intensified glacier melting. Permafrost thawing is a big concern for infrastructure development. Intensified evapotranspiration due to increase of air temperature and seasonal shift of precipitation (less but intensive rainfall in summer and more snow in winter) both are increasing a risk for agriculture, consequently for food security in the country.

A brief description is given below about some technological solutions just an example, which are using or planned to use in Mongolia.

The stagnation of research and development for adaptation stands in sharp contrast to the trend for climate change mitigation technologies, whose share in total innovation more than doubled during the same period. The number of patented inventions in technologies for climate change adaptation has increased steadily over the last two decades globally. But, when considering the total number of inventions across all technologies in all fields, the share of climate adaptation inventions in 2015 was roughly the same as in 1995.

Moreover, adaptation innovation is concentrated in a limited number of countries. There is virtually no transfer of patented knowledge on adaptation to low-income countries. This concentration of innovation activity could, in principle, be compensated by international technology transfer from the innovating countries to developing countries most in need of it.

The dissemination of adaptation technologies related to agriculture and coastal and river protection is particularly low. Whether this shows that technologies for adaptation are less applicable outside the innovating country than other technologies, or that higher barriers exist to their international distribution, is an open question.

Another interesting finding is that innovation and technology transfers do not seem to be driven by future adaptation needs, but by a recipient country's ability to absorb new technology. Typically, industrialized countries with stronger technological capacities face lower adaptation needs and the opposite is true for middle to low-income countries (Worldbank.org).

8.6 Adaptation issue in relevant sectors development policy in Mongolia

- ✓ National Action Programme on Climate Change (NAPCC 2011) focused on national capacity-building for adaptation with an important role of public awareness and participation. It was emphasized to address challenges and gaps related to climate change in line with national development policy.
- ✓ Government policy on disaster risk reduction (2011) was explicitly emphasizing the importance of technology associated with early warning to prevent disaster impacts.
- ✓ Green Development Policy (2014) aims to ensure environmentally friendly economic growth and was, therefore, an important document for work on climate adaptation.
- ✓ Mongolia's Sustainable Development Vision–2030(2016) envisages Mongolia as a leading middle-income country that preserves its ecological balance while eradicating poverty, implicitly reflecting climate adaptation issues.
- ✓ Law on Legal Status of the Mongolian Red Cross Society (2016) included activities to promote human health, prevent disasters and ensure preparedness and reduce risk.
- ✓ The Government Action Programme 2016–2020(2016) reflects principle tasks of the Mongolia's Sustainable Development Vision 2030 making focus on green growth and human health, which intersects with climate– health–livelihoods issues.
- ✓ Mongolia's Initial Biennial Update Report (2017) is an important step in climate mitigation on a national scale. While the BUR recognizes health and livelihoods as key indicators of vulnerabilities to climate change.
- ✓ Third National Communication (2018) discusses climate change knowledge, a greenhouse gas inventory, mitigation, and adaptation. The five key vulnerable sectors are animal husbandry, arable farming, water resources, forest resources, and public health thus adding public health to the INDC priorities.

- ✓ Voluntary Review Report of the Sustainable Development Goals of Mongolia (2019) has indicated more frequent natural disasters, the erosion of natural resources, and altered climates and has considered them as the major impediments to economic growth. Furthermore, climate change shocks are among the main reasons of risk for people who left behind in development.
- ✓ Mongolia's Nationally Determined Contribution (NDC, 2019) addresses explicitly public health (health systems and anticipatory action), food security, and livelihoods vulnerability. Revised NDC has discussed adaptation needs in health and livelihoods that offer action points where the government can play a significant role.
- ✓ "VISION - 2050" approved by the Parliament of Mongolia in 2020 which is national long-term development policy. It has proposed 9 fundamental goals and 50 development targets, including the targets as "Promoting environmental sustainability combined with green growth".

8.7 Determining technologies for climate change adaptation

Based on the UNEP report (UNEP, 2015) on current challenges faced by the agricultural sector with climate events over the past decade and the vulnerability of the sector to predicted climate change, have been identified certain adaptations technologies that can promote an improvement of the resilience of the agro-ecosystems and livelihood.

The list of technologies drawn from multiple sources and the national context, included:

- adaptation technologies proposed in previous national documents;
- technologies currently in practice and supported by the national agricultural policy;
- initiatives in the pipeline (e.g. sheltered farming and rainwater harvesting);
- appropriateness of technologies in the local context (e.g. fog harvesting, grain storage); and
- social acceptability (e.g. restricted use of genetically modified organisms), among others.

The adaptation technologies identified were then regrouped under different categories: sustainable water use and management, planning for climate change variability, soil management, sustainable crop management, sustainable livestock management, sustainable farming system, land use management, and capacity building and stakeholders.

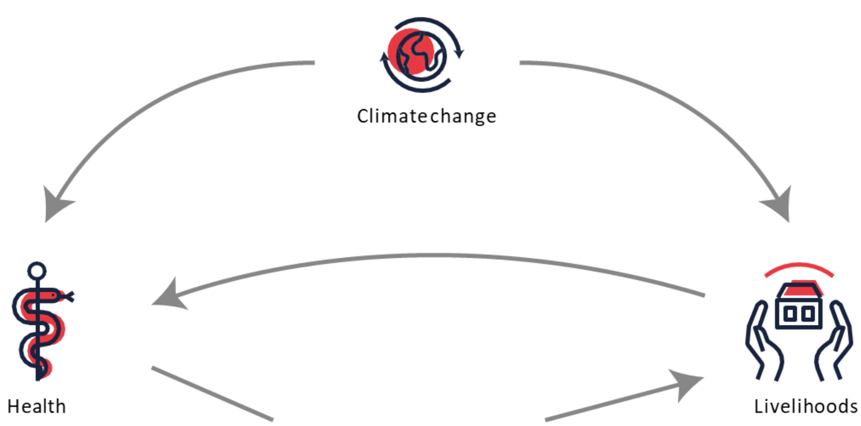
Table 8.6 Summarized classification adaptation technologies, relevant to Mongolia

Category	Adaptation technologies
Water Use and management	Improve water conveyance system
	Use of treated wastewater for irrigation
	Micro irrigation (drip and sprinkler)
	Rainwater harvesting and improved field ponds for water storage
Planning for climate change variability	Improve agro-meteorological information network for forecasting and Early warning - data collection, processing and dissemination
	Reinforcing pest and disease monitoring and early warning system
Soil management	Integrated nutrient management (organic, inorganic, bio- fertilizer, compost)

	Composting of agricultural waste at household and farm level
Sustainable management, crop	Reinforce conservation of locally adapted varieties and seed production of locally adapted crop varieties
	Enhance breeding, of varieties/breeds better adapted to drought, heat, disease
	Low-water consuming crop species and varieties
	Integrated Pest and Disease Management (use of physical control measure and bio-control agents/bio-pesticide and crop management
	Protected cultivation (integrating rainwater harvesting and reuse of leachate)
Sustainable livestock management	Livestock disease management / training
	Livestock insurance scheme
	Biotechnologies – conservation of local adapted livestock breed for use in breeding via controlled mating
Sustainable farming system	Mixed farming
	Tree planting and tree management
Land use management	Watershed management and agroforestry
	Wetland restoration and afforestation
	Monitor land use change/land bank – incentive for sustainable land management
	Mapping of Vulnerable areas (drought, floods)
Capacity building and stakeholder's organization	Capacity building of research and extension to identify and adapt green and environment friendly technologies/indigenous technologies for dissemination to farmers and other relevant stakeholders

Source: UNEP, Determining technologies for climate change adaptation

Public health assessment. Assessment made on possible impact of global warming on human health by the mid of the century indicated that the public health sector in Mongolia has more risk in comparison with other sectors. It was done before Covid19 period and this signal was very important because of recent pandemic situation.



Source: Climate change impacts on health and livelihoods: Mongolia assessment, IFRC

Figure 8.13 Linkage between climate impacts on health and livelihood

Common understanding was that hotter global temperatures will lead to the spread of more infectious diseases such as malaria, dengue, tick-borne encephalitis, a Lyme disease. Most of this will happen in tropical regions or regions close to tropical geographies. Higher temperatures will also lead to increases of food-borne diseases like Salmonella in more developed regions. Since native population in Mongolia has not inherited immunity to those endemic, for hot countries, diseases the public health system in this country needs to develop quite new preparedness structure, based on innovations around infectious diseases.

In the newly updated "Country program for GCF" (CP) the public health sector adaptation topics were reelected as a high priority issue related to climate change adaptation.

BOX 8.1: Climate resilient public health system - PPF

The Country Need *(NDC, 2020)*:

- Cardiovascular and respiratory diseases due to the extreme heat waves;
- Herders are at the greater risk of suffering from non-communicable diseases and mental illnesses in the events of increasing climate-induced disasters;
- Emerging zoonotic and waterborne diseases are likely to affect young children and elderly more severely.
- Another risk could be the spread of tropical or new diseases due to shift of climate zones

The Country Priority:

- Mongolia's NDC – Impact & risk assessment, knowledge awareness raising, and strengthen public health policy and institutional frameworks.
- Vision-2050 - Strengthen public health system based on the participation of citizens, families and employers.

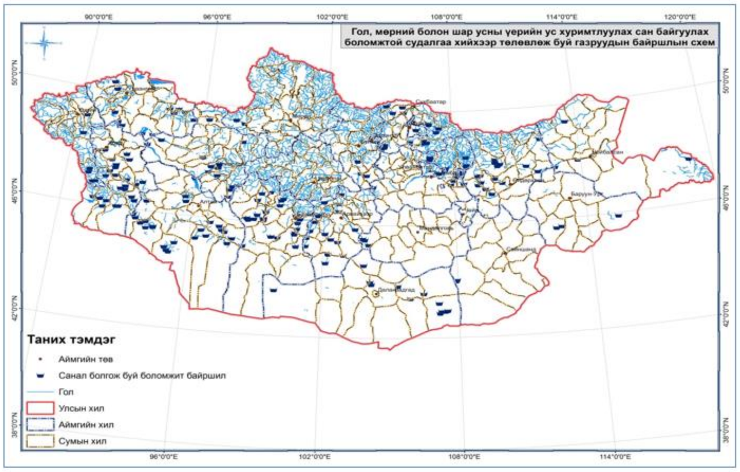
ARA2: Health, well-being, food, and water security

Source: Batjargal Z, 2022

Water reservation and flood prevention. Most of projections on future climate in Mongolia based on Global Climate Models (GCM) show that at least by the mid of the century in Mongolia will dominate drier climate with prolonged droughts, having at the same time, frequent floods due to short but intensive rainfall. Property owners and farmers in vulnerable places will increasingly interested to use technologies that can help them to minimize those potential risks. For instance, can be used seeds and crops that are more tolerant to droughts or resistant to floods. Best solution for more resilient livestock could be optimal combination of inherited adaptive capacity of local community and animals to a certain degree of climate variabilities and modern know how and technologies.

In respect of water reservation more cost effective and environmental sound new approaches, like use of natural setting rather than construction of expensive concrete dams, are suggested to use. One item related to this approach was included in the new CP.

BOX 8.2: Strengthen the adaptive capacity of local communities through the development of ecosystem-based water reservation system – SAP



The project will adapt the cost-effective and ecosystem-based solutions e.g., using the natural settings rather than construction of concrete dams.

Country need:

- Diminising of water resources due to intensified evapotranspiration, glacier melting and permafrost thawing;
- Water scarcity for drinking, environment, industries.

Country ownership:

- Mongolia's NDC 2020
- Vision-2050
- New Revival Policy, 2021
- Mongolia's Integrated Land Management Plan

Source: Batjargal Z, 2022

Efficient irrigation systems. Before transition to market economy the Government was investing in irrigation systems spending substantial amount of budget money. It was created a set of system to produce in more stable way the wheat, vegetables, and forage. But during the translon period most of them abandoned and no more used due to privatization failure. Nowadays farmers are interested to introduce new technologies like "drip irrigation" systems that are much more efficient than they currently use.

Water recycling. For Mongolia this issue is relatively new one and successful industrial scale recycling was established at the Erdenet copper mining factory. It was functioning for more than four decades. Recently started construction of the new water recycling facility near capital city Ulaanbaatar with the support of MCA to produce gray water. Introduction of an appropriate and non-expensive technology is critically needed for use of gray water and harvesting rainwater, in order to use them for crops and everyday human life necessity.

Water purification. Harsher and more wide-spread droughts will lead to a strain on communities and farmers that need fresh water. At the same time, prolonged drought and less chance for replenishment of ground water potentially leading to an increase of salt in ground water. So-called desalination technology has seen an under-investment and local communities are not much aware of the salinity change of water and its impact on health. This problem has been discussed at the different level of the government but did not yet addressed so far adequately.

More resilient crops. High temperatures can lead to droughts and cut annual crop productivity dramatically. Contrary more rainfall can lead to longer or shorter crop seasons. Farmers that grow crops on risk-prone lands, like most part of Mongolian crop production areas, need to select seeds that can withstand higher temperatures, alternating water supplies, and fluctuating crop cycle times. Genetically modified crops (GMC) could play a key role in this movement. But in case of Mongolia use of GMC should be subject of careful consideration because of possible health impact.

Insurance tools. In order to mitigate the risk of extreme weather events and higher temperatures, governments in developing countries, in cooperation with farmers could invest in insurance programs that would pay out when weather related disasters occur. In Mongolia insurance in agriculture sector has not been developed as needed, mostly because of uncertainties in changeable weather conditions and lack of solid motivations based on clear benefit evidence. Index based livestock insurance (IBLI), for instance, represents a promising innovation that could prove the benefits of insurance, specially, important for small stakeholders like herding families and individual householders.

Weather forecasting technologies. Extreme weather conditions, from dust and snowstorms to flooding or extreme drought condition, will become more common in Mongolia, because of the global warming. Weather forecasting has been an area of little innovation and until recently, particularly in Mongolia, for weather prediction has been using so called "synoptic method". Weather forecast is a main duty of the national weather service and it depends heavily on information and communication technology tools, remote sensing, weather satellites, computing, different purpose sensors etc. Last one, for instance, is key component of monitoring stations and need an adequate level of calibration, which is essential for adequate quality of initial measurement data.

Mongolia is not a big country in term of population, but in respect of territory it is not small one and needs to develop extended network for weather and climate monitoring. At present Mongolia has well developed network of meteorological and hydrological stations which is serving as the basic infrastructure for climate monitoring. Domestic and international communication systems are functioning in accordance with internationally agreed and unified rule and procedures. Satellite meteorology and remote sensing facilities are in place. For modernization of existing facilities NAMEM is receiving significant financial support from the Government and actively engaging in multi-lateral and bi-lateral cooperation.

Supercomputing. Weather forecasting and climate information will benefit immensely from more powerful and faster computing facilities that can proceed data and make important, for all principal sectors of economy and social life, predictions in real time. Without supercomputer with adequate volume storage and computing capacity is not possible to produce projections of anticipated scenario of future climate on global and regional scale. (Figure 8.14)

Mongolia is receiving new supercomputer within adaptation project supported by GCF. It will substantially extend the capacity of the national agencies to be engaged more productively in climate change adaptation activities.

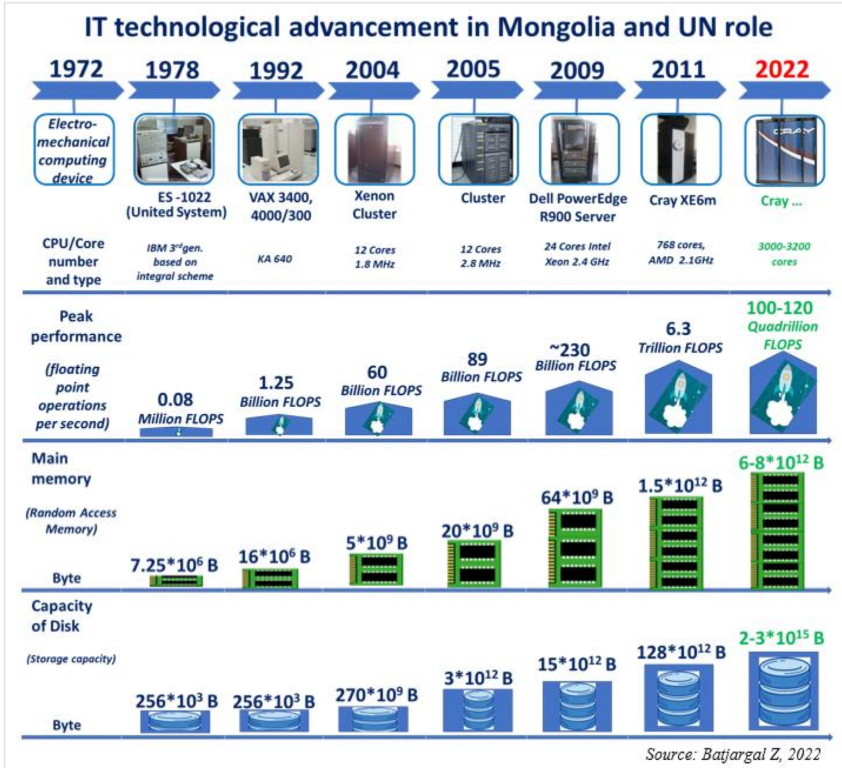


Figure 8.14 IT technological advancement in Mongolia and UN role, Peak performance

Monitoring and Sensors. With all the potential problems and fluctuations in the environment due to global warming, there will be a growth in the need for accurate environmental data, particularly from sensors for different field of measurements. In Mongolia until recently most of observation exercises were conducted directly by humans through human sense. But nowadays most of observer's job transferred to automatic instruments, which are operating without human intervention, fully relying on accuracy of sensors. The sensors are starting point from which a quality of all subsequent procedure outputs will depend. In this regard, the calibration and testing of sensors in accordance of the international standards are crucial to guarantee required quality of information, for instance, for aviation, where even minor inaccuracy of information might lead to tremendous loss of human life.

At present most of meteorological observation which are basic provider of climate information are equipped by modern automatic instruments replacing traditional simple ones like mercury or spirit based thermometers. On the other hand those new tools produced in different countries and imported in different ways and thus not guarantying to have complete and required quality of data due to different standard and graduation for different climate condition. In some case there is a need to keep traditional simple but fully tested tools as a etalon using in parallel to ensure a quality of information for a while.

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CHAPTER 9 CONSTRAINTS, GAPS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

This chapter summarizes constraints and gaps in accelerating climate actions in the country, as well as the support needed in addressing the existing challenges in terms of climate change coordination, monitoring, reporting and verification (MRV), climate finance, and capacity building.

9.1 Institutional arrangement and multi-stakeholder coordination

Institutional set-up. The climate change governance or the institutional arrangement in Mongolia has changed over the years and still has not been set up properly as shown in Table 9.1.

Table 9.1 Changes occurred over the years in the climate change governance of Mongolia

Year	Changes occurred
2010	Climate Change Coordination Office (CCCO) established under the Minister of Environment and Tourism in accordance with the Law on Air – was in charge of the intersectoral coordination, GHG inventory and reporting to the UNFCCC;
2015	CCCO dissolved in prior to the Paris Agreement due to the budget deficits.
2015	Climate Change Project Implementing Unit (CCPIU) established under the Nature Conservation Fund (later formed as Environment and Climate Fund) – in the light of INDC development to the Paris Agreement – carried out the operations of a former CCCO;
2016	Department of Climate Change and International Cooperation established with the two staff in charge of climate change, within the Ministry of Environment and Tourism;
2017	National Committee on Climate Change was established, as chaired by Minister of Environment and Tourism, but was inactive;
2019	National Climate Committee was re-established as chaired by Minister of Environment and Tourism (MET), held a couple of meetings;
2020	CCPIU dissolved as it re-established as Climate Change Research and Cooperation Centre (CCRCC), a state-owned enterprise by the Government Resolution No. 181 of 2020.
2020	Department of Climate Change and International Cooperation reformed as Department of Climate Change composes of an international cooperation division within the Ministry of Environment and Tourism – still with two officers in charge of climate policy and coordination.
2021	National Climate Committee was dissolved, and a new National Committee for Climate Change and Desertification Reduction established under the Prime Minister; was inactive.
2022	MET has been removed from the list of core ministries stipulated in Article 1 of the Law on Government Structure as per its latest amendment – which weakened its legal power in intersectoral coordination.
2022	National Committee for Climate Change and Desertification Reduction was re-established as National Climate Committee under the Deputy Prime Minister.
2023	Department of Climate Change and International Cooperation was reformed as the Department of Climate Change and Policy Planning within the MET.

The existing institutional structure, responsible for climate change is regulated by a number of legal acts and regulations – such as the Law on the Government Structure of Mongolia (2016), National Security Concept (2010), Government Resolution No. 181 "Establishment of State-Owned Enterprise" (2020), Government Resolution No. 333 "On Approval of the Composition and Rules of the National Committee" (2021), Government Resolution No. 350 dated September 22, 2022, "On Revising and Approving the Composition of National Committees, Commissions, and National Councils of the Government", etc.

As per the existing regulations, the central administration authority in change of environment or the Ministry of Environment and Tourism is responsible for designing, developing, coordinating, supporting, and reporting on climate change policies and measures at the national level. Although the Department of Climate Change has established with increased climate change positions within the MET, it has not worked sustainably at its full potential due to a lack of skilled human resources, staff turnover, political influence, and/or inappropriate decisions and ineffective solutions by the management. As of 2022, the MET's legal authority for cross-sectoral coordination on climate change has lessened as its status changed from a core to a line ministry. All these circumstances adversely affect the effective cross-sectoral coordination and successful implementation of climate change actions and measures.

The National Climate Committee (NCC) plays an intersectoral coordination body; it is headed by the Deputy Prime Minister of Mongolia, and the members include a wider scope of officials namely, the Parliamentary committee members, ministers and deputy ministers of all ministries, directors of relevant government agencies and research institutions, advisors to the President, senior advisors to the Prime Minister, and advisors to the head of the Cabinet Secretariat. Civil societies and non-governmental organizations are excluded from its composition. The rights and responsibilities of this non-staff or in-formal committee are limited to monitoring and evaluating the implementation and making recommendations within the scope of the issues. In other words, NCC does not have a legal capacity for making decisions. Furthermore, previous versions of the committee on climate change remained idle or weak as a cross-sectoral coordination body due to various reasons – for instance when the committee is composed of high-level officials, it made operations more challenging regarding the time constraints and limited knowledge of climate change etc.

At the technical level – the CCRCC is to support both the MET and NCC. As stated in the CCRCC's operational rules, its objectives are defined as follows – "*The center is responsible for supporting the implementation of the international agreements, decisions made by the Parliament, the Government, the climate change policy adopted by the central administrative body in charge of environmental issues; coordinating climate change activities undertaken by respective organizations and enterprises; organizing national and international events; and creating and/or supporting the initiative in introducing new or advanced technologies.*"

Yet legally the CCRCC belongs to the National Agency on State Property Policy and Coordination, thus it is not optimal or legally binding to seek guidance and approval from the MET. Importantly, its sustainable and stable operations have been challenged due to unsustainable financing and frequent changes in the management as influenced by politics.

Along the institutional changes – changes in human resources or staff turnover frequently occurred, which makes the whole sector unsustainable as if knowledge and institutional memories erased with the former officers.

Multi-stakeholder Coordination. Furthermore, the policy level – other than the NDC – no national level strategy on climate change in place. As mentioned earlier, the NDC is not fully mainstreamed across all relevant government policies and action plans – when comes to the private sector even a few efforts undertaking for aligning private sector resources with the NDC implementation. The Government of Mongolia has dealt with setting-up the coordination system within the government institutions and with the international partners to a certain level, but not much done on attracting and joining efforts with the private sector stakeholders.

To enhance the coordination among the government ministries and agencies as well as with international partners, Mongolia has joined the NDC Partnership (NDCP) in 2017. The NDCP aims to facilitate and coordinate effective technical and financial assistance to empower those with climate ambition through means like knowledge products and technical assistance. For the effective facilitation of the workplan of the NDCP, four focal points are appointed for key ministries – MET, Ministry of Finance (MOF), Ministry of Food, Agriculture and Light Industry (MOFALI), and Ministry of Economy and Development (a former National Development Agency). Indeed, having focal points within sectoral ministries other than the MET, was effective and a much easier for the MET to synergy works and make collective decisions on NDCP-related matters. Through the NDCP's support, MET has developed an Online NDC Coordination Platform to improve the coordination of activities carried out by implementation and development partners, as well as national stakeholders to implement NDC goals and targets and to track financial flows. Yet, due to the lack of dedicated staff to run the platform, the platform has been idle with less updates, involvement, or input by stakeholders.

On the other hand, the proactive engagement with private sector and direct investment in climate actions remain weak. Stakeholders such as the Chamber of Commerce and Industry, Trade Unions, industrial associations, or other interest and lobbying groups including environmental and gender NGOs or CSOs engage with the government in a silo manner, rather than joining efforts to keep the government accountable.

On the positive note, the banking sector as coordinated by the Mongolian Sustainable Finance Association (MSFA) puts efforts into building capacities and mobilizing finance for sustainable, green, and climate projects and products. Upon the adoption of Mongolia's Green Taxonomy in 2019, commercial banks started the green loan issuance and reporting. Furthermore, two commercial banks namely, XacBank and Trade and Development Bank of Mongolia (TDBM), are accredited by the Green Climate Fund (GCF) in 2016 and 2020 respectively. Financial institutions e.g., Golomt Bank, Khan Bank, and Xac Leasing, accessed the green finance through their collaboration with the multilateral development finance institutions and international financial partners. Through the green loan products issued by commercial banks, the awareness of businesses and consumers on green development and climate change is steadily raising. Additionally, several private companies are implementing small-size projects, mainly in the field of renewable energy and energy efficiency by implementing projects with Japanese companies through Mongolia-Japanese Joint Crediting Mechanism (JCM) since 2013.

Based on ongoing efforts, Mongolian private sector could play an important role in implementing and financing both adaption and mitigation measures. Yet, the private sector's efforts are not fully coordinated with the government's work nor reflected in the NDCs. Hence, the multi-stakeholder coordination mechanism for climate change is crucial in achieving the green and sustainable economic development in the country.

Overall, with the changes in the government and staff turnover, coordination efforts taken by the government including climate focal points as per NDC-P were neither sustainable, productive, nor active. In the future, creating a solid and sustainable multi-stakeholder coordination on climate change which is inclusive of private sector, civil society, and non-governmental organization, is foremost priority. On top of it, attracting the skilled human resources and specialists on climate change and retaining them sustainably is another challenge that must addressed in the near future.

9.2 Monitoring, reporting and verification (MRV)

The existing practices of MRV in Mongolia are centralized on a single agency or the CCRCC, and mainly focused on fulfilling the UNFCCC's reporting requirements – less focused on monitoring climate-related activity data for assessing vulnerability, risks, and impacts of adaptation, mitigation, and tracking finance and verifying the outcomes. The responsibility of the preparation of climate reports under the UNFCCC lays for the MET, yet the processes are not yet systematized to meet the reporting timelines and involve the wide range of stakeholders.

Due to the limited human resources within the MET, the ministry delegated the preparation of climate change reports to the CCRCC (a former Climate Change Project Implementing Unit) – which is re-formed as a self-financing state-owned enterprise. At that time (in 2020) it was assumed that the CCRCC would the main technical agency or climate change think-tank for the MET responsible for the MRV implementation including the estimation of the national GHG inventory, preparation of the implementation reports and communications under the UNFCCC and its Paris Agreement. But current situation (the year 2024) is not consistent with that assumption due to structural and administrative changes and to some extend underestimation of importance of professional and scientific background of the reporting processes.

For the successful implementation of MRV as the requirements strengthened under the Paris Agreement, challenges as introduced in below sessions should be addressed.

Monitoring and Measurement. There is no dedicated monitoring system in place for the purpose of climate change planning, implementation, evaluation, and reporting.

The environmental databases exist which contain information on natural resources, socio-economic and climate parameters, e.g., change in annual temperature, mean monthly temperature, number of hot days, change in annual precipitation, monthly precipitation, extreme weather events. Databases are managed by the National Agency for Meteorology and Environmental Monitoring (NAMEM), Information and Research Institute of Meteorology, Hydrology, and Environment (IRIMHE), Environmental Information Center (EIC), National Statistics Office (NSO), Agency of Land Administration and Management, Geodesy and Cartography (ALAMGaC), Forest Agency (formerly known as Forest research and development center, FRDC), the Energy Regulatory Commission (ERC) etc. These data sources are utilized for the preparation of the national communication, biennial update report, and the GHG inventory by the team of experts, and the CCRCC or a former the former Climate Change Project Implementing Unit (CCPIU).

Despite the existing processes on monitoring and data collection, there are constraints in data availability which evidenced not only in the preparation of GHG inventory, but also in climate-related finance, in assessing vulnerabilities and risks at the local levels or by concerned sectors, and/or measuring climate change impacts for environment, economic and social sectors such as on health, biodiversity, and/or evaluating results of climate change actions and measures. In other words, existing information is not extensive or sufficient to conduct further analysis.

Regards to the measurement, the climate impact-based research works are less undertaken in Mongolia. In most cases, the research is conducted at the request of the government, international projects, and/or the academic purposes – barely utilized for climate change decision making. Generally, the lack of mandate, finance, and nationally approved methodologies are the main hurdles in the quality of data collection, long-term monitoring, and policy-based research works on climate change.

Reporting. As mandated, the CCRCC prepares the national climate change reports to the UNFCCC with the support of the GEF’s Enabling Activities projects engaging the government agencies, professional firms, and a national team of experts.

Previously, the former CCPIU (as of now CCRCC) has prepared and submitted to the UNFCCC – INDC (2015), First Biennial Update Report (iBUR, 2017), Third National Communication (TNC, 2018), and NDC of Mongolia (2020). For preparing the national reports, TNC and BUR, the former CCPIU (now CCRCC) utilized Bilateral Memorandum of Understanding (MOU) to formalize the data sharing responsibilities between the government agencies and institutions, e.g., Ministry of Energy (MOE), Ministry of Road and Transport Development (MRTD), MOFALI, Ministry of Construction and Urban Development (MCUD), National Statistics Office (NSO) and Mayor’s office of Ulaanbaatar city. However, CCRCC concluded that these MOUs were not effective, stating that none of these agencies provide the data in a timely matter or in a full-length, and only a few agencies share some information. Therefore, the enhancement of mandates for ministries and government agencies in relation to the preparation of the Enhanced Transparency Report under the Paris Agreement is a crucial instrument in the improvement of cooperation and engagement.

Verification. At the national level, the validation rather than the stringent verification is organized by the CCRCC. In prior to the UNFCCC submission, multistakeholder consultations are taken place to consolidate and validate the findings and recommendations.

For the GHG inventory report, the quality assurance (QA) is overseen by the GHG inventory team at the CCRCC, but the actual work is conducted by a third-party or external consultants. But there are only a handful of qualified experts capable of technical reviews of the GHG inventory. In case of 2017 BUR, an independent national consultant has done QA, reviewing the entire inventory, verifying the data quality, completeness, and accuracy of estimations etc. Other than the GHG inventory, any other assessment or climate change project/programme does not go under the third-party reviews unless subscribed by the financiers. Overall, Mongolia has a limited experience in verifying the results – it lacks formal processes, procedures, and human resources.

Overall gaps and challenges in the MRV. Based on the qualitative findings resulted from the technical assistances e.g., the Paris-aligned MRV recommendations by the NDC Partnership/Gold Standard, the Capacity building initiatives for transparency (CBIT) in the Agricultural, Forest and Land-use sectors by the GEF/FAO, the following main challenges are identified.

Despite the changes made in the institutional arrangements – e.g., establishment of National Climate Committee (NCC) and CCRCC – there remain significant challenges to be addressed, which are summarised below.

Weak legal framework and institutional arrangements. The roles and responsibilities of reporting under the Enhanced Transparency Framework need to be strengthened with the approved procedures and guidelines for the national MRV; it should be decentralized or responsibilities to be delegated to the various institutions to ensure the long-term sustainability. The following responsibilities should be mandated, including but not limited to:

- the cooperation of research institutions in data collection, monitoring, and climate change impact research.
- the utilization or integration of climate change research findings into the national, sectoral, and subnational development policies and plans;
- data provision and involvement in the GHG inventory; and
- transparent monitoring and reporting of progress of NDCs, and support received including the financial support, capacity building, and technology transfers.

2. Limited budget and finance. All activities relating to the national reporting under the UNFCCC are financed through the GEF-UNEP Enabling Activities Project. The CCRCC is likely to face financial challenges in its operation unless there is sustainable financial support from the Government. Furthermore, additional studies are necessary to improve the coverage and accuracy of climate change vulnerability, risks and impacts for economic sectors and sub-national and local regions. Data collection and climate science works shall be undertaken continuously – thus it requires the sustainable and long-term finance.

3. Timeliness of reporting under the UNFCCC. All parties to the Paris Agreement shall submit their BTR containing the national GHG inventory, and the information necessary to track progress made in implementing of the NDC, starting from 2024 and every two years thereafter. Mongolia's past reporting timelines cannot meet this timeliness requirement.

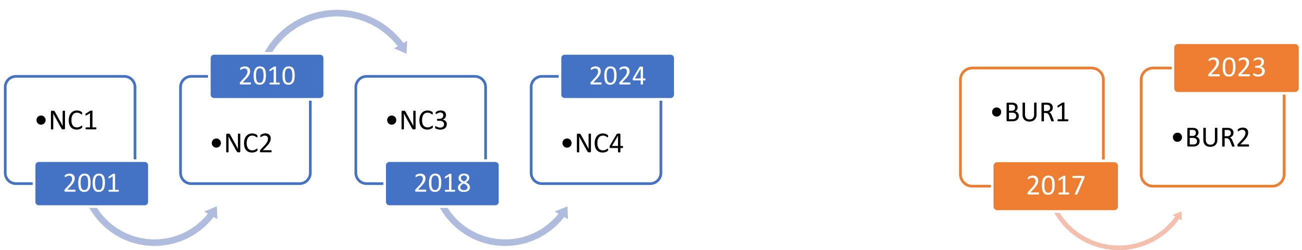

Figure 9.1 National Communication (left) & Biennial Update Report (right) Timelines

As presented in Figure 9.1, there are gaps (4-9 years) between reports which need to be closed to ensure the regular timing of report preparation and submission.

4. Limited human resources capacity at the national, sectoral, subnational, and local levels, which prohibits the effective cooperation and utilization of existing information in policy planning, as well as awareness raising of decision makers and the public on climate change. Staff turnover and obtaining non-specialized officers for climate change positions are even worsening the situation. Training key staff and organizations involved in the GHG inventory preparation, measuring the progress of adaptation and mitigation activities are the capacity-building recommendations of a team of technical experts (TTE) which conducted a technical analysis of the submitted first Biennial Update Report of Mongolia.

5. Limited tools, equipment, and methodologies to improve the quality of climate research and assessment, e.g., climate change vulnerabilities, risk, and impact assessments, and to enhance the data processing and analysis as well as data sharing and archiving systems. There are no methodologies approved at the national level for assessing climate change impacts, risks on the economic and financial sectors, and/or assessing climate impacts of policies as well as project-level GHG reductions and co-benefits.

It is clear there is a substantial amount of work to be done to systematise and improve the effectiveness of the current MRV System. The opportunity is to use these new requirements of Paris Agreement as a catalyst to make a step-change and improve the existing MRV System.

9.3 Climate Finance

Mongolia pre-estimated its climate finance need in its NDC, as USD 11.5 Billion by 2030. Yet, NDCs are not included in the medium-term or annual budget frameworks of the Government – which puts the NDC implementation in a risk. The country is facing budget deficits while inflation is soaring due to macroeconomic issues i.e., low-economic performance, external risks, corruption, volatile political, and policy environment, etc. These issues further elevate the country's borrowing costs and reduce foreign investments. Under the given circumstances and situations, both public and private funds have been limited or expensive for scaling up climate technologies and actions in the country. In addition, the awareness and technical/scientific knowledge of climate change – i.e., financing mitigation and adaptation activities – among many public and private sector stakeholders are lacking which also adversely affects mobilizing domestic climate finance. There could be the budget allocated as co-funding to the international climate change projects/programs but, since the budget tagging does not have climate categories, these public finances are left untracked.

Regarding the mobilization of domestic green finance, the MET piloted the green loan subsidy programme with three commercial banks (the State Bank, Khan Bank, and XacBank) from 2019 to 2020, to reduce air pollution and climate change; the MET budgeted 3.75 billion MNT for the program, reducing an interest rate to 9% on green loans compared to the consumer loan interest rate of 14% on average. The programme was discontinued due to the COVID-19; as well the impacts and ex-post data on green loans were not visible to decision-makers.

As mentioned earlier, to increase green finance in the country, in 2019, Mongolia's first Green Taxonomy was developed by the MSFA as supported by international partners and approved by a joint decision of the Financial Stability Board and the Bank of Mongolia (BoM). Consequently, in 2020, the BoM approved a regulation mandating commercial banks to report their green finance issuance by the Mongolian Green Taxonomy. As per an integrated report by the BoM, 306.7 billion MNT (approximately USD 88.2 million[5]) of green loans have issued by commercial banks at the end of 2021 in Mongolia. Unfortunately, compared to the need for climate finance as estimated in Mongolia's NDC as USD 11.5 Billion, the commercial green finance cannot even make up 1% (approximately 0.8%) of the climate finance needed in Mongolia. Moreover, the finance is not disaggregated by mitigation and adaptation, also impacts of green finance are not enclosed in the green finance statistics by the BoM which puts a barrier in tracking and evaluating domestic (private) climate finance.

Not specifically to raise finance for climate actions, but generally to increase the environmental finance, a few efforts being undertaken by the government in collaboration with the international and private sector partners (UNDP, KFW, TNC, and commercial banks) – namely the Environmental Trust Fund, Billion-Tree Fund etc.

Given the circumstances, climate actions in Mongolia highly rely on the international climate finance and private sector; financial support received from the international partners is introduced in the section below.

[5] Based on a rate of January 20, 2023 ($1 = 3475.56 MNT), the Bank of Mongolia.

9.4 Support received

The government of Mongolia is highly relied on the financial and technical assistance support of donor countries, multilateral and bi-lateral development agencies and funds for strengthening its capacity and implementing climate change actions. The responsibility of multilateral and bilateral cooperation and coordination of development assistance programmes has shifted from the MoF to the newly established Ministry of Economy and Development (MED). Within the MED, the Division for Credit and Aid Policy within the Department for Development Financing is established, responsible for the Government's consolidated credit and aid management (official development aids - ODA), cooperation with multi- and bi-lateral institutions, co-financing, and database, monitoring credit and aid projects, and programmes of multi- and bilateral financial institutions. Other than the ODA, the specialized or international climate funds which are channelled through various delivering agencies are not monitored or tracked by a single government entity rather monitored by multiple entities. For example, the GCF-funded programmes/projects, which are monitored by the Climate Change Research and Cooperation Center (CCRCC), and sector ministries separately implement and monitor the internationally funded climate activities – energy-related activities are coordinated at the Ministry of Energy, agriculture sector measures are with the Ministry of Food, Agriculture and Light and so forth.

In accordance with the independent assessment on climate-related development finance flow based on the OECD's DAC External Development Finance Statistics, Mongolia has received USD 1.29 billion climate-related finance between 2017-2019[6] as assessed by the author. Figure 9.2 shows the flow of climate-related development finance in Mongolia from 2017-2019 by sources, instruments, and by sector. As shown in the Figure 9.2, 67% or approximately USD 864 million of the total funds received is allocated for mitigation, 17% or USD 215 million for adaptation, and a remaining 17% or USD 216 million for adaptation and mitigation combined projects.

Among the donor countries, the South Korea was the largest donor with USD 396 million finance provided – of which USD 383 million of debt financing was for the affordable housing project in Ulaanbaatar. The Asian Development Bank (ADB) was the lead among the multilateral development banks through its project financing of USD 291.4 million for renewable energy, air quality, tourism development, health care services, road development and green affordable housing sectors. Within the multilateral funds, the Green Climate Fund (GCF) was the largest provider of climate finance to Mongolia; from 2017-2019 USD 313 million worth of the GCF projects and programmes are being implemented.

[6] https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm

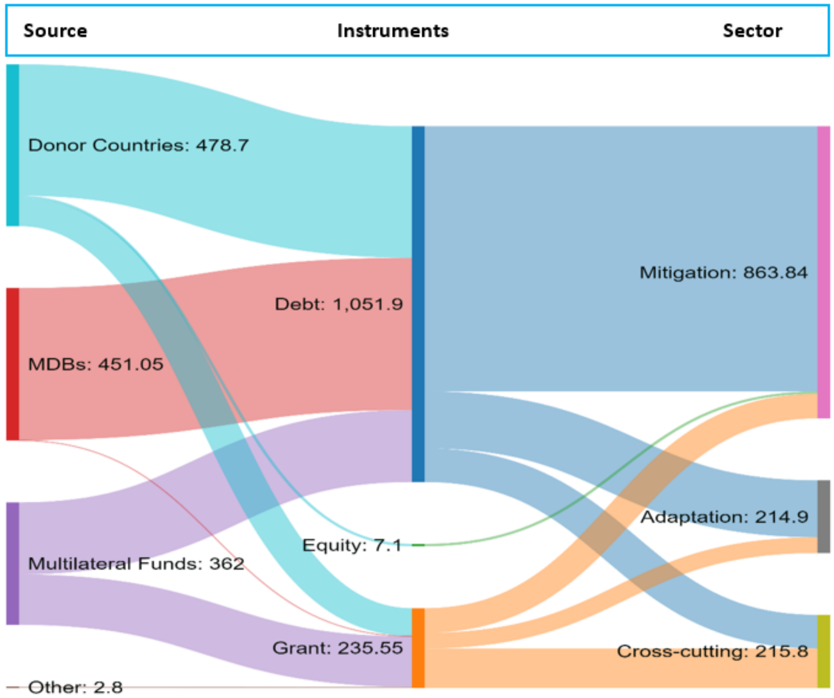

Figure 9.2 Climate-related development finance flow (USD M) in Mongolia from 2017-2019

The government of Mongolia actively cooperated with the GCF accredited entities including its direct access entity – XacBank – and developed the quality of climate projects and accessed GCF financing as shown in the following Table 9.2.

Table 9.2 Single-country full funding projects and programmes approved by the GCF for Mongolia

#	AE	Approval	Project Name	GCF Financing (USD)	Co-financing (USD)	Total (USD)
1	XacBank	2016	MSME Business Loan Program for GHG Emission Reduction	20,000,000	40,000,000	60,000,000
2	XacBank	2017	Renewable Energy Program #1 - Solar	8,650,050	8,906,870	17,556,920
3	ADB	2018	Ulaanbaatar Green Affordable Housing and Resilient Urban Renewal Project (AHURP)	145,000,000	399,011,000	544,011,000
4	XacBank	2018	Energy Efficient Consumption Loan Programme (SAP)	10,000,000	11,500,000	21,500,000
5	XacBank	2020	MGFC	26,650,000	23,000,000	49,650,000
6	UNDP	2020	Adaptation	23,100,000	56,200,000	79,300,000

7	ADB	2021	ASDIP	175,000,000	560,000,000	735,000,000
Sub Total				**408,400,050**	**1,098,617,870**	**1,507,017,920**

Additionally, Mongolia is part of the three regional programmes approved by the GCF – but the implementation of these programmes is not yet started. Those are GCF-EBRD Sustainable Energy Financing Facilities, Green Cities Facility by EBRD, and Climate Investor Once by FMO.

Regards to the GCF's readiness and preparatory support scheme, Mongolia has implemented and been implementing eight programmes as listed in Table 9.3.

Table 9.3 GCF Readiness and Preparatory Support Programmes in Mongolia

#	AE or Delivery Partner	Purpose	GCF Financing (USD)	Status
1	XacBank	Establishing and strengthening National Designated Authority (NDA) and Focal Point (NFP), and Strategic frameworks for engagement with the Fund, including the preparation of country programmes	300,000	Complete
2	Global Green Growth Institute (GGGI)	Readiness Support for Enhancing Access to Green Finance in Mongolia	350,000	Complete
3	UNEP	Scaling-up of Implementation of Low-Carbon District Heating Systems in Mongolia	370,000	Complete
4	XacBank	Energy Savings Insurance Model Development	300,000	Complete
5	XacBank	Mongolia: Strengthening in-country coordination and engagement with the Fund and aligning the development of Nationally Determined Contribution and revision of the Country Program with the country's Sustainable Development Vision 2030	296,300	Complete
6	UNEP	Building capacity to advance National Adaptation Plan Process in Mongolia (NAP) project	2,890,000	Under implementation
7	TDBM	Readiness Support to Strengthen Sustainable Finance Practices in Mongolia and Encourage Regional Knowledge Sharing	291,784	Under implementation
8	GGGI	Strengthening institutional and technical capacity to support the NDC implementation and mainstreaming climate change into subnational development planning (multi-year; 2021-2023)	1,000,000	Under implementation
Total			**5,798,084**	

Besides the GCF projects and programmes, there are internationally funded climate projects being undertaken which are instrumental in the NDC implementation (i) the "NDC Action" project financed by the IKI and implemented through the UN Environment Programme and Copenhagen Climate Center (CCC) which offers 10 partner countries including Mongolia to translate their Nationally Determined Contributions (NDCs) into concrete sector strategies and actions ready for financing and implementation; (ii) “Capacity development for climate policy in the countries of Southeast, Eastern Europe, the South Caucasus and Central Asia, Phase III” which is being implemented by GIZ. The programme supports the NDC development, capacity building as well as the feasibility of climate change law in Mongolia; (iii) Capacity building initiatives for transparency (CBIT) in the Agricultural, Forest and Land-use sectors project by the GEF/FAO, supports the enhancing MRV in the selected sectors, (iv) “Scaling up Climate Ambition on Land Use and Agriculture through NDCs and National Adaptation Plans “(SCALA) programme financed by German Government and implemented through the UNDP and UNFAO, supports the development of relevant tools and methodologies to enhance the evidence base for the fulfilment of Mongolia’s NDC and National Adaptation Plan (NAP) goals ect. Table 9.4 shows the list of climate projects implementing in Mongolia, funded by international organizations.

Table 9.4 Climate change projects, capacity building and technical assistance

No	Project Title & Implementing Period	Funding Organization, Budget	Objective
1	"Ensuring tolerance and stability of Mongolia's native nature" project Period: (2018-2025)	GEF-grants, 7,900,000 USD	Mitigation of ecosystem degradation. It aims to improve ecosystem services by reducing the degradation of pasture and forest resources and protecting biodiversity through sustainable livelihoods in the Sayan, Khangai mountains, and the Southern Gobi region.
2	Sustainable Landscapes and Biodiversity Conservation of the Eastern Mongolian Dry steppe Period: (2021-2026)	GEF 5,354,586 USD	Mitigation of ecosystem degradation . Based on the participation of parties to the integrated level of the land and the market-value network, the aim is to reduce the degradation of ecosystems in arid regions and prevent the loss of biological diversity by supporting nature conservation and sustainable and adapted livelihoods of local people in the steppe region of eastern Mongolia.
3	Development of the Fourth National Communication Report and Second BUR on the Implementation of the UNFCCC Period: (2019-2022)	GEF 946,666 USD	According to the decisions of 17/CP8 and 2/CP.17 issued by the Conference of the Parties and other guidelines and instructions, to develop and prepare the Fourth National Communication BURII and submit it to the Office of the UNFCCC
4	Strengthening a national capacity-building project to improve climate-change adaptation planning processes Period: (2019-2022)	GCF UNEP 2,890,000 USD	Strengthening of capacity building . The project aims to strengthen the institutional and technical capacity of the parties involved in improving the climate change adaptation planning process at the national and local levels.

No	Project Title & Implementing Period	Funding Organization, Budget	Objective
5	“Regional project “Waste and Climate Change" Period: (2017-2022)	Government of Germany, UNEP-IETC 168,705 USD	Strengthening the capacity of policymakers and implementers to reduce GHG emissions from waste and short-lived pollutants that affect climate change in Mongolia, Bhutan and Nepal based on the concept of a zero-waste economy
6	"Prevention and Reduction of Sand and Dust Storms Caused by Dry Regions of Mongolia" Period: (2019-2022)	UNCCD 564,000 USD	Strengthening of capacity building . Create a sustainable land management to reduce the risk and impact of sand and dust storms
7	"Contributing to Ecosystem Conservation by Supporting Specially Protected Areas" (SPACES) Project Period: (2019-2024)	The EU, BMZ, grants 10,830,000 Euros	Strengthening of capacity building. The primary conditions for the sustainable development of specially protected areas have improved.
8	Agricultural Management and ecosystem sustainability (stream) project Period: (2021-2024)	The EU 1,650.000 Euros	Strengthening of capacity building . To solve the problems faced with the food system and climate change in Mongolia and increase the capacity for landscape management through innovative, sustainable approaches.
9	Joint Crediting Mechanism Period: (2013-2030)	Government of Japan 2,500,000 yen	Mongolia and Japan signed an agreement to establish the "Low Carbon Development Partnership" to mitigate climate change and reduce GHGs.
10	Development Program in the Forestry sector Period: (2021-2023)	Japanese Fund on reduction of poverty and ADB 779,000 USD	Increase the sustainability and productivity of the forest sector in Mongolia by providing technical assistance.
11	Mongolian Korean "Green Wall" project Period: (2022-2026)	Forest Agency of the Republic of Korea 1,718,484 USD (per year)	Afforestation . To give the Mongolian Government the forested areas and strips in several phases over five years.
12	Mongolia: Supporting the Climate Change Agenda through Advanced Statistics [7]Period:(2023–2026)	Asian Development Bank	The knowledge and support technical assistance will support the partnership between the Statistics and Data Innovation Unit of the Office of the Chief Economist and Director General in the Economic Research and Regional Cooperation Department and Statistics Korea (KOSTAT) to enhance the statistical capacity in Mongolia.

7 57028-001: Supporting the Climate Change Agenda through Advanced Statistics | Asian Development Bank (adb.org)

No	Project Title & Implementing Period	Funding Organization, Budget	Objective
13	Regional : Improved Decision-Making for Climate Resilient Development in Asia and the Pacific [8] Period: (2020–2024)	Asian Development Bank	The knowledge and support technical assistance (TA) will support selected developing member countries (DMCs) of the Asian Development Bank in three countries including Mongolia to strengthen (i) country systems for climate risk-informed fiscal decision making; and (ii) knowledge on climate risk-informed decision-making.
14	Supporting Renewable Energy Development [9] Period: (2020-2024)	Asian Development Bank	The ensuing project is to support the government of Mongolia in expanding renewable energy. In spite of vast renewable energy potential, Mongolia depends on 93% of total electricity production from coal fired thermal power plants
	Mongolia: Renewable Heating Demonstration in Remote Areas[10] (2022-2025)	Asian Development Bank	The proposed project will demonstrate renewable energy heating system viability in a remote area of Mongolia. The project will support commissioning of the system, its operation and maintenance over two winters, and capacity development among regional leaders and heating technicians. This project will demonstrate the potential for a technology that can meet the heating demands in cold areas, be maintained even in remote regions, reduce air pollution, and contribute to greenhouse gas mitigation.

9.5 Support needed

As previously mentioned, gaps and constraints Mongolia faced– insufficient coordination, no transparent MRV, weak mandate, limited finance, and limited human resources – the realization of its NDC and fulfillment of transparency requirements to the Paris Agreement would be a challenging task for Mongolia. Table 9.5 presents the summary of the support needed.

Table 9.5 Support needed in accelerating climate actions in Mongolia

№	Themes	Support needed
1	Climate science and research	• Strengthen the collaboration among research institutions and academia and partnerships on policy and science; • Enhance the policy-oriented research linking the policy and science partnerships; • Development of methodologies e.g., climate vulnerabilities, risks, and impacts on finance, health, gender, children, economy, etc. • Strengthen the impact-based data collection, monitoring and evaluation;

8 54412-001: Improved Decision-Making for Climate Resilient Development in Asia and the Pacific | Asian Development Bank (adb.org)

9 52240-002: Supporting Renewable Energy Development | Asian Development Bank (adb.org)

10 54360-001: Renewable Heating Demonstration in Remote Areas | Asian Development Bank (adb.org)

		• Expansion of laboratories at the universities supporting climate change innovations and technologies; • Strengthen the access to long-term or sustainable finance for research and academia.
2	Stakeholder coordination	• Strengthen the mandate, institutional arrangement, accountability, and oversight governance – inclusion of the independent review of performances, etc. • Strengthen the existing online platform as coordination tools. • Establish the coordination mechanism – an economic incentive-based system could attract various stakeholders. • Strengthen the finance as well as human resources to coordinate climate change policies and actions nationwide with the government, research and academia, private sector, international partners, local stakeholders, NGOs etc.
3	Policy planning	• Support the integration of science-based policy planning, prioritization, and budgeting practices. • Strengthen the capacities and accountability mechanism for the Units or Agencies operate under and/or within ministries e.g., a unit responsible for research and analysis within the Ministry of Economy and Development, Ministry of Environment and Tourism, and research agencies of other ministries. • Maintain the sustainability of the government structure and its human resources - enabling the undisruptive or continuous policy planning process.
4	MRV	• Introduce the climate-budget tagging to enable the monitoring budget allocation and expenditure for climate-related actions; • Mandate the roles and responsibilities, processes, and procedures – methodologies and guidelines for tracking climate finance, NDC progress etc., shall be developed. • Utilize the digital systems to ensure the transparency and inclusive participation, and ease data sharing and reporting processes.
5	Human resources	• Strengthen and develop policies to prepare human resources in climate change, employ specialized personals, and sustain the human resources and reduce the staff turn-over rate; • Enhance the awareness and capacities of policy makers at all levels – Parliament, Government, Citizen Representatives Hurals at city, provincial and soum. • Strengthen the local government organizations' capacities on climate change. • Develop the climate professionals training programmes and institutionalize it, e.g., prepare training of trainers – and establish the climate trainers and scientists' networks. • Integrate the climate change into all major curriculums of universities and technical schools including the building engineer, forest engineer,

		water engineer, biology, economic and finance etc; introduce the advanced level degree programs on climate change. • Enhance capacities of the Lifelong learning Centers and utilize the Centers to increase awareness and educate the public on climate change. • Enhance capacities of civil society organizations supporting the meaningful participation in climate change decision making implementation, monitoring, and evaluation. • Strengthen and utilize the youth and elders, those have the distinct traditional and new knowledge, and power to influence the future generations in adapting to climate change, and mitigating GHG emissions. • Empower women, and increase their involvement in climate actions, which can start at the households with lifestyle changes e.g., saving energy, water, recycling, reducing waste etc.
6	Mobilize finance	• Develop a climate technology list on priority sectors in support of guiding the climate investment of private and public entities or businesses. • Implementation of the Country Programme for the Green Climate Fund, as updated by 2022 – it contains the prioritized mitigation and adaptation actions for fund mobilization. • Research and pilot innovative incentive mechanisms such as tax subsidies, loan interest subsidies, carbon market, insurance, and guarantees to enable the mutually beneficial scheme for various stakeholders to take accelerated actions in reducing GHG emissions and adapting to climate change.

Mongolia continuously has been incorporating GHG emission reduction measures into national programs, legislative bases, and documents. The government program "Vision 2050" and the Nationally Determined Contribution (NDC) are the most recent and primary policy documents. According to the mentioned documents, below key barriers, constraints, gaps, and financial, technical, and technological needs in implementing GHG emission reductions measures are listed in Table 9.6.

Table 9.6 Issues encountered in the implementation of measures to reduce GHG emissions

Barriers	Gaps	Financial needs	Technology needs
• Insufficient and inadequate action planning for implementation and requirements of laws and legal policies on climate change • Lack of financial resources for implementing measures to reduce and mitigate the negative effects of climate change.	Currently, Mongolia does not have a specific law on climate change that regulates interdisciplinary and national activities to solve problems related to climate change. Basic concepts, principles, and legal regulations on climate change are not reflected in the primary	• Directing climate finance to priority sectors for the implementation of the NDC objectives • To build their internal capacity, sectors can rely on their resources to receive long-term external support. • Disclosure of financial flows	• Technologies for the Use of Renewable Energy Sources • Technologies to improve the efficiency of electricity and heat production. • Introduction of Energy-Effective Technologies in the Industry

• Inadequate technology and human resources • Weak governance, financing, implementation, and intersectoral coordination • Lack of legal and policy implementation and planning for measures to mitigate climate change • Uncertainty in the implementation analysis and conclusions of the studies on the possible impact and future trends of CC, and measures on climate change mitigation. • Climate change issues are not explicitly addressed in national or sectoral development plans and programs. • Inadequate financial leverage, lack of funds and financial resources, uncertain macroeconomic environment. • The political situation is unstable (high risk for investors), lack of government control over the implementation and enforcement of the legal framework.	national development policy documents. • The participation of parties at the sector level is unclear in legal documents. • Have not yet formed a transparency system. • There is no such system that measures and reports the implementation of the NDC transparently. • It is necessary to create a national system for the implementation of policies and measures aimed at reducing climate change • Carbon market development is weak	• A total of 11.5 billion USD was needed to be allocated for the implementation of the NDC goals. • USD 6.3 billion is needed for mitigation measures. • USD 5.2 billion is needed for adaptation measures. • 80% will be financed by foreign loans, aid, and other investments, and 20% by the state budget and other revenues and sources.	• Increase the heat retention capacity of the building. • Introduction of Electric Vehicles • Fuel Quality Improvement and replacement • Improve the processing of livestock manure. • Protection against soil damage and erosion.

Sectors	Barriers	Gaps	Financial needs	Technology needs
Energy	• Inadequate laws and regulations • Policy succession and continuity are lost. • The cost is high. • The source of the funding is uncertain.		• 2,800.0 billion MNT to increase renewable energy sources. • 1,400.0 billion MNT to improve production efficiency. • 3,080.0 billion MNT for the construction of a large new source of clean energy with high technology.	• Use energy-efficient technologies and low-carbon energy sources • Clean coal technology and clean fuel production • Construction of a combined coal-gas thermal power plant • Increasing renewable energy sources

	•Technological backwardness and extensive dependence on imports •Free-market competition is weak and low. There is a lot of government involvement, and the free-market mechanism has not been introduced.		• To increase the efficiency of energy consumption: Industry 1,120.0 Building 840.0 Transport 980.0 billion MNT • The amount of necessary investment in the energy sector is estimated to be 10.22 trillion MNT (NDC).	• Construction of a large new source of clean energy with high technology
Agriculture (Arable farming)	• Agricultural areas have overlapped with livestock pastures. • Crop production is extremely dependent on nature and climate conditions	• Abandonment and loss of farmland due to poorly planned farming and inappropriate land use • The transparency of government support to farmers is weak and unclear	• 2,520 billion MNT are needed for the measures taken in the agriculture sectors (agriculture and livestock) (NDC).	• Introduction of advanced tillage technology in cultivated and fallow areas • Increase the type of cultivated plants and the recurrence of planting • Introduction of drip irrigation system to reduce water loss
Agriculture (Livestock)	•The number of headstocks has exceeded the carrying capacity of the pasture. •Weak pasture management •Poor pasture watering •The methods and techniques used, and processing animal manure are weak. •Animal disease outbreaks are high	• Improve legal regulations for pasture use • Establishing a pasture use tax system • Appropriate use of pastures, monitoring, and increasing community participation (TNC)		• Create an early warning system to prevent livestock loss due to dzud and drought • Improving the quality, breed, and stock of livestock • Development and improvement of livestock management to prevent infectious animal diseases • Mitigation of pasture degradation

Forest	Degradation of forests (forest fires, pests, illegal logging)	• Irrigation system for forest plantation forest • Lack of forest professionals, capacity building	840.0 billion MNT (NDC)	• Introduction of planting technology. • Use of aircraft to fight forest fires • Introduction of biological technology against insects and pests • Improving the efficiency of forest clearance technology
Industrial	• There is a lack of technology that reduces GHGs. • The processing industry is not yet very developed	Industrial Complex	23 million USD (TNC)	• Formation of a pre-treatment system in the industrial sector
Waste	• Separation of waste by Types and sources unaccustomed. • Weak management of open waste disposal at sites. • Inadequacies and discrepancies in data and information	• Improving the legal framework for incentive systems related to waste reduction. • Public Awareness, Training, and promotion • Introduction Recycling System. • Recycling of Ash	1,400 billion MNT (NDC)	• Eco Park construction technology • Water-saving technology • Gray water use • Technology to Improve the capacity and efficiency of wastewater treatment plants and facilities

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CHAPTER 10. OTHER INFORMATION

10.1 Climate change monitoring and service

10.1.1 Climate, water and environment

Systematic observation of climate. Meteorological observation in Mongolia was first started in 1869, but the first station of the national network of the National Hydrometeorological Service of Mongolia was established in 1936. Since then, the meteorological observation network has been expanding (Figure 10.1). In Mongolia, hydro-meteorological observations are carried out by the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), which operated under the National Agency for Meteorology and Environmental Monitoring (NAMEM) within the Ministry of Environment and Tourism. The IRIMHE's primary role is to serve real-time and predicted information of weather, climate, water, and environment as operationally based on scientific research outputs. Currently, throughout Mongolia, 137 meteorological stations are operating and carrying out permanent observation under the standard programme of the World Meteorological Organizations (WMO).

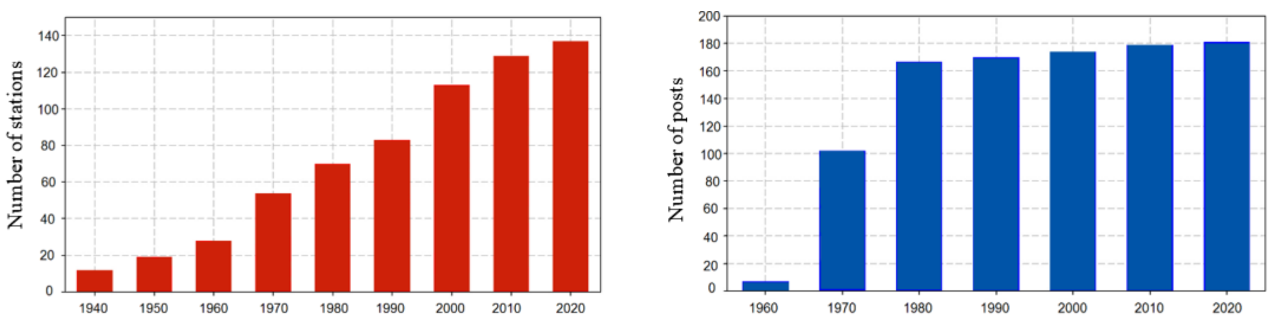


Figure 10.1 Expansion of the national network of meteorological observation and measurement

In addition, there are 181 meteorological posts which only conducts observations during the daytime by a single observer, totaling 330, are operating in the centre of soums, which are the primary administrative unit of Mongolia. The geographic location of stations and posts in the network of the National Weather Service is shown in Figure 10.2.

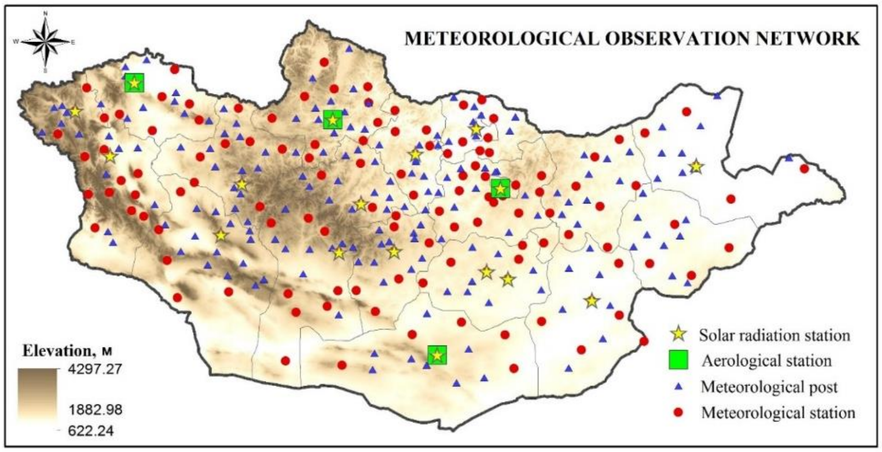


Figure 10.2 Locations of meteorological, solar and aerological stations and posts

Observations and measurements regularly are done at meteorological station 8 times a day (15, 18, 21, 00, 03, 06, 09, and 12 GMT) and at posts 3 times per a day (00, 06 and 12 GMT) performing by the programs shown in Table 10.1.

Table 10.1 Programs for meteorology, solar and aerology stations

Observation and measurement at meteorological station (every 8 hour a day)	Observation and measurement at meteorological post (every 4-hour a day)	Measurement at solar radiation meteorological (every minuts)	Aerological measurement (every minutes)
Air and soil temperature Air pressure Wind direction and speed Relative, absolute, deficit of moisture Precipitation Visibility Clouds and its types Phenomena (more than 30 types) Snow cover and height Snow cover density Soil temperature, Sunshine duration	Air and soil temperature Wind direction and speed Precipitation Visibilty Clouds and its types Phenomena (more than 30 types) Snow cover and snow depth	Total radiation Reflected, direct and diffuse radiation Net radiation Sunshine duration	Geopotential height of air temperature geopotential height, humidity, moisture deficit, wind direction and speed at special points of standard pressure surface.

The hydro-meteorological and environmental database is accumulating 10-70 years of a database of observation based on the meteorological stations and posts. The database contains air temperature, surface soil temperature, soil depth temperature, atmospheric pressure and its trend, air humidity, wind, precipitation, weather phenomena, cloudiness, and visibility. The data of 63 stations of the meteorological observation network are included in the list of base stations of synoptic and climate observation network (GCOS) and exchange information internationally. Soil depth temperature used to be measured at a depth of from 20 cm to 320 cm, nowadays measurements are made from 5 cm to 320 cm at 24 weather stations.

Since 2003, the high-sensitivity automatic weather stations have been installed in the national weather network, and measurements are being made at 124 stations and 52 posts as of 2022 (Figure 10.3). However, the presence of automatic instruments obtained from 7 different companies, such as those assembled in Mongolia, China (CAMS620), Finland/ Vaisala (MAWS301, AWS330), Korea (JDL) cause difficulties in ensuring data uniformity.

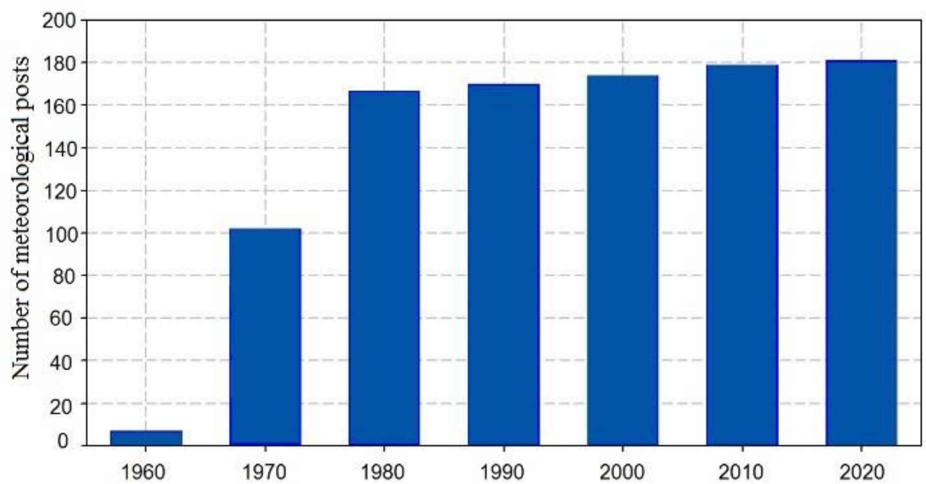


Figure 10.3 Number of automated weather station in the national weather network

Solar radiation observation. Mongolia started to observe the solar radiation in 1961. From the 1970s until 2004-2005, Mongolia had 32 stations were operating to make measurement of solar direct and indirect radiation, long- and short-wave radiation balance and surface albedo.

The number of stations was reduced to 17 due to rapid development of new technology and the dismantled the old mechanical tools (Russian made) (see Figure 10.2). In 2005, the high-sensitivity automatic weather stations (AWSs) first introduced into the national solar radiation observation network, and currently, 17 stations are used to measure total, direct radiation, reflected radiation, and radiation balance. The weather stations such as Uliastai, Ulaangom, Murun, Dalanzadgad, and Ulaanbaatar are included in the solar radiation observation network of GCOS, and information is exchanged with the international center (GGO). Currently, except for five operational stations included in WMO's actinometer network and another six stations still utilize old instruments (Russian made) to measure the total radiation and radiation balance.

Previously, the sunshine duration was recorded at 32 meteorological stations, since 2008 to nowadays, after introducing AWSs sunshine duration continues to measure only at 14 solar radiation stations.

Aerology. In Mongolia, a weather balloon was launched initially in 1939, and aerological observation (radiosondes) began in 1941. There were operating 14 aerological stations until the 1990s, but now at only 4 stations such as Murun, Ulaangom, Dalanzadgad, and Ulaanbaatar stations, radiosondes are launched 1-2 times daily, and continuing observations and measurements are made according to the program shown in Table 10.1.

Agrometeorological observation network. The Agricultural Meteorology Program of the World Meteorological Organization (WMO) aims to provide weather and climate services to support sustainable agricultural development, increase productivity, and contribute to food security, and climate services to provide decision makers in climate-vulnerable sectors with better information to help them adapt to climate change.

As for Mongolia, on the one hand, it has an agricultural sector with pastoralism and non-irrigated farming, and on the other hand, it belongs to a region with a fragile ecosystem where climate change is rapidly progressing. Thus, there is a tendency to be negative impacted by climate change, so these two aspects should be studied and taken comprehensively. In Mongolia, agricultural land (grassland) occupies 73.8% of the total area, produces 31.5% of the GDP, and employs 53.9% of the total workforce in this sector.

Research studies such as research on the past and future climate change and its impact assessment is being carried out using its own potential, not far behind the international level, but the process of using research results and putting them into practice is still lacking.

For example, ministries, agencies, and business organizations have a general understanding of climate change, but do not include it clearly in their strategic plans and work plans, and do not budget funds and expenses, which is the main reason for failure.

Due to the lack of state budget for the monitoring and research measures of the National Hydrometeorological Service, the permanent and long-term monitoring and research program of the meteorological monitoring network has been stopped or closed due to a lack of equipment in somewhere and, the conditions for missing data are increasing year by year.

In the future, it is necessary to pay special attention to the obtain of a real environmental database with the aim of proving that the land cover is changing rapidly, and the land potential is changing and deteriorating, and to quickly provide climate services to the government and the people.

Systematic observations. Long-term agricultural meteorological monitoring and research work is being systematically organized and developed at the National Hydrometeorological Service. An overview of agricultural climate monitoring:

Pasture monitoring. Pastureland monitoring has been conducted through 318 meteorological stations and posts since 1960. The pasture condition observation network is divided into three types:

- Phenology of pasture plants, biomass (soum level-330 meteorological stations and sites)
- Pasture degradation or desertification (bagh level-1519 sites)
- Common pasture pests and rodents (soum level-330 meteorological stations and sites)

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 (soums/meteorological stations) by weighing method, and also, estimates the moisture in the soil of the fallow field. The main measurements are:

- Soil moisture of every 10 cm layer to a depth of 5-100 cm
- Productive and reserve moisture
- Agro-hydrological characteristics of soil

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 weighting method. Since 2014, began to measures the soil's moisture by automatic measuring devices at sites 26 in some selected pasture and crop fields.

Livestock meteorological monitoring. Observation for impacts of environmental factors to livestock had been conducted in 10 soums representing different natural zones from 1976 until 1990 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)
- Yield of wool and cashmere
- Yield of milk
- Feeding and watering livestock
- Micro-climate offense, shelters for animals etc. are being observed.

Crop monitoring. The 44 meteorological stations and posts are observing wheat and potato phenology inlcuding phenology phases, heights, density, thickness, damage rates, causes and harvest of wheat, potatoes, and vegetables in the agricultural regions of Mongolia. In some sites, precipitation and other crop productivity observations are conducted (e.g., weight of 1000 seeds).

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, 136 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 10.4).

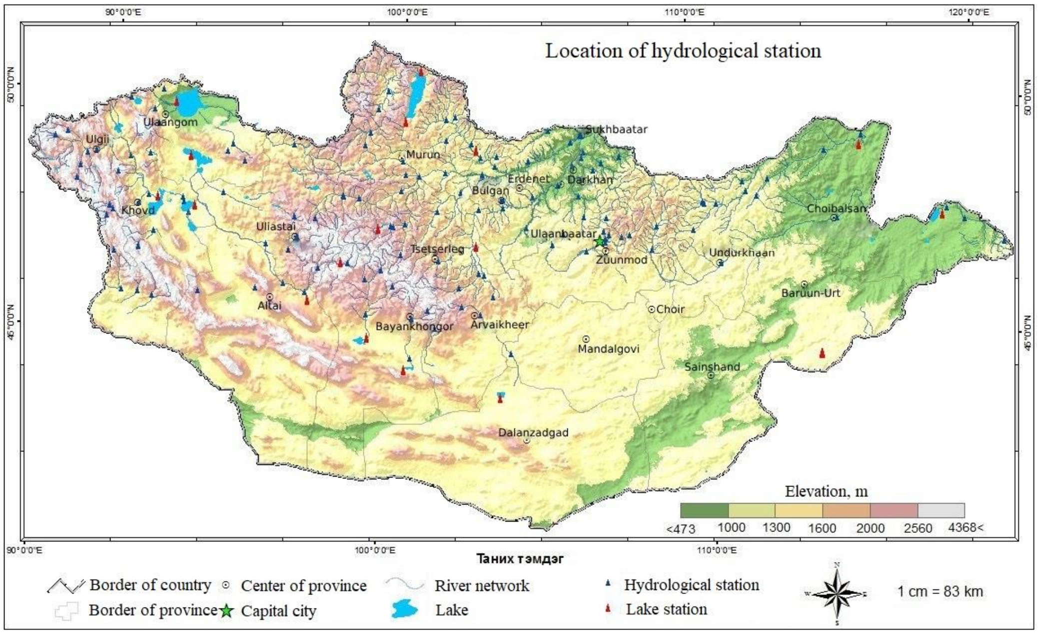


Figure 10.4 Locations of hydrological monitoring posts

In other words, since the Third National Communication Report, the network of observation and measurement of the surface water has been expanded with in the Kherlen, Khogshin Orhon, Delgermurun and Oigon lakes (Figure 10.5).

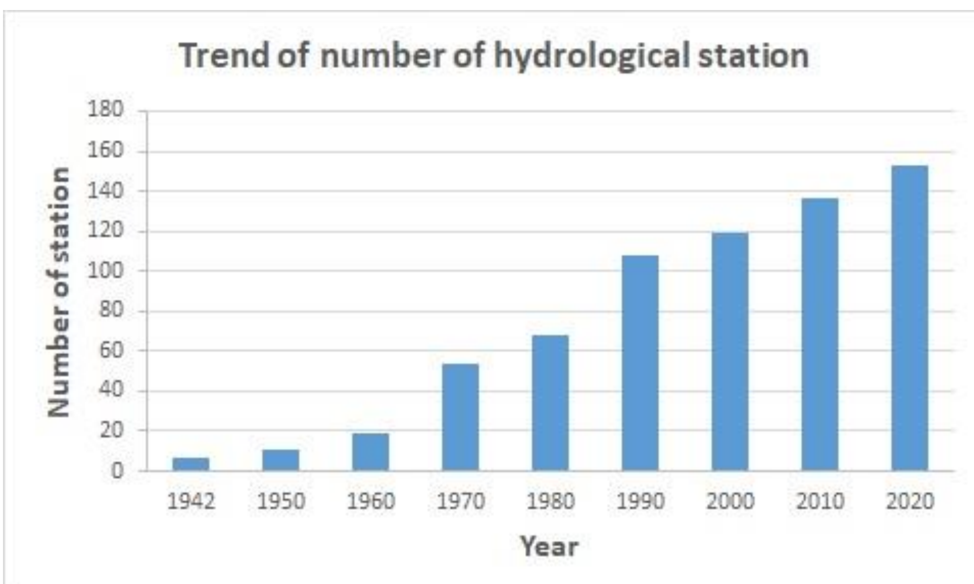


Figure 10.5 Expansion of surface water observation network in Mongolia

In addition, samples of water plankton, benthos species of aquatic organisms and Phytoplanktons are collected at 106 hydrological stations and carrying out further analysis. Samples for water chemistry and water pollution are collected at 161 sites and conducting research analysis for water chemical composition, nutrient pollution, and heavy metals. Observation and measurement sites of ground water resources which are wells, boreholes and spring yield measurements have been expanded in the past. In particularly, ground water observation 40 sites, spring yield measurement 19 sites that expanded by more 2 sites, named Orgih and Dagshin which are situated in the Dariganga soum of Sukhbaatar province. Moreover, as of 2020, at 9 sites conducted observation for open water evaporation and evapotranspiration.

During past five years, one of the improvement of surface water observations and measurements network is the wide use of automatic sensors for measuring water level and temperature. It was the beginning of automatic observation network. As of today, total 26 hydrological posts are simultaneously observing water level and temperature with automatic sensors (Figure 10.6).

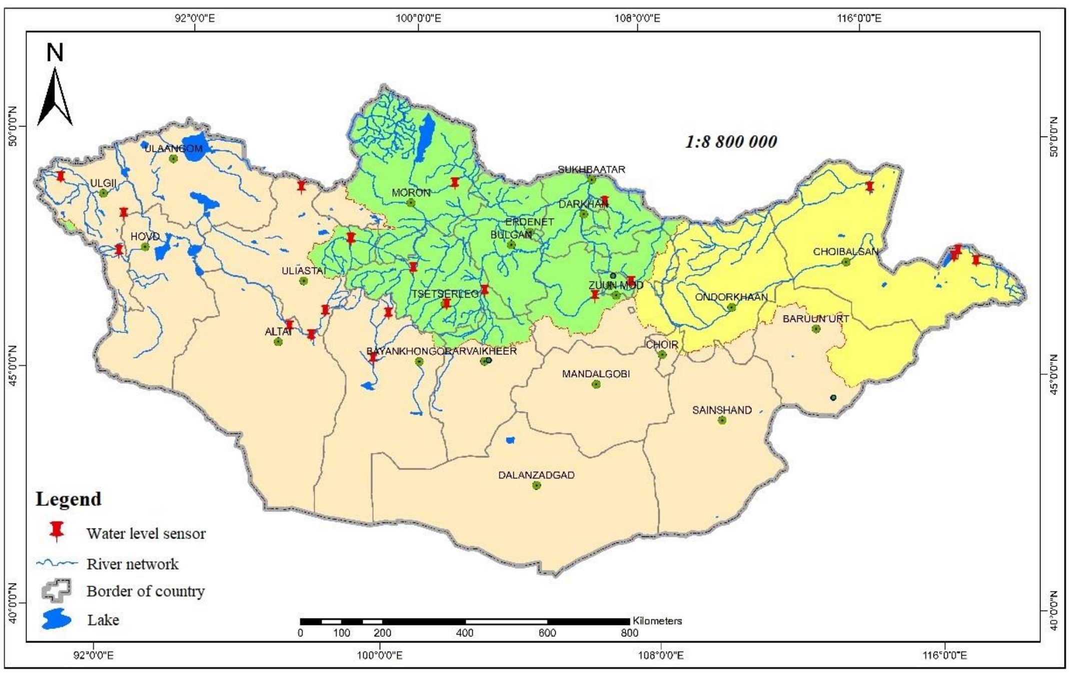


Figure 10.6 Location of hydrological monitoring posts equipped with automatic sensors

In addition, significant progress made for establishing the network of water balance study. As of today, water balance study conducted in the basins of Selbe river, Khustai-Bayangol, Ganga and Ugii lakes. In particular, hydrometerological network of observation and measurement has been formed in the Ganga lake basin that includes all meteorological elements measured at the Dariganga station such as precipitation measurement at 4 points, the lake water level measurement at 2 sites, spring yield measurement at 3 sites, and automatic water level measurement at 1 site (Figure 10.7).

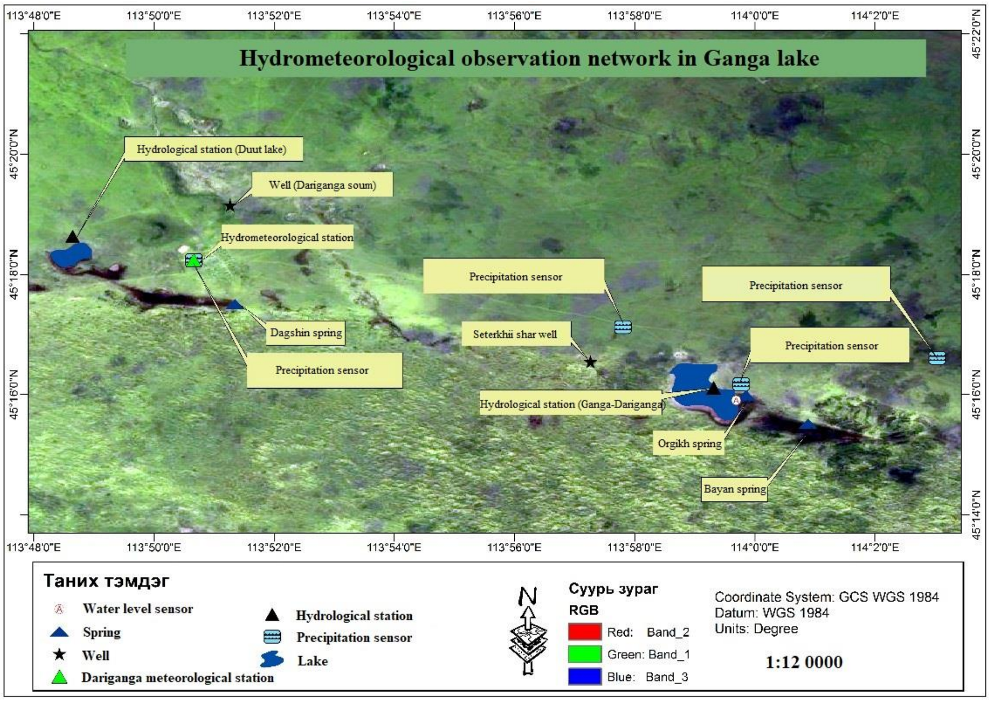


Figure 10.7 Hydrometeorological observation network in Ganga lake, 2018

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-1950. Although, the first observation borehole for permafrost monitoring had been installed by mid of 1950 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 the Information and IRIMHE and the Institute of Geography and Geoecology with support of some international programmes such as the Global observation network for terrestrial permafrost (the Global Terrestrial Network for Permafrost /GTN-P/), circumpolar active layer monitoring of the polar region, thermal state of permafrost etc., and monitoring boreholes belong to the IGG and IRIMHE.

Glacier studies and monitoring. Glacier mass balance observation conducted since 2003 in the Tavanbogd, Tsambagarav, and Munkhkhairkhan ranges: a melting and accumulation of glaciers; glacier area and thickness; flow regime of glacier originated rivers; and climate and weather observations at glaciers. There are different types of glaciers such as Potanin and Turgen that are valley-type glaciers and Tsambagarav and Sutai are ice-cap-like type glaciers. Four automatic weather stations were installed near the glaciers: in 2005 (Tsambagarav), 2012 and 2014 (Potanin), and 2013 (Turgen) to monitor local meteorological parameters. To define the mass balance, installed stakes at 50–100 m elevation intervals at the Potanin (14 stakes), Tsambagarav (5 stakes), Turgen (7 stakes), and Sutai (4 stakes) glaciers, and acquired semi-annual measurements in 2003, 2010, 2013, and 2015, respectively (Figure 10.8).

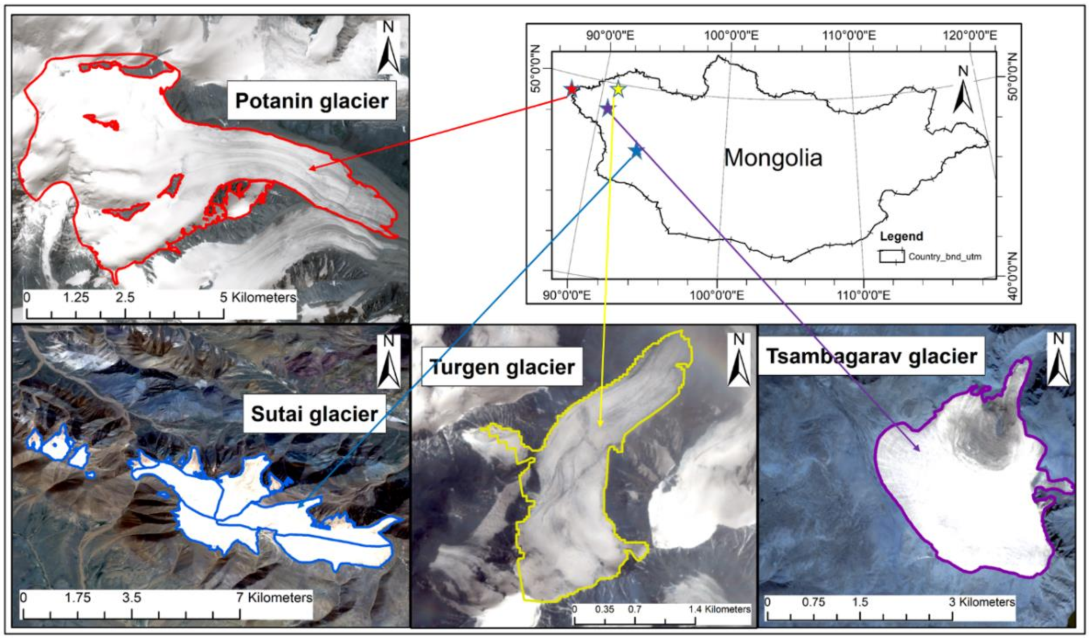


Figure 10.8 Glacier monitoring network

Greenhouse gas monitoring. In 1991, Mongolia established a greenhouse gas monitoring station at the Ulaan-Uul site ("Red Mountain") in Erdene soum of Dornogobi province, which is included a global greenhouse gas observation network of the National Oceanic and Atmospheric Administration (NOAA) of the USA, for the first time in the Central Asia. From 1991 to today, based on the data, the atmospheric greenhouse gas concentrations are defined in the Climate Monitoring Diagnosis Laboratory (CMDL) of NOAA in USA. The observation data are published and archived in the world greenhouse gas database in Tokyo Centre, Japan.

At present research institutions of Mongolia and Japan are jointly developing methodology for the monitoring of GHG using data from the Japanese specialized sattelity GOSAT. First results were reflected in the recently submitted Mongolian BUR2 (BUR2, 2023). The long-term cooperation through the GOSAT-project has also led to the formation and enhancement of institutional capacity in terms of technology and analytical methods for use of the GOSAT series data.

Recently, inverse modelling frameworks to estimate surface GHG emissions have rapidly developed. The inverse model can estimate GHG emissions using the observed concentration of GHG gases in the atmosphere. For a successful Global Stocktake, it is essential to give a verification/quality check (QC) on the GHG emission inventories by the bottom-up method using an independent approach. Notably, this is the first case to have a good practice verifying the GHG inventory by inverse modelling in BUR (Watanabe at al, 2022).

Dust storm monitoring. With the start of instrumental observation for climate and weather in 1936, visual observation for dust storms was also started along with the development of a meteorological observation network, dust storm observation has been expanded and developed. As of 2021, synoptic visual observation for dust storm is conducting at 137 meteorological stations and 181 meteorological posts.

Today, many countries worldwide use satellite techniques for monitoring sandstorms, fugitive dust to the atmosphere and volcanic ash, and detected results apply for different research purposes. Such activities started in Mongolia in the 2000s. By 2021, the number of new dust monitoring stations has reached 9.

Based on data obtained from above climate, water and environmental monitorings, data analysis were made and the results were provided as a climate service in timely matter as follows:

Reviews and recommendations:

- Review of 10^{th} days-1, 11, 21 of every month
- Monthly review at the beginning of each month
- Distribution maps of grasshoppers and rodents, April to October
- Review of soil moisture, April to October
- Summary of past winter's weather conditions, Mar 12
- Summary of past spring's weather conditions, Jun 12
- Summary of past summer's weather conditions, Sep 12
- Advice on weather conditions during calving, Feb 26
- Review of weather conditions during the growing season of cereals, Sep 22
- Harvest recommendation, Aug 2
- Review of soil moisture spring and autumn survey, Apr and Nov

Forecasts:

- Soil moisture content of cultivated fields, Apr 02
- Soil moisture during planting, May 02
- Time of soil begins to thaw, Mar 26
- Time of stage of grain formation, Jul 26
- Crop yield, Jul 02
- Potato yield, Jul 02
- Biomass of pasture plants, Jul 02
- Time of soil begins to freeze, Sep 26
- Reduction of sheep fatness, Nov 22
- Sheep fattness gain, Apr 22

Special needs reviews and recommendations:

- Winter-spring season's pasture carrying capacity, Aug 25 (by the Government Resolution, since 2001)
- Drought and dzud assessment (by the Government Resolution, since 2001)
- Dzud risk maps (since 2015)
- Recommendation for spring planting (since 2000)

In line with the fact that the negative impact and vulnerability of climate change is increasing in Mongolia, in the future to increase and expand climate services in the agricultural sector.

10.1.2 Climate Service System

In Mongolia, Climate service system (CSS) and its possible optimum structure has been determined by considering linkage with other Global Framework of Climate Service (GFCS) and the main components are shown in Figure 10.9. Here, the CSS consists of following main parts:

- Observation, modelling
- Main climate products
- User oriented climate service products, which are dedicated for adaptation and reducing impact and risk
- Climate change impact, vulnerable and risk assessment, which are translated from science language
- End users platform.

Also, product provider always assesses the end user's requirements and needs, and improves the system based on their suggestion and feedback. Simultaneously, organizes the training for users on what is a climate service, how to utilize its products, and their detailed explanation.

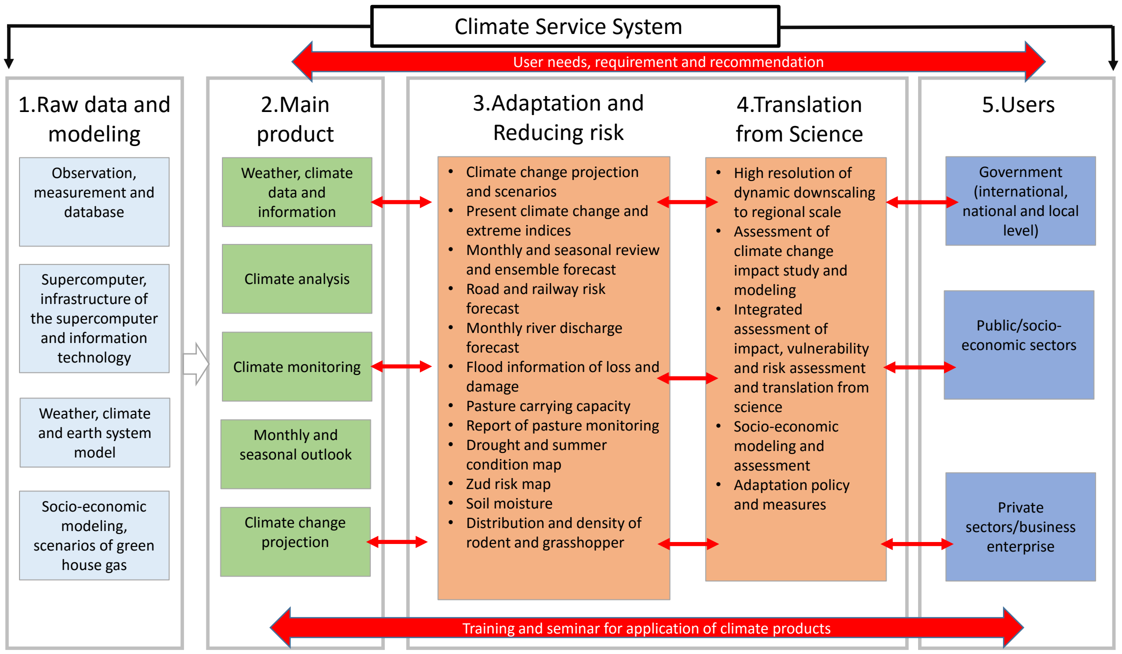


Figure 10.9 Structure of climate service system

Main content of information and service products for the CSS user platform is shown in Figure 10.10 and described as briefly as follows:

1. Climate resource and regime. User could download latest 30 years' climate standart norm at meteorological stations and posts between 1991-2020, as well as getting maps of the applied meteorological and climate. It is possible to see monthly and annual climate to review and download into the files.

2. Monthly and seasonal outlook. The climate depends on atmospheric general circulation and its variables regime formed during multiple years, their anomaly outlook up to 3 months including position of pressure system, are shown over Eurasian territory using ensemble model outputs. Also, temperature and precipitation outlook of the monthly and seasonal anomaly over Mongolia is depicted in the CSS.

3. Background information related to the NDC. Present circumstances of climate change and its trend, future climate scenaroius and projections, assessments of climate change impact, vulnerability and risk in Mongolia, are reflected into the NDC document. This information and products will regularly be updated up on release of new National Communication on Climate Change.

4. Background information related to the NAP. Main output from the National Communication such as integrated assessment of natural and socio-economic sectors of Mongolia, are graphically demonstrated by 0-1 score as a normalized number. In the map, it shows current vulnerability of each provinces and its future risks. Therefore, identified adaptation needs by region and sectors across the country.

5. Livestock. Due to climate change, intensity of drought and dzud is increasing, therefore, it requires to define indices to express intensity and its trend, pasture biomass, and animal weight forecasts. Also, on the risk map the user can obtain information and products on pasture carrying capacity in end of summer for winter preparedness and migration route, and regions with the high probability of dzud. The user can see drought and summer conditions of own province and soum. Finally, "Report of Pasture Monitoring" can be download from this platform.

6. Arable farming. Change of extreme climate indicies, which mostly related to loss of yield, and their trends are disseminated to users and help them make decision on adaptation technology and the long term planning. Also, the forecast of soil moisture and crop yield helps farmers to select agro-technology during planting period, and the drought and summer condition map helps to reduce risk of loss crop yield.

7. Water resource. The platform provides the water balance element such as precipitation and discharge change and their trend. The frequency of flood, its damage and loss information, changes in the glacier melt including its area and mass balance are provided in the annual basis. Also, water quality information based on biological approach, outlook of the river discharge will be updated monthly and posted in the platform. It gives opportunity to regularly operate the hydropower station operation.

8. Infrastructure. (Forecast for road and railway risk). Along the road and railway from north to south direction weather high impact extreme events are classified into snow storm, heavy snow, high intensity rain and strong wind, and their forecast will be issued every 3-hour interval with 72 hour advanced time. It gives opportunity to reduce risk of high impact weather events and increase the climate resilience.

1. Climate regime and resource
- Climate standard and mapping (137 stations, 181 posts, 1991-2020)
  - ✓ Monthly, annual temperature
  - ✓ Maximum and minimum temperature
  - ✓ Annual precipitation
  - ✓ Daily maximum precipitation
  - ✓ High resolution climate norm and its map
- Applied climate
  - ✓ Growing season length
  - ✓ Date of froze on soil (o0)
  - ✓ Date of transferring +5 and +10 degree Celsius
  - ✓ Occurrence and frequency of dust
- Past monthly and annual review
  - ✓ Monthly and annual review
  - ✓ Annual climate review
  - ✓ E-monthly and annual review

2. Monthly and seasonal outlook
- Regime and outlook the general atmospheric circulation
  - ✓ Mean and anomaly of the 500 Pha geopotential height and front upper level 500 location
  - ✓ Mean and anomaly of the converted to sea level pressure
  - ✓ Mean and anomaly of air temperature
  - ✓ Mean and anomaly of precpitation
- Monthly and seasonal forecast
  - ✓ Monthly forecast of air temperature anomaly
  - ✓ Monthly forecast of precipitation
  - ✓ Seasonal (3 months) forecast of air temperature anomaly
  - ✓ Seasonal (3 months) forecast of precipitation

3. *Background information related to the National Determined Contribution (NDC)*
- Present climate change and its trends
  - ✓ Present change of annual mean temperature and precpitation
  - ✓ Their spatial distribution
- Future projection and scenarios
  - ✓ Ensemble projection of annual mean temperature and precpitation
  - ✓ Their spatial distribution
- Impact, vulnerability and risk
  - ✓ Normalized index of the vulnerability and risk assessment for environmental and socio-economic sectors

4. *Background information related to the National Adaptation Plan*
- Brief summary of the impact, vulnerability and risk assessment
  - ✓ Brief summary of Mongolian of the impact, vulnerability and risk assessment in table format
  - ✓ Reginal normalized index of the impact, vulnerability and risk assessment
- Aimag level the impact, vulnerability and risk assessment
  - ✓ Aimag level normalized index of the impact, vulnerability and risk assessment
  - ✓ Current and future vulnerability and risk map

5.Livestock
- Drought and zud undex change and trend
- Review, advisory and forecast
  - ✓ Pasture biomass/yield
  - ✓ Animal weight
- Pasture carrying capacity
- Report of the pasture monitoring and condition
- Drought and summer condition map
- Distribution and density information of rodent and grashoper
- Zud risk map

6.Arable farming
- Extreme climate condition and its change
  - ✓ Hot days, growing season length, heat wave and dryness index
  - ✓ Drought index change
- Review and outlook
  - Crop yield
  - Soil moisture
  - Drought and summer condition map

7.Water resource
- Present change
  - ✓ Precipitation
  - ✓ River discharge
  - ✓ Dryness index
  - ✓ Dried up lake information and location
  - ✓ Lake level change
  - ✓ Lose and damage of the flood in annually
- Change of glacier area and annual mass balance
- Water quality assessed by biological approach
- Monthly river discharge outlook

8. Infrastructure (Road and railway risk forecast)
- Road
  - ✓ Extreme events of snow storm and heavy snow
  - ✓ Disastrous events of snow storm and heavy snow
- Railway
  - ✓ Extreme events of snow storm, heavy snow, intensity rain and strong wind
  - ✓ Disastrous events of snow storm, heavy snow, intensity rain and strong wind

Figure 10.10 Main content of the platform for Climate Service System

All above mentioned information, products, and services are fundamentals of the CSS, which in turn helps to reduce risk of individuals and organizations, and increase resilience and adaptative capacity. Figure 10.11 shows the screenshort of the CSS web page with the user-interface-platform with 8 main categories of products.

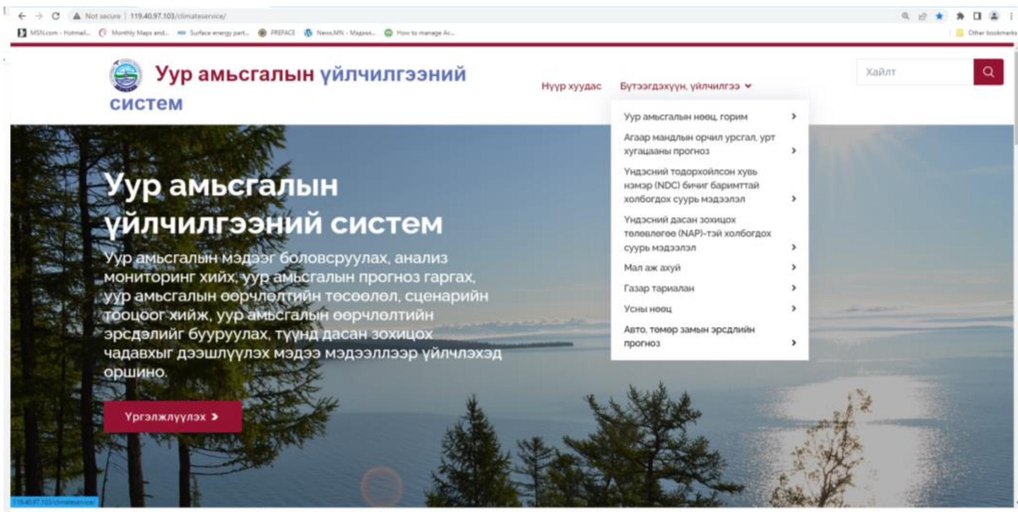


Figure 10.11 Web page of the CSS with main category of climate service product

10.2 Climate change considerations into social, economic, and environmental policies and actions

This section presents the efforts and changes have made in terms of climate change integration in policies and actions, technology transfer, research and systematic observation of climate change, education and awareness raising, and gender mainstreaming.

Development Policy Framework. Significant changes have been made in the legal and policy environment as the Parliament of Mongolia amended the Law on Development Policy and Planning and Management in 2020 to ensure the sustainability and correlation of development policy planning and implementation. The Law prescribes the framework structure for the national development policies – which shall consist of a single long-term policy, seven cross-sectoral mid-term (10 years) targeted programs, two of four- or five-year planning documents, and an annual action plan and budget; altogether there shall be twelve (12) types of national development policy documents adopted at the long-, mid-, and short-term. Figure 10.12 shows details of a new development policy structure in Mongolia.

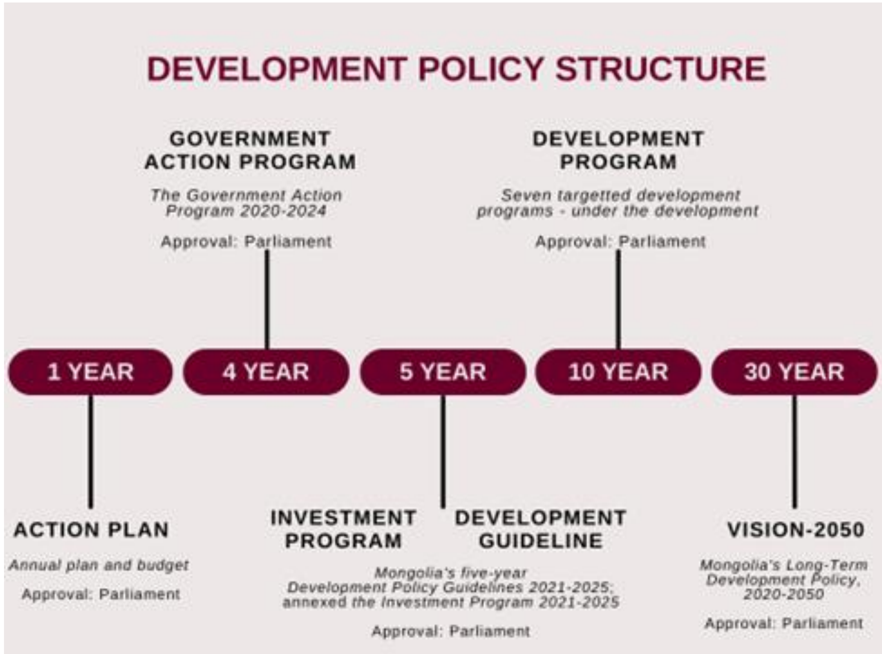


Figure 10.12 Mongolia's Development Policy Structure under the revised Law on Development Policy and Planning and Management (2020)

As illustrated in Figure 10.12, a long-term development policy for Mongolia has been adopted by the Parliament in June 2020 as the Vision-2050 (PoM, 2020a). Aligning with the Vision-2050, the Parliament approved the Action Plan of the Government of Mongolia for 2020-2024 (PoM, 2020b), and Mongolia's Five-Year Development Policy Guidelines for 2021-2025 in August 2020 (PoM, 2020c). However, mid-term development programs - targeted to (i) human development, (ii) social development, (iii) environment, (iv) governance, (v) regional development, (vi) economy and infrastructure development, (vii) national competitiveness capacity development program – are submitted to the Parliament as a package for its consideration; yet as the end of 2022 these development programs are not approved. However, as to build back better after dire socio-economic situations caused by the COVID-19 pandemic, the New Revival Policy (2021-2030) was adopted by the Parliament in December 2021(PoM, 2021).

In parallel to the development and adoption of new policies, many sectoral policies and programs are nulled due to the Law on Development Policy and Planning and Management (2020) e.g., Green Development Policy, State Policy on Energy, State Policy on Food and Agriculture, Mongolian Livestock National Program, State Policy on Forest, State Policy on Industry, State Policy on Disaster Prevention etc. Additionally, more than 50 laws identified for further amendments.

Moreover, the said law prescribes the expansion of an existing government structure establishing a new ministry, namely the Ministry of Economy and Development (MED), as in operation since 2022, to ensure the sustainable and inclusive economic development achieved over time in the country by implementing the Vision-2050.

Reflection of Climate Change in the Policy Documents. Green Development Policy (2014-2021) was Mongolia's first effort to make a transition toward a green economy – ensuring the environmentally sustainable and inclusive future development. Although it is nullified in 2021, the green development concept itself is embedded at a certain extent in Mongolia's development policies and actions including the Vision-2050 Policy, the Government Action Programme (PoM, 2020b), and a New Revival Policy of Mongolia (PoM, 2021), and of course in the Nationally Determined Contribution (NDC, 2019) and its Implementation Plan (NCC, 2021) etc.

In the following sections, the information on climate-related objectives embedded in the key development policies are presented.

The Vision-2050 (PoM, 2020a): The long-term policy, the Vision-2050 encloses of 9 fundamental goals, objectives, and milestones to be implemented in three phases (2021-2030, 2031-2040, 2041-2050). Its sixth goal focuses on green development as it states to *"Promote an environmentally friendly green development, maintain balance of ecosystem, ensure an environmental sustainability, create conditions for present and future generations to reap its benefits, and improve the quality of human life"*.

The four objectives defined under the Green Development goal, each having sub-objectives and milestones to be reached by phase by phase. The main objectives include:

i. Evaluate and protect the value and benefits of nature and maintain a balance of primary ecosystems;
ii. Rehabilitate natural resources, reduce scarcity, create productive resources, and pass them on to future generations;
iii. Prevent water scarcity, accumulate surface water, and create conditions to fully meet needs;
iv. Contribute to international efforts to mitigate climate change by developing a low emission, productive and inclusive green economy.

As indicated in objectives – both climate change adaptation and mitigation related targets and milestones are determined . For instance, the climate-neutrality target has been defined in the third phase (2041-2050), which determined as *"the period to continuously strengthen adaptation to climate change and improve sustainable production and consumption*" under the fourth objective of the green development goal.

Besides the objectives, sub-objectives and milestones outlined in the sixth or Green Development section of the Vision-2050, concepts of green technology, green cities, sustainable agriculture, efficient use of natural resources and energy are integrated into other sections – for example, under the Ulaanbaatar and Satellite Cities (Goal 9 of Vision-2050), it plans to support renewable energy generation by households for their use as well as supply to the grid to generate additional incomes, also to develop a resilient city which is fully prepared in terms of information sharing, communication and resource management in the event of natural disasters, climate change, potential disasters, and emergency. Another example is to enhance local disaster protection capacity and strengthen infrastructure to assess risks and plan against disasters, which is encompassed in the Safe and Safety Society (Goal 7 of Vision-2050).

Although to a certain extent, climate change related issues are addressed or integrated in the Vision-2050, there is a room for improvement – for instance there is a carbon neutrality target defined yet, no mitigation objectives in key emitting sector are defined; no mentioning of a low-carbon economic transition. In general, climate change has not been reflected in a comprehensive and systematic way to impose obligations on the emitting sectors; all targets are listed under a green development objective as defined as only environmental sector problems will not solve many of challenges and barriers in mitigating GHG emissions as well as the current poor interdisciplinary coordination, multilateral cooperation, and mobilizing finance.

The Government Action Plan, (PoM, 2020b): The Government Action Plan (GAP) lays out actions to be implemented by the government in years of 2020 to 2024. Given the challenges brought by the COVID-19 pandemic, the Government put forward actions to recover from post COVID-19 socioeconomic challenges, ensure the environmental balance, and strengthen the governance and local development. The GAP covers six main areas – (i) policy on recovery from the post COVID-19 economic and social setbacks, (ii) policy on human development, (iii) policy on economic development, (iv) policy on governance, (v) policy on green development, and (vi) policy on the development of cities and local administrative units.

Within its green development scope, following 12 targets set forth for implementation until 2024 those include:

i. Reduce the Ulaanbaatar's air pollution by 80%;
ii. Conduct a comprehensive risk assessment on ecosystem pollution on the Khuvsgul Lake;
iii. Ensure the freshwater supply in the Ulaanbaatar through the utilization of recycled and greywater in industries;
iv. Reduce soil pollution by introducing eco-toilets in ger areas as well as campsites;
v. Establish the policy environment to incentivize or reward the citizens and companies those planted trees contributing towards the target to increase the forest area to 8.6 percent;
vi. Expand the state protection of freshwater resources and watershed areas;
vii. Create the utilization resources of endangered plants and animals through breeding;
viii. Rehabilitate 8 thousand hectares of land which degraded and left from mining operations;
ix. Support environmentally friendly, resource-efficient industries, and build the waster-to-energy and hazardous waste recycling plants;
x. Increase the water level of the Tuul river basin by prohibiting mining activities and rehabilitating the basin areas;

xi. Conduct the technical, economic, and environmental feasibility assessments of the "Blue Horse" project in Orkhon-Ongi and Kherlen-Toonot areas to create the nature-based water reservation systems using surface, rain, and snow water; start the construction works.

xii. Reduce the country's GHG emissions by 12.3% by 2024 compared to the BAU in 2010 through the implementation of mitigation and adaptation actions and measures.

The later GHG emission reduction target is to be achieved through the implementation of eight actions i.e., enhancing the climate change legal environment, implementation of Mongolia's NDC to the Paris Agreement, increasing the green finance, identification, and implementation of mitigation measures in construction sector, strengthening the early warning systems, and hydro-meteorological stations.

Importantly, these actions and measures to be implemented through the annual action plan and budget as approved by the Parliament; however as of 2022 – there is no budget allocation for actions towards reducing GHG emissions as referred in the Government Action Programme.

The New Revival Policy (PoM, 2021): The New Revival Policy 2021-2030 (PoM, 2021) is a midterm development policy aimed at strengthening the economic independence, minimizing adverse socioeconomic impacts of the COVID-19, laying the foundation for the successful implementation of Vision-2050, and strengthening economic, infrastructure, and government productivity for the next 10 years. The policy emphasizes public-private partnerships and foreign investors as the foundation for addressing six critical issues, which hinder the country's development. It targets to increase the economic growth by an average of 6 percent, GDP per capita by 2 percent, the labor force participation rate to 65 percent; expansion of ports by three times, and energy generation capacity by twice in the next ten years. The six main areas include:

i. Port Revival
ii. Energy Revival
iii. Industrial Revival
iv. City and Provincial Revival
v. Green Development Revival
vi. Government Productivity Revival

Within its Green Development Revival, four objectives are set forth, and are:

- Create enabling environment for the successful implementation of a Billion Tree Campaign to contribute towards mitigating climate change;
- Conserve water resources, ensure the sufficient and safe drinking water supply, increase water supply for Gobi regions, create the water reservoirs and ponds, utilize the greywater, and rehabilitate dried rivers, springs, and streams;
- Establish the solid waste recycling facilities for regions and cities based on the advanced and environmentally sound technologies;

- Determine the green development models and principles by integrating the traditional environmental approaches in the economic and industrial revival policy implementation.

In the broader context, the expansion of operations and further development of emitting sectors are reflected in the New Revival Policy such as expanding the operations of such as construction or expansion of several coal-fired thermal and power plants, transmission networks, transportation systems, and developing mining and agricultural production. When determining and implementing development objectives of emitting yet economically priority sectors, the important principles, or requirements such as assessing GHG emissions, introducing optimal and advanced technologies to ensure the achievement of climate change and sustainable development goals, are not fully reflected in the New Revival Policy. Hence, there is a risk of increased economy wide GHG emissions due to the implementation of the New Revival Policy.

Nationally Determined Contribution (NDC, 2019) and its Implementation Plan (2021): The Parliament of Mongolia ratified the Paris Agreement (PA) in 2016, confirming to take both adaptation and mitigation actions and measures. The PA's implementing instrument – NDCs or actions and measures – shall be defined, implemented, and updated by all parties every five years from 2020. Under the UNFCCC and the goals outlined by the PA, Mongolia puts forward the GHG emission reductions target in its Intended Nationally Determined Contribution (INDC, 2015) of 2015, and later upgraded Nationally Determined Contribution of 2019 (NDC, 2019). Both INDC and NDC have approved at the Government level.

As the Paris Agreement calls upon all Parties to prepare an updated NDC by 2020, Mongolia has enhanced its mitigation commitments of reducing GHG emissions by 14% in the INDC (INDC, 2015) to 22.7% in NDC (NDC, 2019) (excluding LULUCF) below the business as usual scenario by 2030. The existing or Mongolia's NDC (2020) target is equivalent to an annual reduction of approximately 16.9 $MtCO_2e$ of economy-wide emissions. Mongolia's NDC outlined a series of both mitigation and adaptation related policies and measures that the country has committed to implementing through 2030 in energy production, energy consumption (transportation, construction, industry), agriculture, industrial processes, waste and forest sectors. In addition to the unconditional efforts, Mongolia's NDC identified conditional measures e.g., carbon capture and storage and waste-to-energy technology, as well as the carbon removal potential in the forest sector. If these additional measures are implemented, the total GHG reduction target could reach 44.9% by 2030, compared to the BAU baseline of 2010. In addition to the identified mitigation and adaptation policies and measures, the Government of Mongolia included the initial estimation of climate finance needed for its NDC implementation – as of USD 11.5 billion.

Furthermore, Minister of Environment and Tourism approved NDC Implementation Action Plan or Strategy in 2021 as a roadmap to guide various actors across ministries, institutions, and territories towards the achievement of climate goals. In the framework of the NDC Implementation Strategy, the government has identified several short-term needs and enabling conditions to translate Mongolia's NDC goals into actions at the national and subnational level. Some of these requirements are being incurred by the government but others need financial support from external sources such as private and international funds. Besides the international support and projects – the NDC related actions have not been implemented, nor well coordinated, nor financially supported by the budget due to various reasons i.e., government instability, high turnover of government officers, limited budget, insufficient reflection of NDC related actions in the annual Government workplan and budget.

The Sustainable Finance Roadmap (2022): The sustainable finance principles aligned with IFC's Environmental, and Social Performance Standards have been voluntarily adopted by Mongolian commercial banks since 2013, as supported by the Mongolian Bankers Association (MBA). Later in 2017, Mongolia's Sustainable Finance Association NGO (MSFA) has established as an affiliate of the MBA and has been supporting the financial sector to adopt policies and practices, and build capacities to transition towards sustainable, green, and climate finance. To increase green finance in the country, in 2019, Mongolia's first Green Taxonomy was developed by the MSFA as supported by international partners and approved by a joint decision of the Financial Stability Board and the Bank of Mongolia (BoM). Consequently, in 2020, the BoM approved a regulation mandating commercial banks to report their green finance issuance by the Mongolian Green Taxonomy. As per an integrated report by the BoM, 306.7 billion MNT (approximately USD 88.2 million[11]) of green loans have issued by commercial banks at the end of 2021 in Mongolia. Unfortunately, compared to the need for climate finance as estimated in Mongolia's NDC as USD 11.5 Billion, commercial green finance cannot even make up 1% (approximately 0.8%) of the climate finance needed in Mongolia. In parallel, to enable the concessional financial sources, the Government of Mongolia and commercial banks jointly developed a project to establish the national green finance vehicle, the Mongolian Green Finance Corporation, (MGFC), and submitted it to the Green Climate Fund, which was successfully approved in 2020. However, the project has not been implemented yet. Once the MGFC is operationalized, 'wholesale' financing for commercial banks in the field of energy efficiency would be enabled – but the question remains as 'the level of readiness of companies and citizens in taking up the energy efficiency finance. Given the scale of sustainable and green finance in Mongolia, stakeholders acknowledge the clear need to accelerate fund mobilization for mitigating climate-related financial risks and achieving sustainable development goals. Thus, the financial sector actors jointly developed and approved the Sustainable Finance Roadmap for 2022-2030 on March 29, 2022.

The Sustainable Finance Roadmap has an objective to create an integrated and multi-stakeholder-based sustainable finance system by 2030 which aligned with the country's sustainable development and climate agendas. It defined the six main goals and 25 actions to achieve its objective. The goals are:

i. Enable the infrastructure and policy framework for sustainable finance – including the strategy, governance, taxonomy, training and monitoring, and evaluation systems;

[11] Based on a rate of January 20, 2023 ($1 = 3475.56 MNT), the Bank of Mongolia.

ii. Create the direct budgetary and fiscal measures on sustainable and green finance – including green expenditure, procurement, environmental tax, etc.;
iii. Increase the capital flows – through lending, bond, insurance, etc.;
iv. Strengthen the national green financial institutions – such as the Mongolian Green Finance Corporation and other state-owned institutions.
v. Strengthen the ESG and Climate-risk management systems – such as climate scenario, risk analysis, GHG accounting, target-setting, etc.;
vi. Promote transparency and disclosure – including sustainability and ESG reporting.

Yet, due to the voluntary nature of sustainable and green finance works in the financial sector and without the strong legal foundation to must adopt ESG policies, reduce GHG emissions, and report transparently – uncertainties remain in the implementation of the Sustainable Finance Roadmap, its alignment with the NDC, and multi-stakeholder coordination.

10.2.1 Environmentally Sound Technologies (ESTs) Development and Transfer

The article 4.5 of the UNFCCC promotes the development and transfer of ESTs from developed to developing states, including the enhancement of endogenous capacities and technologies of developing countries, to realize the global climate change objectives.

As defined by the UNFCCC, the environmentally sound technologies are less polluting, better environmental performance relative to old technologies, use resources in sustainable manner, recycle more of their waste and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. Also, ESTs are not only individual technologies, rather defined as total systems that include know-how, procedures, goods and services, and equipment, as well as organizational and managerial procedures for promoting the environmental sustainability.

In these efforts, Mongolia has engaged in bilateral and multilateral cooperation while, enhancing its legal and policy frameworks in support of technology transfers. For instance, through Mongolia-Japan Joint Crediting Mechanism, solar energy, and energy efficient technologies (electricity transmission and heat-only boilers) are successfully transferred and being maintained; through the Green Climate Fund's support the National Agency for Meteorology and Environmental Monitoring is being equipped with a high-performance computer for analysis and forecasting of climate change in Mongolia. Moreover, the commercial banks issue green loans for energy efficiency and renewable energy technologies.

Regards to the institutional arrangement, stakeholders' roles and responsibilities are mandated by laws listed in the Table 10.2. There are the National Council on Science and Technology as an independent advisory group, followed by the Ministry of the Education and Science (MES), and the Ministry Environment of Tourism (MET) coordinate the technology development and transfer related cooperation with multi-stakeholders. Within the MET, the dedicated division on Innovation and Clean Technology has established acknowledging the importance of innovation and environmentally technologies for the country's green development. Other ministries e.g., the Ministry of Energy, the Ministry of Mining and Heavy Industry, the Ministry of Food, Agriculture and Light Industry, the Ministry of Construction and Urban Development, the Ministry of Road and Transportation Development are equally important in introducing the innovation and clean technologies in the sectors.

The Ministry of Environment and Tourism has been organizing an annual exhibition on Green Technology since 2013 in collaboration with the multi-stakeholders; through this platform policies, actions, as well as challenges are discussed, and technology developers and importers show-case their products such as energy-efficient electric heaters, ger insulation, eco-toilets, and waste recycling etc.

The number of policies put in place to promote and incentivise the ESTs transfer e.g., the list of ESTs (Annex 1) from tax exemptions, rewarding or recognition of individuals and entities with green certificates. The Environment Information Center (EIC) of the IRIMHE collects and publishes the information on environmentally friendly technologies in Mongolia through its website, www.eic.mn. A full list of ESTs is in the Annex 1, which comprises of 262 technologies with majorities of them are the renewable energy, air pollution, water, and waste treatment technologies – reflecting the environmental issues of the country.

Table 10.2 presents the existing laws and regulations for the support on environmentally sound technologies.

Table 10.2 Laws and regulations support the environmentally sound technologies

№	Policy documents	Type of legislation, adopted year	Related provision of			
			Technology development	Technology transfer	Promote investment in clean technology, leverage tax, credits	Incentives to the citizen, private sector of the introduction of ESTs
1	Law on Environmental Protection	Law, Act Adopted in 1995-03-30	-	-	-	+
2	Law on Technology Transfer	Law, Act Adopted on 1998-05-07	-	+	-	-
3	Law on Science and Technology					
4	Law on Innovation	Law, Act Adopted on 2012-05-22	+	+	+	+
5	List of Tax Exempted (Customs and VAT) Renewable Energy Technologies	Government Resolution, Adopted in 2016-04-04	+	+	+	-

6	Procedure on recognition of citizens, businesses, and entities introduced environmentally sound and advanced technic, technologies, and methods	Procedure, Adopted in 2017-09-27	-	-	-	+
7	List of environmentally sound technologies – which use natural resources efficiently and reduce pollutions	Government Resolution, adopted in 2013, and updated on 2019-12-25	-	+	+	-
8	Mongolia's National Determined Contribution	Government Resolution, Adopted in 2019-11	-	+	-	-
9	"Vision 2050" Long Term Development Policy of Mongolia	Parliament, Adopted in 2020-05-13	+	+	+	-
Total provisions		9	3	6	4	3

+ reflected

- not reflected

Regards to climate-specific technologies, Technology Needs Assessment (TNA, 2013) has been conducted in 2013. The TNA aims to identify clean technologies that are best suited for climate change mitigation and adaptation to facilitate a smooth transfer of the selected technologies. Also, Mongolia's Third National Communication (TNC, 2018) to the UNFCCC, includes the adaptation technologies needs for reducing vulnerability and risks. With the limited knowledge and know-hows of public and private sectors, these climate technology needs assessments serve as a practical guide. Hence, the climate technologies assessments shall be updated in the context of Mongolia's Nationally Determined Contributions, and ongoing National Adaptation Plan.

10.2.2 Climate change education and awareness raising

Context. The Article 6 of the UNFCCC and Article 12 of the Paris Agreement are directed at reducing negative impacts of climate change by adopting Action for Climate Empowerment (ACE) agenda call on governments to educate, empower and engage all stakeholders and major groups on policies and actions relating to climate change. The ACE aims to empower all member of society to engage in climate action through six focus areas which are education, training, public awareness, public participation, public access to information, and international cooperation on these issues. Currently, the MET is leading the preparation process of the ACE agenda in the country in collaboration with the MES and other stakeholders.

With the emphasis on education being the key aspect for the sustainable development, the Government of Mongolia with the support of Swiss Agency for Development and Cooperation (SDC) implemented "Education for Sustainable Development" project between 2013 to 2018 to integrate the sustainable development principles into the national education systems and frameworks. With the support of this project, the Government of Mongolia adopted the National Program on Education for Sustainable Development (ESD, 2018-2022) which aims at educating the public on nature conservation, preservation of culture, history and heritage, climate change, environmentally friendly, resource efficient culture, healthy lifestyles. To support the implementation of the National Program on ESD, the second phase of the ESD project by the SDC is being implemented. As a result of ESD project phase one, the secondary education curriculum is reformed integrating the SD principles while engaging 19,249 teachers and 147,031 students nationwide (GoM, 2018). And numbers of journalists and media specialists (over 200) nationwide are trained on effective communication and dissemination of information on the sustainable development. Throughout the second phase of ESD project, on-the-job trainings and practical tools for teachers and local authorities are being provided (GoM, 2018).

Furthermore, in 2020 the Minister of Education and Science approved the Educational Sector Mid-term Development Plan for 2021-2030 (MES), which aims at developing the education sector aligning with the country's mid-long-term development policies. This plan embedded the green development as one of the fundamental principles for the sectoral development (Figure 10.13).

Figure 10.13 Principles of Education Sector Mid-term Development Plan, Ministry of Education and Science, 2020

In 2019, the UNICEF in Mongolia has analysed the impact of climate change on education sector in collaboration with the MES, and found the impacts including 'the reduced access to education especially in the harsh, cold winters when roads are impassable or too dangerous, and after flash floods when roads are destroyed – as well as missing school or dropping out of school due to health complications (particularly in winter) (MES, 2019). It further adversely affect the learning outcomes as a study highlighted. Schools in the provinces or micro-administrative units have insufficient access to water and sanitation facilities, energy, and food which, were highlighted as important issues that affect students' well-being during climate-related disasters. Further the study recommends the four priority policy measures to be taken in enhancing climate change education and resiliency of education sector, and those are:

1. *Enhancing data and improving the evidence base for decision making* – incorporating environment and climate indicators in the education sector information system and conduct education sector specific vulnerability and risk assessments.
2. *Increase strategies to ensure continued education under a climate-related disasters* – building climate resilient education facilities, and creating alternative education modalities such as mobile ger schools and distance learning etc.
3. *Improve learning to address climate change impacts* – updating national curriculum reflecting the climate science and ensuring the children as the agents for change.
4. *Strengthen the systems* – preparing the teachers, school staff and authorities, ensuring climate sensitive education planning, and enhancing collaboration with relevant agencies, and increase the access to finance.

According to the "Coping with Climate shocks in Mongolia" household panel survey (NSO, 2015), the dzud impacts on children and households accessed and concluded the similar results of the UNICEP study. For example, the dzud reduces the access to education of children from herders' households, furthermore during the dzud children of pre-school age are more strongly affected than those of school ages, and herders' households in remote areas more strongly affected than households in district and province centers.

Considering the adverse impacts of climate change on children and herders' families, much more efforts shall be given in awareness raising and building capacities of these vulnerable groups. Indeed, climate change education is the key component of the sustainable development education. The climate change policy implementation would be effective and successful with the capacitated and educated people throughout the country.

Nevertheless, in the past efforts are being taken in areas of climate change education and awareness raising in formal and non-formal education sectors – yet some initiatives are not implemented sustainably nor synergized nor aligned with existing programs due to unsustainable governance system and turnovers.

As introduced in the following sections, it can be concluded that climate change is not fully integrated into the education sector i.e., formal, non-formal and higher education programmes to the extent to drive the transformational change needed to achieve a low-carbon and climate resilient development.

But an overall concept on causes of climate change, sources of greenhouse gases, impacts of climate change etc. are integrated in educational curriculums – as presented in a formal education section below.

Formal general education. Climate change education for sustainable development is quite a new concept in Mongolia which is education for sustainable development was initially discussed in policy level documents since 1997. And the country has been starting point of integrating the related concepts into the education system. But ecological policy and ecological education issues are strongly based on biological science perspectives in Mongolia, and climate change education for addressing sustainable development issues is still not declared at the official policy level (Navchaa T., 2018). However, in 2019, the minister of education, culture, science and sports approved the curriculum for primary, middle and high school students by Order A/492 on "Approval of the Program". In addition, the minister also approved the curriculum for pre-school education with Order of A/494 on "Approval of the Program". Those approved orders are reflecting the concepts of sustainable development education, climate change, and green development policy (MET, 2020).

On that account, the textbooks are often come to drive the curriculum. Therefore, reviewing the primary and secondary school's textbooks will show the result of how the curriculum included sustainable development and climate change education. The Table 10.4 illustrates consolidated textbook's content of climate change, environment, ecosystem, and sustainable development. From primary level to upper secondary level there is 30 curriculum of natural science subject. Six of them citated the environment, ecosystem, pollutions, and sustainable development. Four of them specified the climate change issue, that are the geography 7th, 8th, 10th and 11th textbooks. In 12th grade, there is no related textbook of nature and science and other specific classes. Apart from the main courses, students select their curriculum based on their future path in Mongolia.

Table 10.3 Climate change curriculum in primary, secondary schools

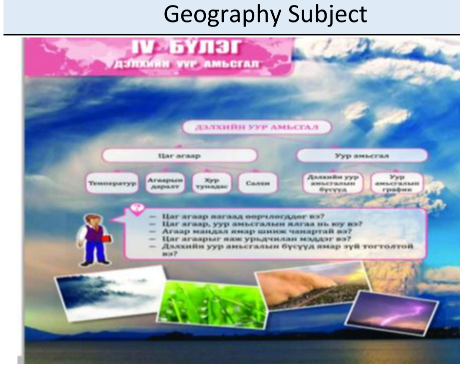
Subjects	Level	Curriculum by grades	Textbooks	Climate change, environment, ecosystem, sustainable development	Published year
Human and Nature	Primary	Human and Nature 1	Human and Nature I	-	2019
		Human and Nature 2	Human and Nature II	-	2019
		Human and Nature 3	Human and Nature III	+	2019
		Human and Nature 4	Human and Nature IV	+	2019
		Human and Nature 5	Human and Nature V	-	2019
Natural science	Lower Secondary	Natural science 6	Natural science VI	-	2019
Physics	Lower Secondary	Physics 7	Physics VII	-	2019
		Physics 8	Physics VIII	-	2019

		Physics 9	Physics IX	-	2019
	Upper Secondary	Physics 10	Physics X	-	2019
		Physics 11	Physics XI	-	2019
		Physics 12			
Biology	Lower Secondary	Biology 7	Biology VII	-	2019
		Biology 8	Biology VIII	-	2019
		Biology 9	Biology IX	+	2019
	Upper Secondary	Biology 10	Biology X	-	2019
		Biology 11	Biology XI	-	2019
		Biology 12			
Chemistry 2	Lower Secondary	Chemistry 7	Chemistry VII	-	2019
		Chemistry 8	Chemistry VIII	+	2019
		Chemistry 9	Chemistry IX	+	2019
	Upper Secondary	Chemistry 10	Chemistry X	-	2019
		Chemistry 11	Chemistry XI	-	2019
		Chemistry 12			
Geography	Lower Secondary	Geography 7	Geography VII	+++	2019
		Geography 8	Geography VIII	+++	2019
		Geography 9	Geography IX	+	2019
	Upper Secondary	Geography 10	Geography X	+++	2018
		Geography 11	Geography XI	+++	2019
		Geography 12			

- *Not reflected*
+ *Citated the subject of environment pollution etc.*
+++ *Specified climate change*

While recognizing the importance of content-specific concepts such as ecology, we do not see education is response to climate change as simply the provision of new curriculum inputs, rather the challenges of climate change require all concerned to look to fundamentals and examine the degree to which existing educational provision is adapted to and prepares people for radically different.

Table 10.4 Climate change related contents included in the geography textbooks, 7-11th Grades

Geography Subject	Syllabus Content
 **7th grade**	Includes observing and measuring weather, comparing climate differences between areas using climate maps, diagrams, and other information, providing examples of contributing to mitigating the effects of climate change

 **8th grade**	Covers climate change of Mongolia such as the characteristics of Mongolia's climate, factors, and geographical distribution of climate elements.
 **9th grade**	Comprises of the sustainable development concepts
 **10th and 11th grades**	Changing climate and how individual can contribute to the mitigation and adaptation actions.

Non-formal general education. In Mongolia, a non-formal education sector is introduced since early 1990s and regulated by the Law on Education (terminated). As to develop the non-formal education sector, the life-long learning centers are established at provinces, cities, and districts. These centers provide training on the following areas: (i) communication and ethics, (ii) family and health, (iii) civil rights and politics, (iv) culture and beauty, (v) art of living, and (vi) science.

In 2019, the UNESCO conducted the education policy review and baseline studies in collaboration with the Mongolian Institute for Educational Research, and some national experts. These studies recommended that the lifelong learning centers can play a much stronger role in promoting green and sustainable economy, protecting herders' livelihood, and promoting equality (UNESCO, 2019). Further, emphasized that learning areas shall be expanded incorporating concepts of sustainable development, climate change, water and energy efficiency, and household finance etc (Batchuluun Y., 2019). Following the recommendations, the promotion of green development through the Lifelong Learning Centers included in the Education Sector Mid-term Development Plan (2021-2030) approved by the order A/96 of Minister of Education and Science in October 2020 (MES, 2020).

Eco School Program. Eco school program enables the pre-schools, secondary schools and colleges to reduce their environmental impacts and adopt the sustainable practices through the implementation of ISO 14001 environmental management system. The International Eco School Program has first introduced in Mongolian secondary schools in 2007 through the support of Swiss Agency for Development and Cooperation (SDC). Over the years, the Program has expanded covering not only the secondary schools, but kindergartens and colleges as nationwide activities and supports are facilitated by the national operator of the International Eco School Program – the Information and Training Center for Nature and Environment NGO (https://www.feemongolia.mn/). As of 2021, nationwide 335 secondary schools, 189 kindergartens and 6 colleges are registered in the program and being implemented the ISO 14001 environmental management system, which aims at promoting an environmental-friendly lifestyle.

The main purpose of the Eco-School programme is to educate and empower young people to make positive decisions and become change makers for the environmentally sustainable world. The Eco School programme provides three rewards to the schools based on their excellency of environmental activities – as ranked from a lowest to the highest, are:

- Bronze Award
- Silver Award
- Green Flag Award

To achieve the highest award, Green Flag Award, schools/kindergartens shall work through the Seven Step Framework which designed as a simple environmental management system (ISO 14001): forming high-level committee comprises of school management team, students and or parents, review of existing situations identifying baselines, develop actions and plans, continuous monitoring and implementation, education awareness raising, and evaluate the results. Some schools have received support in implementing environmental actions and plans such as the Education for Sustainable Development Project.

The school No.122 located in Takhilt, the outer skirt town of Ulaanbaatar is one of good examples of eco schools in the country; in 2019 a ground-source heat pumps installed at the school (as supported by the National Committee on Reducing Air and Environmental Pollution), as its result school's heating costs lowered by 2.7 times, while a warm and comfortable environment created for students and teachers. Although this is not a specialized school, the school enables children with disabilities to attend for reducing disparities among children. Moreover, with the support of partners i.e., Education for Sustainable Development Project, "Incubator for Children's Development" or a specialized cabinet was created to nurture creativity while enabling the supportive environment to study.

Green Passport. In 2018, under the leadership of Minister of Environment and Tourism, "Green Passport" national campaign launched and implemented with the motto of changing our perspective. The champaign aimed to empower the youth and future generations towards adopting nature and environmentally conscious habits, actions, and attitude to live green. The passport has 12 pages with different content such as water, waste, green environment, traditional methods of natural conservation. The pupils or anyone with Green Passport, should keep records on this passport and use it as a tool for leading and educating others including family members and friends in green lifestyle and natural conservation.

Through the campaign, 148,500 pupils or 24.7% of the total number of secondary schools' students from 543 secondary schools nationwide are owned their Green Passports. Students engaged in 11 national level convention, and over 19,000 students' increased their capacities in participating the training events. As its result in 2019 – 1.6 million litre water and 8 million kW energy saved, seedlings planted in 33.4 thousand ha area, and 1.7 ton batteries collected. Furthermore, "Green Passport – Green Grove" were created in 21 provinces, and 9 districts of Ulaanbaatar – each covers 3.5 ha totalling to 105 ha of area.

Unfortunately, due to the change of government in 2020, the Green Passport campaign has become barely active or no leadership or support provided from the government side.

Youth Parliament. Another initiative was the Youth Parliament of Mongolia, which launched in 2021 under the support of the Parliament's subcommittee on Sustainable Development Goals and the United Nations Resident Coordinator Office in Mongolia (https://www.pressreader.com/mongolia/the-ub-post/20211004/281556588990641). The Parliament selection was open for students in 9-11th grades, and 76 children from 21 provinces and nine districts of Ulaanbaatar were selected. Its aim is to increase the awareness of youth on democracy, human rights, freedoms, legislation, and decision-making. Through training and events, the Parliament is to promote the sustainable development goals, climate change, children's health, and nutrition intake for more inclusive, environmentally friendly, and socially oriented changes throughout the country.

Other initiatives and programs. The Zorig Foundation, a local NGO established in 1998, offers short-term programs for high-school students, university students, young leaders, and professional nationwide such as Mongolia's Youth Scientists, the Rural Environmental Leadership Programme, the Environmental Fellowship Programme, and Young Leadership Program (https://zorigsan.mn/). These programmes engage young leaders from variety of sectors and collectively work on addressing the main challenges including climate change of the country and offer the opportunities to pilot their solutions at the small scale.

The Future Energy Leaders – Mongolia Programme is another initiative of the World Energy Council Mongolia National Committee (http://mongolenergyclub.com/), which aims to prepare young professionals in the energy sector to become leaders of tomorrow by developing their capacities. The programme selects energy professional on competitive basis and provides a year-long comprehensive learning opportunities via in-class and field visits; climate change, low-carbon energy, and energy transition, innovative technologies are the topic covered.

Higher education. As of 2021, there are 37 universities, 48 institute, and 3 colleges in Mongolia (meds.gov.mn). In recent years there has been significant decrease in the number of students in the areas of environmental studies. For comparison, in the year of 2008-2009 the number of students studying in these specialties in universities was 10,900 while in the year of 2018-2019, this number reduced to 4,200 students (NSO, 2019).

Researchers and experts on climate studies are trained by the National University of Mongolia (NUM) in Ulaanbaatar, and School of Agro ecology and Business of the Mongolian University of Life Sciences (MULS) branch in Darkhan-Uul province. Both universities offer meteorology and climate change courses, and master-level programs on climate change research. As per the NUM, it has a long-standing bachelor and master-level programs on meteorology which were introduced in 1962; later in 2018 the NUM developed and approved the bachelor's program on climate change but discontinued due to a lack of enrollment. In 2022, the NUM newly introduced 3-credit course on Climate Change Adaptation as one of core courses in environmental science degree; the program development is supported by the National Adaptation Planning project by MET, GCF and UN Environment.

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" started in 2015, 2 credits or 16 hours of lecture in a 32-hour seminar on environmental education at a bachelor-level are offered at the University of Education.

In general, there is a limited number of higher-education programs on climate change available – at the same time the interest of students in studying climate change remains low. Thus, a great attention shall be given in increasing awareness among high-school graduates and university students on climate change – providing details on a vast research area for climate change and socio-economic sectors, climate job trends, and future career outlooks etc. On the other hand, the innovative advanced degree

– master and doctoral level – programs to be developed by linking impacts of climate change and challenges in addressing climate change with various other majors such as climate change in public health, finance, international relations, public policy, architecture, engineering, and tourism etc. Since climate change is cross-sectoral subject, all higher education majors could integrate climate change elements in the field of study.

10.2.3 Information sharing, and networking

The government of Mongolia has given importance to the information sharing, networking, and public awareness on environmental protection, green development, and climate change.

The central government administration authority responsible for climate change information and knowledge sharing and networking is the MET and its agencies, namely:

- National Agency for Meteorology and Environment Monitoring (NAMEM)
- Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE),
- Environmental Information Center (EIC).

Additionally, the MET developed a platform on the NDC, https://ndc.mne.gov.mn/, to inform stakeholders, engage in the implementation, and track the progress towards NDCs.

Another information sharing agency is the Climate Change Research and Cooperation Center (CCRCC), which distributes the information on the national GHG inventory, the national climate change reports, and the GCF-funded projects and programmes through their website, http://www.ccrcc.mn/. The information on Mongolia-Japan Joint Crediting Mechanism and its projects are shared through https://www.jcm-mongolia.com/. The CCRCC also works toward promoting a public awareness on climate change as it creates several podcasts covering sub-themes within climate change.

With the support of GCF Readiness and Preparatory support, the government of Mongolia aims to introduce the climate services system via http://climate-service.mn/climateservice/ under the IRIMHE.

Also, the MET organizes an annual environmental open day engaging line ministries, agencies, NGOs, CSOs, private companies, and international partners' which are implementing environmental and climate projects and activities. The open day event gives opportunities to present the works, share information and network among stakeholders. Besides the environmental open day, the government utilizes the international environmental days e.g., Earth Day, Earth Hour, Forest, Water, Biodiversity, Meteorological Days, to raise the public awareness on environmental protection.

The national and sectoral conferences and workshops such as NDC Forum by the MET, Sustainable Finance Forum by the Mongolian Sustainable Finance Association, Renewable Energy Forum by the Mongolian Renewables Industries Association, and events organized by the projects and programmes have become another important platform to share information and network among multi-stakeholders.

As commercial banks introduced their green financial products into the market, the awareness of private companies and consumers about products and technologies that are environmentally sound and reduces GHG emissions has increased steadily. Even the Bloomberg TV Mongolia launched the Sustainability Award among the leading companies.

The formal media and social media or Facebook’s coverages on climate change are relatively increasing – NDCs, Paris Agreement, and the importance of forestation activities etc., are being introduced and promoted through the TV channels. A few Facebook pages dedicated for climate change education run by the CCRCC, NGOs, and individuals.

10.2.4 Gender-responsive climate change

Upon the recognition of climate change as a gender-differed issue, the UNFCCC first adopted the Lima Work Programme on Gender (LWPG) was adopted in 2014 (Decision 18/CP.20). Later the LWPG was extended with Gender Action Plan (GAP) adopted in 2017, which reviewed and further enhanced at the COP25 in 2019 as 5-year Enhanced Lima Work Program on Gender, and Gender Action Plan (2019-2024). The UNFCCC decision *“recognizes that the full, meaningful and equal participation and leadership of women in all aspects of the UNFCCC process and in national and local-level climate policy and action is vital for achieving long-term climate goals” and states that “gender-responsive implementation and means of implementation of climate policy and action can enable Parties to raise ambition” (UNFCCC, 2020).*

Mongolia, as one of few countries that have reached a medium level of gender equity, performs well in gender equity global rankings such as the World Economic Forum’s 2021 Gender Gap Index with a score of 0.716 (69^{th} out of 156 countries) (WEF, 2021). As shown in Figure 10.14, Mongolia ranks first in the world for gender parity in “health and survival,” 23^{rd} for “economic participation and opportunity,” and 73^{rd} for “educational attainment,” but only 116^{th} for “political empowerment” (WEF, 2021).

	2006 score		2021 score	
Global Gender Gap Index	**42**	**0.682**	**69**	**0.716**
Economic participation and opportunity	21	0.704	23	0.769
Educational attainment	20	0.999	73	0.993
Health and survival	1	0.980	1	0.980
Political empowerment	101	0.046	116	0.122

Figure 10.14 Mongolia Country Score, Global Gender Gap Index, World Economic Forum, 2021

Like any other socio-economic matters, climate change impacts on women and men differ, so do their contributions in addressing climate change considering differing roles within households and 40% of livelihood is dependent on pasture-based agriculture and livestock farming which is highly vulnerable to climate change etc. During the 2010 dzud, 217,000 households or 769,000 individuals (28% of the population) were affected; of those affected, 43,555 households lost their entire herd; an additional 163,780 households lost at least half (SCM, 2016). This caused many herder families to migrate to neighboring provinces or capital cities, where they experienced challenges and had issues accessing basic services such as health care, transportation, and education. According to 2020 statistics, 124,300 female herders were registered nationwide (NSO, 2020). Women, children, and the elderly were identified particularly vulnerable during dzud. Due to dzud and extreme road conditions, most rural hospitals are not able to reach herders to conduct prevention check-ups – particularly for pregnant women, newly born infants, and elderly people – or respond to emergency calls, etc. During the dzud of 2016, a total of 965,000 people – mostly herders – were affected and faced devastating cold and snowstorms, lost livestock, and experienced food insecurity; 5,019 expectant women, 20,874 children aged under five years, 6,117 people with disabilities, and 4,173 households living below the national poverty line were among the affected populations (IFoRC, 2016). Furthermore, women and girls experience limited access to sexual and reproductive health supplies and care and increased vulnerability to gender-based violence.

Regards to the legal frameworks, Mongolia is highly committed as the concepts on prohibiting discrimination and ensuring gender equality are embedded in the Constitution of Mongolia as well as the Law on the Promotion of Gender Equality (LPGE), and the National Programme on Gender Equality (NPGE). The LPGE further enabled the development of 11 gender responsive sector strategies – including the Population, Labor and Social Protection Sector Strategy; the Food, Agriculture, and Light Industry Sector Strategy; and the Environmental Sector Strategy; all of which are explicit in the promotion of gender equality and non-discrimination (https://www.ncge.gov.mn/legals/42). The implementation of are being coordinated and facilitated by the National Committee on Gender, and its Secretariat under the supervision of the Prime Minister.

While the LPGE and NPGE serve as a gender responsive legal and policy frameworks, it is found that the sector laws and policies that affect women's resilience to climate change and disasters in Mongolia are not yet gender mainstreamed as referred in the Women's Resilience in Mongolia (ADB, 2022). Sectoral laws and policies on disaster risk management, energy, environment, including its NDC do not explicitly mention gender equality or commitments. However, gender assessments and actions are undertaken as a part of the internationally financed climate and development projects/programmes – thus at a certain level, the local capacities and stakeholders' knowledge on gender-responsive climate actions seem to be gradually increasing.

Although there are limited studies and sex-disaggregated data exist in the country, the existing data as well as the gender-related legal and policy frameworks, indicate the clear need for enhanced capacities on gender-responsive climate policies, actions and data collection.

A below Figure 10.15 shows the recommendations by ADB's report on Women's Resilience in Mongolia.

Specific Recommendations:

(i) **Develop an Emergency Management Sector Gender Strategy** in the short term, to ensure protection and equality principles for disaster risk reduction are in place.

(ii) **Review the National Program of Community Participatory Disaster Risk Reduction (2015–2025)** at its mid-point from a gender perspective and advocate for the inclusion of specific gender equality targets and the promotion of gender inclusive approaches to community participation in DRR.

(iii) **Develop regulations under the Law on Environmental Protection and the Environmental Impact Assessment (EIA) Law** to increase the gender responsiveness of public participation in environmental policy.

(iv) **Develop an Energy Sector Gender-Responsive Policy** to identify key gender dimensions of the energy sector and include equality and on-discrimination principles in one of Mongolia's critical sectors.

General Recommendations:

(i) **Collection and analysis of disaggregated data needs to be prioritized.**

(ii) **Increasing women's participation in environmental decision making is essential.**

(iii) **Consolidate a gender responsive approach to climate change and disaster risk.**

Figure 10.15 Recommendations included in the report, Women's Resilience in Mongolia, ADB, 2022

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ANNEX 1. ENVIRONMENTALLY SOUND TECHNOLOGIES LIST

№	*Technology name*	*Purpose*	*Types*	*Country of origin*
1	Heat saver /G-saver/	Reduce air pollution	Residential	MN
2	Water purifier	Reduce water pollution	Industrial	MN
3	Wind engine /Wind turbine/	Renewable energy	Industrial	US
4	TARA PaperMek-I	Recycle waste paper	Commercial	IN
5	Flame stove	Reduce air pollution	Residential	MN
6	Ultra filter	Filter	Industrial	MN
7	Effective micro-organism	Reduce soil pollution	Industrial	MN
8	TARA-Papermek-V	Recycle waste paper	Residential	IN
9	TARA PaperMek-XV	Recycle waste paper	Residential	IN
10	Monocrystalline solar panel	Renewable energy	Industrial	CN
11	15-77 Wind engine	Renewable energy	Industrial	US
12	50 W solar system	Renewable energy	Residential	MN
13	50 W solar panel	Solar panel	Residential	MN
14	100 W solar panel	Renewable energy	Residential	MN
15	100 W solar system	Solar power generator	Residential	MN
16	200 W solar system	Solar power generator	Residential	MN
17	Wind power turbine	Renewable energy	Industrial	US
18	E20/435 Solar Panel	Solar Panel	Residential	US
19	Zimmatic 7500P irrigation system	Irrigation, farming	Industrial	US
20	Boiler stove /ILCH/	Reduce air pollution, energy efficiency	Residential	MN
21	Gas stove	Reduce air pollution, energy efficiency	Residential	CN
22	Water purifier	Reduce water pollution	Industrial	US
23	UW water sterilizer	Water sterilizer	Residential	CN
24	Smart-ash burning garbage stove	Neutralize garbage	Industrial	US
25	MBR- Membrane Bio Reactor	WWTP, water treatment	Industrial	US
26	Bergey Excel-10kW	Renewable energy, wind power plant	Residential	US
27	Bergey Excel 6kW	Renewable energy, wind power plant	Residential	US
28	Bergey Excel 1kW	Renewable energy, wind power plant	Residential	US
29	HIT® photovoltaic module: N 240 / N 245	Solar power generator	Residential	US
30	HIT® photovoltaic modules: N240/ N235	Solar power generator	Residential	US
31	295-305-Watt Polycrystalline Solar module	Solar power generator	Industrial	CN
32	250-265Watt Monocrystalline Solar Module	Solar power generator	Residential	CN
33	240-260Watt Polycrystalline Solar Module	Solar panel	Residential	CN
34	Monocrystalline Photovoltaic CeSuniva® ARTisun® Select Monocrystalline Photovoltaic Cells	Solar panel	Residential	US

35	ARTISUN® Select 200 Monocrystalline Cells	Solar panel	Residential	US
36	SunPower X-21 Series Solar Panels	Solar panel	Residential	US
37	SunPower E-20 Series Solar Panels	Solar panel	-	US
38	JACM6SR-3 (Cypress2)	Solar Cell	-	US
39	JACM5SF-2 (Cypress2)	Solar Cell	-	US
40	JACM6SF-3 (Cypress2)	Solar Cell	-	US
41	JACM6SR-3	Solar Cell	-	US
42	JACM5SF-2	Solar Cell	-	US
43	JACM6SF-3	Solar Cell	-	US
44	JAC P6RF-3 (Cypress2)	Solar Cell	-	US
45	JACP6WR-0	Solar Cell	-	US
46	JACP6RF-3	Solar Cell	-	US
47	Solartech M-156-2	Solar Cell	-	TW
48	E-Ton 6" Mono-crystalline Solar Cell, 2 Bus Bar	Solar Cell	-	TW
49	E-Ton 6" Mono-crystalline Solar Cell, 3 Bus Bar	Solar Cell	-	TW
50	E-Ton 6" Multi-crystalline 2BB	Solar Cell	-	TW
51	E-Ton 6" Multi-crystalline Solar Cell, 3 Bus Bar	Solar Cell	-	TW
52	E-Ton 6" Mono-crystalline Solar Cell, 2 Bus Bar II	Solar Cell	-	TW
53	E-Ton 6" Mono-crystalline Solar Cell, 3 Bus Bar II	Solar Cell	-	TW
54	E-Ton 6" Multi-crystalline Solar Cell, 2 Bus Bar II	Solar Cell	-	TW
55	E-Ton 6" Multi-crystalline Solar Cell, 3 Bus Bar II	Solar Cell	-	TW
56	Motech IM156 Cell	Solar Cell	-	TW
57	Motech IM156B3 Cell	Solar Cell	-	TW
58	Motech XS156B3 Cell	Solar Cell	-	TW
59	Motech IM14 PV Module	Solar power generator	-	TW
60	Motech IM60 PV Module	Solar power generator	-	TW
61	Motech IM60+ PV Module	Solar power generator	-	TW
62	Motech IM60 Black PV Module	Solar power generator	-	TW
63	Motech IM72 PV Module	Solar power generator	-	TW
64	Motech XS42 PV Module	Solar power generator	-	TW
65	Motech XS48 PV Module	Solar power generator	-	TW
66	Motech XS54 PV Module	Solar power generator	-	TW
67	Motech XS60 PV Module	Solar power generator	-	TW
68	Motech XS60 Black PV Module	Solar power generator	-	TW
69	Motech XS60+ PV Module	Solar power generator	-	TW
70	Motech XS72 PV Module	Solar power generator	-	TW
71	Motech XS72+ PV Module	Solar power generator	-	TW
72	Motech IM72+ PV Module	Solar power generator	-	TW
73	Solartech M-156-3	Solar Cell	-	TW
74	Fuel fired steam generator	Available technology methods/ environmentally friendly practices	-	-

75	Ger stove	Available technology methods/ environmentally friendly practices	-	-
76	Waste incineration	Available technology methods/ environmentally friendly practices	-	-
77	Cremation	Available technology methods/ environmentally friendly practices	-	-
78	Textile and leather dyeing /chloranil/	Available technology methods/ environmentally friendly practices	-	-
79	Waste incineration facility	Available technology methods/ environmentally friendly practices	-	-
80	Used oil refining plant	Available technology methods/ environmentally friendly practices	-	-
81	Paper recycling technology	Recycle paper	-	CN
82	Metal recycling machine	Recycling waste materials	-	CN
83	Plastic crusher and washer	Recycling waste materials	-	CN
84	Wind turbine	Renewable energy	-	CN
85	Night storage heater	Energy efficiency	Residential	DE
86	Water storage heater for night	Energy efficiency	Residential	DE
87	WWK 300A Heat Pump	Energy efficiency	Residential	DE
88	Bioclere	Water treatment	Residential	US
89	Aqua CELL	Water treatment	Residential	US
90	Aqua FAS	Water treatment	Residential	US
91	Magellan® Wastewater Treatment	Wastewater treatment	Residential	US
92	Urban Green™ Rainwater Harvesting	Rainwater harvesting	Residential	US
93	Urban Green™ Biofilter	Water treatment	-	US
94	Stormwater Management Storm Filter®	Water treatment	-	US
95	Bio STORM Stormwater Treatment	Water treatment	-	US
96	Micro FAST® Wastewater Treatment	Water treatment	-	US
97	Air Purifiers (Cleaners)	Air purifier	Residential	US
98	Ulzii full combustion stove	Energy efficiency	Residential	MN
99	Khas full combustion stove	Energy efficiency	Residential	MN
100	Daemwool insulation material	Energy efficiency	Residential	MN
101	Bokra chimney technology	Energy efficiency	-	-
102	WSB® clean pro	Water treatment	Residential	DE
103	Termoblok	Energy efficiency	Residential	-
104	SS801 Brick (Ion brick)	Energy efficiency	Industrial	-
105	JK 125 – Compost Tumbler	Recycling fertilizer	Residential	US
106	JK 270 – Compost Tumbler	Recycling fertilizer	Residential	US

107	JK 400 – Compost Tumbler	Recycling fertilizer	Residential	US
108	JK 5100 – Commercial Composter	Recycling fertilizer	-	US
109	Solatube Daylighting Systems	Solar energy, energy efficiency	Residential	US
110	Bio container	Recycling fertilizer	Industrial	US
111	Ventive S	Air purifier	-	GB
112	Stroma Solar PV	Solar power generator	-	GB
113	E-3120 50kW Wind Turbine	Renewable energy, wind power plant	-	GB
114	Evance R9000 - 5kW Wind Turbine	Renewable energy, wind power plant	-	GB
115	Radflek radiator	Energy efficiency radiator	-	GB
116	Strebel Biotech Boiler 25||40	Energy efficiency	Residential	GB
117	Strebel Taurus biomass boiler	Energy efficiency boiler	-	GB
118	Boiler Waste Heat Recovery System	Reuse wastewater	Industrial	HK
119	Biozone MobiZone	Air purifier	Residential	HK
120	Biozone PR	Air purifier	Residential	HK
121	Biozone Excel Zone	Air purifier	Residential	HK
122	Biozone Air Care	Air purifier	-	HK
123	Biozone Air Care S	Air purifier	Residential	HK
124	Biozone Mini PowerZone	Air purifier	-	HK
125	Biozone PowerZone	Air purifier	Residential	HK
126	Biozone InDuct	Air purifier	Industrial	HK
127	Biozone Ice Zone	Air purifier	Industrial	HK
128	RA-AC201 air purifier	Air purifier	-	CN
129	Solar Thermal Vacuum Tube	Solar power generator	-	GB
130	Vertical Access Wind Turbines (VAWT)	Renewable energy, wind turbine	Commercial	GB
131	Anaerobic Digestion	Bio Gas	Commercial	GB
132	Waste Container GROEN	Waste management	-	ID
133	Northern Power 60-23 Wind Turbine	Renewable energy, wind turbine	Industrial	US
134	Northern Power 100 Wind Turbine	Renewable energy, wind turbine	-	US
135	Northern Power 100 Arctic	Renewable energy, wind turbine	Residential	US
136	The Guardian Air and REME	Air purifier	-	CN
137	OzoneMAX OZ-30	Water treatment	Commercial	US
138	OzoneMAX OZ-60	Water treatment	Commercial	US
139	Scale Blaster: Residential SB-75	Water treatment	Residential	US
140	Scale Blaster: Residential SB-175	Water treatment	Residential	US
141	Scale Blaster: Residential MAX	Water treatment	Residential	US
142	Scale Blaster: Commercial SB-200LC	Water treatment	Commercial	US
143	Scale Blaster: Commercial SB-250	Water treatment	Commercial	US

144	Scale Blaster: Commercial SB-350	Water treatment	Commercial	US
145	Scale Blaster: Commercial SB-450	Water treatment	Commercial	US
146	Scale Blaster: Commercial SB-650	Water treatment	Commercial	US
147	Scale Blaster: Commercial DISH-1200	Water treatment	Commercial	US
148	Scale Blaster: Industrial SB-1200	Water treatment	Industrial	US
149	Scale Blaster: Industrial SB-2000	Water treatment	Industrial	US
150	Scale Blaster: Industrial SB-2800	Water treatment	Industrial	US
151	Scale Blaster: Industrial SB-3600	Water treatment	Industrial	US
152	Scale Blaster: Industrial SB-4000	Water treatment	Industrial	US
153	Mineral Pure: Residential RC-50	Water treatment	Residential	US
154	Mineral Pure: Residential R-40	Water treatment	Residential	US
155	Mineral Pure: Residential R-20	Water treatment	Residential	US
156	Mineral Pure: Residential SPA 1R	Water treatment	Residential	US
157	Mineral Pure: Residential SPA 2R	Water treatment	Residential	US
158	Mineral Pure: Commercial CS-75	Water treatment	Commercial	US
159	Mineral Pure: Commercial CS-150	Water treatment	Commercial	US
160	Mineral Pure: Commercial CS-225	Water treatment	Commercial	US
161	Mineral Pure: Commercial CS-300	Water treatment	Commercial	US
162	Mineral Pure: Commercial CS-450	Water treatment	Commercial	US
163	Mineral Pure: Commercial CS-600	Water treatment	Commercial	US
164	Mineral Pure: Industrial CT-75	Water treatment	Industrial	US
165	Mineral Pure: Industrial CT-150	Water treatment	Industrial	US
166	Mineral Pure: Industrial CT-225	Water treatment	Industrial	US
167	Mineral Pure: Industrial CT-300	Water treatment	Industrial	US
168	Weltem HPC-3000	Ventilation	Residential	KR
169	Weltem HPC-5000	Ventilation	Residential	KR
170	Weltem HPC-6000	Ventilation	Residential	KR
171	Weltem WMC-2500	Ventilation	Commercial	KR
172	Weltem WPC-3000	Ventilation	Commercial	KR
173	Weltem WPC-4000	Ventilation	Commercial	KR
174	Weltem WPW-4000	Ventilation	Commercial	KR
175	Weltem WPC-5000	Ventilation	Commercial	KR
176	Weltem WPC-4000W	Ventilation	Commercial	KR
177	Weltem WPC-7000	Ventilation	Commercial	KR
178	Weltem WPC-9000	Ventilation	Commercial	KR
179	Weltem WPC-15000	Ventilation	Commercial	KR
180	Weltem WPC-15000	Ventilation	Commercial	KR
181	Weltem WSC-4000	Ventilation	Commercial	KR
182	Weltem WSC-6000	Ventilation	Commercial	KR
183	7 Series - 700A11	Geothermal energy, renewable energy	Residential	US
184	5 Series - 500A11	Geothermal energy, renewable energy	Residential	US

185	Synergy3D	Geothermal energy, renewable energy	Residential	US
186	Legend	Geothermal energy, renewable energy	Residential	US
187	5 Series - 500R11	Geothermal energy, renewable energy	Residential	US
188	5 Series - 500RO11	Geothermal energy, renewable energy	Residential	US
189	Envision™ Series Outdoor Split	Geothermal energy, renewable energy	Residential	US
190	5 Series - 502W12	Geothermal energy, renewable energy	Residential	US
191	Envision™ Series NSW	Geothermal energy, renewable energy	Residential	US
192	Envision™ Series NDW	Geothermal energy, renewable energy	Residential	US
193	Protection of urban areas from wind and sand movement	Green zone, sand movement	Commercial	MN
194	Rehabilitation technology for pastureland	Rehabilitation	Commercial	MN
195	Creating green zone near to the settlement	Green Facilities, Plantation	Commercial	MN
196	Use of river water from high mountains in agriculture and livestock sector	Proper use of water		MN
197	Technology of natural afforestation by growing saxaul /zag/ in the wooden bucket	Afforestation	Commercial	MN
198	Collecting spring water for the agricultural use	Land irrigation	Commercial	MN
199	Reap the degraded pasture wormwood and restore basic pasture vegetation	Rehabilitation	Commercial	MN
200	Rehabilitation of abandoned arable land by perennial cultivation	Rehabilitation	Commercial	MN
201	Planting guatan under the cover	Planting	Commercial	MN
202	Make compost by fermenting sangas	Composting	Commercial	MN
203	Energy Star Heat Pumps	Geothermal energy, renewable energy	Residential	US
204	Mitsubishi Diamond KitTM	PV, Solar energy generator	Residential	US
205	Mitsubishi Diamond MountTM	PV, Solar energy generator	Industrial	US
206	Philips Room Air Purifier	Air purifier	Residential	GB
207	Energy Star Heat Air Conditioner	Air purifier	Residential	US
208	AUV Stick Light+ PCO	Air purifier		US
209	AUVM Stick Light+ PCO	Air purifier	Residential	US
210	Commercial PHI Unit	Air purifier	Commercial	US
211	Packaged PHI Unit	Air purifier	Commercial	US
212	PTAC HVAC Air Purification	Air purifier	Commercial	US
213	Guardian Air Desktop	Air purifier	Residential	US
214	Guardian Air HVAC Cell	Air purifier	Commercial	US

215	Power Spout Pelton	Power generation from water	-	-
216	Tidal power	Power generation from water	Indusrtrial	FR
217	Haliade™ 150-6MW offshore wind turbine	Renewable energy, Wind turbine	Commercial	FR
218	Bulb hydro turbines	Power generation from water	-	FR
219	Kaplan hydro turbines	Power generation from water	Commercial	FR
220	Francis hydro turbines	Power generation from water	Industrial	FR
221	Pelton hydro turbines	Power generation from water	-	FR
222	Pump hydro turbines	Power generation from water	Industrial	FR
223	Steam turbines for geothermal power	Renewable energy, Geothermal energy	Industrial	FR
224	Viridor Plastic Recycling	Waste recycling, plastic	Industrial	GB
225	Viridor Electrical Recycling	Waste recycling, electric	Industrial	GB
226	Viridor Glass Recycling	Waste recycling, glass	Industrial	US
227	Viridor Paper Recycling	Waste recycling, paper	Industrial	GB
228	Viridor Composting	Recycling, compost	Industrial	GB
229	Viridor Energy from Waste	Waste recycling	Industrial	GB
230	Kyocera SP KD325	Solar panel	Residential	JP
231	Kyocera SP KD320	Solar panel	Residential	JP
232	Kyocera SP KD250	Solar panel	Residential	JP
233	Kyocera SP KD245	Solar panel	Residential	JP
234	Kyocera SP KD220	Solar panel	Residential	JP
235	Kyocera SP KD140	Solar panel	Residential	JP
236	Kestrel e160i (600W)	Renewable energy, wind power plant	Residential	ZA
237	Kestrel E230I (800W)	Renewable energy, wind power plant	Residential	ZA
238	Kestrel E300I (1 KW)	Renewable energy, wind power plant	Residential	ZA
239	Kestrel E400N (3.5KW)	Renewable energy, wind power plant	Commercial	ZA
240	Kestrel e400nb (3.5kW) with brake	Renewable energy, wind power plant	Commercial	ZA
241	SOLARMOUNT-I™	Solar panel	Residential	US
242	SOLARMOUNT-E™	Solar panel	Residential	US
243	SOLARMOUNT™	Solar panel	Residential	US
244	WSB® clean basic 4-10 Residents	Water treatment	Residential	DE

245	WSB® clean basic 4-30 Residents	Water treatment	Residential	DE
246	WSB® clean basic 25-53 Residents	Water treatment	Residential	DE
247	WSB® clean gastro	Water treatment	Commercial	DE
248	WSB® clean max	Water treatment	Commercial	DE
249	Ultra-Super Critical Boilers	Ultra-Supercritical	Industrial	DK
250	L&T Supercritical Boiler	Supercritical energy	Industrial	IN
251	L&T Supercritical Turbine-Generators	Supercritical energy	Industrial	IN
252	Spiral Wound Universal Pressure (SWUP) Supercritical Boilers	Supercritical energy	Industrial	IN
253	TBWES Subcritical Boilers	Supercritical energy	Industrial	IN
254	Membranbelebungsanlage- Ultra Sept-Anlage	Waste water treatment	Commercial	DE
255	Pflanzenklaeranlage-Palutech Bodenfilter	Waste water treatment	Commercial	DE
256	Rolls glass crusher - Cylinders mill	Waste reduction	Commercial	IT
257	Cylinder presses - mod. CL-P	Waste reduction	Industrial	IT
258	Wire and Weee Recycling Systems Electrical Cable Grinder-separator - mod. RC	Waste sorting	Industrial	-
259	Electrical Cable Stripper - mod. SC	Waste sorting	Industrial	IT
260	Non-ferrous metals separator - mod. SNF	Waste sorting	-	-
261	787mm tissue-papiermaschine	Waste recycling	-	CN
262	Bio-Bus	Bio-Bus	-	GB