CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE

Faculty of Tropical AgriSciences

Department of Sustainable Technology

STUDY OF REASONS THE DESERTIFICATION IN AREA GOBI, MONGOLIA

Bachelor Thesis

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BACHELOR THESIS ASSIGNMENT

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Thesis title
Study of reasons the desertification in area Gobi, Mongolia.

Objectives of thesis
The purpose of this bachelor thesis is to study technological methods in order to decrease desertification in Gobi desert, Mongolia. For example: Reforestation - Green Wall, Watering - underground water sources (water ponds).

Methodology
While doing this bachelor thesis, the methods of searching will be used, collecting, analyzing and compiling information. Data and information in given problems from various sources will be applied.
Current environmental problems.
Limited natural freshwater resources in some areas of former communist regimes was supported by the rapid urbanization and industrial growth that had negative effects on the environment and strong air pollution in Ulaanbaatar, deforestation, excessive and converting of virgin land to agricultural production increased soil erosion from wind and rain, desertification and mining activities had a detrimental effect on the environment.
In the bachelor thesis, the text editor Microsoft Word will be used, pdf document viewer Acrobat Reader, internet browser Internet Explorer program.

Schedule for processing
Until July 2013.....Collect data
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Until January 2014..... Handover bachelor thesis to supervisor for review
Until March 2014..... Complete bachelor thesis

The proposed extent of the thesis
40-50 pages

Keywords
Desertification, desert, soil degradation, climate, Mongolia

Recommended information sources

International Conference on Desertification, Ulaanbaatar, Mongolia page 19.
Dagvadorj. D., Mijiddorj ,R., Natsagdorj,L. 1994. Climate change in Mongolia.
Articles in Meteorology, Number 17. Ulaanbaatar, Mongolia, page 3-10. Mongolian
Statistical Yearbook 1998, National Statistical Office of Mongolia, Ulaanbaatar, page 287
United Nations 1994, National Plan of Action to Combat Desertification (NPACD), Ulaanbaatar, page 266,

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Electronic approval: April 23. 2014

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Dean

Declaration

I, Unenbat Batkhuyag,do hereby declare that this thesis is the result of my own investigation and research and that it has not been submitted in part or full for any other degree or to any other University. All the work of other researchers has been duly acknowledged.

I remain fully responsible for my and all errors of omission, interpretation and any other shortcomings.

In Prague 2014

Student signature:...../Unenbat Batkhuyag/

Acknowledgement

First and foremost I wish to extend my profound appreciation to the Faculty of Tropical AgriSciences, Czech University of Life sciences faculty staff for the „knowledge“ passed to me. Indeed knowledge is only power when it is shared.

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Abstracts (English)

The desertification impact on economy, society and livelihood of population has become a major global challenge. In Mongolia, it threatens to destroy even a unique nomadic life culture. Therefore, there is a need to develop a strategy which will allow participation and involvement at all level to tackle the impact of land degradation, desertification and biodiversity loss. Because of this, it is necessary to integrate advanced science, technology, and knowledge in process of combating and coping with desertification. The purpose of this study is to implement effectiveness based well-defined long-term objectives, and comprehensive planning.

The ongoing degradation of the natural resource base of Mongolia is part of a vicious circle in which the causes and the effects of degradation reinforce each other, leading to an ever increasing pace of devastation. This is most visible in the desert steppes of the Gobi region which turn into desert and are not able anymore to feed the animals of the herders who move and more towards north and the centre of the country. It is imperative to reverse this trend and to safeguard the environmental conditions which are the basis for social and economic development.

The various theoretical and practical desertification factors are collected and thoroughly analysed from different kind of materials and statistics, which were main subjects to bring fundamental ideas and approaches. Also, effective measurements and programs from various organizations and governments are studied and noted.

Key words: desertification, desert, land degradation, climate, Mongolia.

Abstrakt (Czech)

Dopad desertifikace na hospodářství, společnost a obživy obyvatelstva se stal hlavním globálním problémem. Tento problém hrozí i v Mongolsku, protože může zničit unikátní tradiční způsob obživy – kočovné pastevectví. Proto je potřeba vypracovávat strategii, která umožní účast a zapojení na všech úrovních k řešení dopadů degradace půdy, desertifikace a úbytku přírodní rozmanitosti. Z tohoto důvodu je nutné integrovat moderní vědu, technologii a znalosti v procesu boje a zvládání desertifikace. Účelem této bakalářské práce je provést účinná opatření na základě dobře definovaných dlouhodobých cílů a komplexního plánování.

Pokračující degradace přírodních zdrojů Mongolska je součástí začarovaného kruhu, ve kterém se příčiny a následky degradace navzájem posilují, což vede ke stále se zvyšujícímu tempu devastace. Nejvíce je to viditelné v polopoušti Gobi, která se mění v poušť, a proto se pastevci přemísťují více k severu a do centra města, protože nejsou schopni chovat dobytek (zmenšení pastevní plochy pro dobytek). Proto je nezbytné zastavit vývoj degradace a zajistit podmínky ochrany životního prostředí, které jsou základem pro sociální a hospodářský rozvoj.

V této bakalářské práci jsou vybrány různé teoretické a praktické desertifikační faktory, jenž jsou důkladně analyzovány z různých druhů materiálů a statistik, které se staly hlavními tématy a přinesly základní myšlenky a přístupy. Také byly použity a poznamenány efektivní měření a programy z různých organizací a vlád.

Klíčová slova: Desertifikace, poušť, degradace půdy, klima, Mongolsko.

List of Abbreviations

CCD	Convention to Combat Desertification
EC	European Commission
FAO	The Food and Agriculture Organization
GDP	Gross domestic product
MSAVI	The modified soil-adjusted vegetation index
MNE	Ministry of Nature and Enviroments
NAP CD	National Action Plans on Combating Desertification
UNEP	The United Nations Environment programme
UNCED	United Nations Conference on Environment and Development
USEPA	The United States Environmental Protection Agency

Content

1 Introduction

1.1 A brief introduction of Mongolia

Mongolia is seen as a large landlocked country between two larger countries-Russia and China. Located on mountains and plateaus, it's one of the world's highest countries, with an average elevation of 1,580 meters. Mongolia suffers temperature extremes, with southern Mongolia dominated by the Gobi desert, and a large area of forest existing in the north. Precipitation is also very low in Mongolia. Average annual precipitation varies from about 400mm in the northern regions to less than 100-50 mm in the southern Gobi region. Precipitation also changes with altitude, with annual totals higher than 400mm confined to the mountainous areas where the growing season is also the shortest. Two-thirds to three-quarters of the annual precipitation occurs between June and August. [1]

As for the population, compared with other countries, the population of Mongolia is very small, but its growth rate maintains a high level. Today, the Mongolia has more than 2.7 million people with over 1 million people living in rural areas and is mainly engaged in traditional livestock herding and some crop production. The population density is one person per 1.6 square km. 68% of the total populations are young people under the age of 35. The average life expectancy is just over 65 years. The present urban population is above 1 million. Ulaanbaatar has 1 million inhabitants-one third of the total population of Mongolia.

Nowadays in Mongolia about 20 ethnic groups are either of Mongol or Turkish origin. Mongolian ethnic groups are divided into 3 main groups: they are the *Oirat* (eastern Mongolia), *Khalkha* and *Barga* in the west. About 80% of population is of the *Khalkha* ethnic group. In the western part of the country, a significant slice of the population speaks a dialect of Turkish. The largest of these ethnic groups are the Kazakhs, about 5% of population, and the *Uriankhai*located in *Tuva, Tsaatan*, and *Khoton*. Economic activity in Mongolia has traditionally been based on herding and agriculture, although the development of extensive mineral deposits of copper, coal, molybdenum, tin, tungsten, and gold have emerged as a driver of industrial production. Soviet assistance, at its height one-third of GDP, disappeared almost overnight in 1990-1991, leading to a very deep recession. Economic growth returned due to reform which embraced free-market economics and the extensive privatization of the formerly state-run economy. [2, 3]

2 Objective

The overall objective of the study is to explore the current situation of the desertification in a semi-desert environments of the Gobi region in southern Mongolia and by examining the various reasons behind it, the present study aims to recommend solutions to prevent and furthermore solve desertification problems.

2.1 Specific objectives

To determine and describe the causes of desertification of Gobi area to propose the theoretical possibilities of rehabilitation of Gobi area through the known technologies such as:

- Implementation of soil erosion control (by wind and water) by planting windbreaks and cover crops. Improvement in soil fertility with agroforestry systems, cover crops, and conservation of ground and surface water.

- Implementation of sustainable forest management techniques, forest plantations in appropriate areas to satisfy demand for forestry products, and tree seedlings and other measures to support afforestation.

- Promotion of reforestation and afforestation to protect selected water catchment areas.

- Strengthening institutions for environmental management (such as ministries and environmental protection agencies) to provide technical support to the development of sector strategies.

-Carry out strategic environmental impact assessments for large-scale infrastructure projects and other development strategies that are likely to have a major impact on the environment.

-Development and implementation of pollution control standards.

- Better dissemination and use of existing environmental monitoring and assessments at national and local levels; provision of funds, technical support, and tools for countries to undertake monitoring, data collection, and harmonization based on established standards (based on core set of indicators). Strengthening systems for monitoring environmental pollution to help enforce regulation for pollution control.

- Improve management of natural resources through market mechanisms, strengthened regulation and enforcement, and investments in the management of critical ecosystems.

3 Methods and Materials

In this study, main source of materials are from conference publications from Mongolian and International researchers who conducted their research on Gobi region that faces the threat of desertification and land degradation in Mongolia and internet source that has a data on the relative facts.

Main method of research is to collect data and information in this field and comparing and analysing them for further usage on the outcome. The collected material is focused mainly on crucial factors that shapes desertification and are analysed to come up with effective counter measures.

Desertification/Land degradation in Mongolia is serious environmental problems that threaten to destroy the country's productive capacity, environmental assets and even its nomadic culture. It is generally agreed that about 70 % of Mongolia's territory is affected by desertification in certain degree, leading to deprived livelihoods and poverty in rural area. [8]

Climate change is pronounced in Mongolia with an increase of the mean annual temperature of 2.1 °C between 1940 and 2007 whit an accelerating trend in recent years. While temperatures have been increasing, the mean annual precipitation has been decreasing in the south and in the centre while in other areas it has been slightly increasing.

3.1 Gobi desert, Mongolia

The **Gobi** is a large desert region in Asia. It covers parts of northern and north-western China, and of southern Mongolia. The desert basins of the Gobi are bounded by the Altai Mountain sand the grasslands and steppes of Mongolia on the north, by the Hexi Corridor and Tibetan Plate auto the southwest, and by the North China Plain to the southeast. The Gobi is most notable in history as part of the great Mongol Empire, and as the location of several important cities along the Silk Road. [4]

Figure 1: Gobi Area [5].

The Gobi is made up of several distinct ecological and geographic regions based on variations in climate and topography. One is the **Eastern Gobi desert steppe eco region**, a pale arctic eco region in the deserts and xeric shrub lands biome, home to the Bactrian camel and various other animals. It is a rain shadow desert formed by the Himalaya range blocking rain-carrying clouds from the Indian Ocean from reaching the Gobi territory.

3.1.1 Life in Gobi

Extreme climate and temperature fluctuations, at times within 24 hours, are characteristic features of this region. For a region marked by such weather extremes, Gobi boasts of being highly diverse in terms of fauna. The animals found here range from tiny insects to large mammals like the Bactrian camel and species like snow leopards which come visiting from the neighboring regions. [6]

3.1.2 Animals of the Gobi desert

Camels, also known as the ‘ship of the desert’, are one of the common animals seen in deserts across the globe. Restricted to the Gobi and Taklamakan desert, the Bactrian camel has some distinctive features. It has two humps, which stores food in the form of fat, which can be converted into water. This enables the camel to remain without food or water for about two weeks. Camels have long legs and padded feet to prevent their feet from sinking into the sand and help in keeping their body above the hot surface of the sand. Their nostrils

also have flaps that help in sealing the nose during a sandstorm, to prevent sand particles from entering it. They can bear the extreme heat and they have thick coats to reflect the sun's rays. [6, 7]

Figure 2: Bactrian camel in the Gobi [8]

The Gobi bear (Ursusarctosgobiensis) is much smaller than its cousins, the brown bears. This bear, also known as Mazaalai bear in local Mongolian language, can be found in the rocky regions of the Gobi desert. It is an omnivore with a diet consisting of berries, grass roots, lizards and mice etc. It also survives on insects and grasshoppers. These bears practice hibernation or winter sleep. The Gobi bear is on the endangered animals list with only about 30 left.

Figure 3:The Gobi bear (Ursusarctosgobiensis) [9]

The Gobi desert is also a home to Golden Eagle, the Desert Tarantula, Gopher Snake, Grey Wolf, Ibex, Snow Leopard, Gobi Jerboa, Kangaroo Rat, Musk Ox, Plate-tailed Gecko, Wild Ass, Wild Horse etc. [8]

3.1.3 Plants in the Gobi

Although it may seem like a barren, rocky wasteland, the Gobi Desert harbors some sparse plant life. The extremely low level of annual rainfall still provides enough moisture for a few desert plants to survive the otherwise harsh environment.

The saxaul tree is perhaps the most important plant in the Gobi. This remarkable tree is one of the only sources of water available in the midst of rock and sand. Water reserves collect behind the tree's bark, allowing both humans and animals to harvest the moisture. The bark may even be squeezed, yielding more precious water. [8]

Figure 4: The Sax in Gobi [7]

However, the saxaul is not the only plant that survives in the world's fifth largest desert. While the saxaul tree provides much needed water to Gobi's animal life, wild onions offer that same fauna a food source. These wild onions even offer a supply source to humans traveling over the Gobi Desert. [5,7]

Beyond sources of food and water, Gobi also hosts a few species of desert shrubbery and grass. Convolvulus and tamarix are two such shrubs, both of which can survive the temperature extremes and low rainfall of the desert while adding a bit of colour to the scenery. Small patches of needle and bridle grass also dot the rocky landscape.

One plant is unique to a specific area of the Gobi Desert: Saltwort. This weed-like plant has and extremely high tolerance to salt, making it the ideal plant life to thrive in the least vegetative area of the region, the Salt Desert. The salt content of this area of the Gobi is so high that it prevents most other plant life from surviving. [10]

3.1.4 Climate

The Gobi is a cold desert, with frost and occasionally snow occurring on its dunes. The climate is acutely continental and dry: winter is severe, spring is dry and cold, and summer is warm. The annual temperature range is considerable, with average lows in

January reaching −40 °C and average highs in July climbing to 45 °C, daily temperature ranges also can be quite large. The annual total precipitation varies from less than 50 mm in the west to more than 200 mm in the northeast. Monsoon like conditions exist in the eastern regions, which receive most of their precipitation in summer. Northerly and north westerly winds prevail over the Gobi in autumn, winter, and spring. [11]

3.2 Enviromental problems

3.2.1 Desertification

UNEP in early 1990 defined desertification as 'land degradation in arid, semi-arid and dry humid areas resulting mainly from adverse human impact'- specified land degradation as desertification. Land degradation is a process which implies a reduction of potential productivity of the land. In a broader sense, land degradation is considered as an "alteration to all aspects of the natural (or biophysical) environment by human actions to the detriment of vegetation, soils, landform, water (surface and sub-surface) and ecosystems". Land degradation in non-equilibrium rangelands may be defined in terms of loss of resilience (i.e., land's ability to recover from a disturbance) and is linked with lower economic productivity through reduction in forage consumption by stock. Land degradation is also considered to be a collective degradation of different components of the land such as water, biotic and soil resources. More recently, a report of the United Nations Conference on Environment and Development (UNCED) defined desertification as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities (UNCED, 1992). However, this definition does not distinguish between whether desertification is a process (a natural phenomenon marked by regular changes that lead to a particular result) and whether it is a condition (a state of being) created by land degradation. In addition, desertification appears when land degradation becomes irreversible or when loss of total productivity reaches from 50 % to 66 %. [9, 15]

Desertification of arid and semi-arid lands has become an increasingly important global ecological problem over the past 20 years. In Mongolia, the main type of desertification is degradation of vegetation cover caused by irrational utilization of pastures (overgrazing, cutting of trees and shrubs for fuel, development of soil biogenic crusts), and an increase of deforested and denuded land. Over 90 percent of the land area in Mongolia is

classified as a fragile dry-land and 72.3 percent of it is affected by desertification, according to the Desertification Research Centre of Geo-ecology Institute. This desertification process results in an alarming expansion of the Gobi desert. The Gobi desert, one of the world's great deserts, covers much of the southern part of Mongolia. Unlike the Sahara, there are a few sand dunes in the Gobi, rather you'll find large barren expenses of gravel plains and rocky outcrops. The climate here is extreme. Temperatures reach + 40° C in summer, while decrease to - 40° C in winter. The precipitation average is less than 100 mm per year, while some areas only get rain once every two or three years. Strong winds of up to 140 km/h make travel dangerous in spring and fall. The expansion of the Gobi is attributed mostly to human activities, notably deforestation, overgrazing, and depletion of water resources. As a result of overgrazing degradation of vegetative cover takes place in these areas. Increasing land pressure potentially threatens the fragile environment of Mongolia, hardly capable of higher productivity, and thus contributes to desertification. The pressure on land is threatening and in some areas already exceeding the conditions for sustainable development. [9, 18]

Desertification can be traced to the rapid decrease of surface water resources and levels caused by climate change and human activities. From 1970 to 2007, 887 rivers, 2096 springs and 1166 lakes have dried out.

Overgrazing is a major cause of land degradation and desertification in Mongolia. This is a result of inappropriate access regulations to pasture land. According to an assessment by the Agency for Land Affairs, Construction, Geodesy and Cartography, the livestock population is increasing continuously in the past few years and pasture carrying capacity was exceeded by 32.5 %, which is equivalent to an excess of 16 million sheep units. Due to changes in livestock head formation, the number of goats increased and constitutes 46 % of the formation of livestock head thus resulting in overgrazing. [5,18]

Since 1970, 125 thousand hectares of saxaul stands have been destroyed and 370 thousand hectares lost their regenerative capacity due to people`s utilization of saxual timber as an energy source for heating and cooking. Abandoned croplands, mining activities and unpaved multi-track roads also directly contribute to land degradation and desertification.

3.2.2 Forest ecosystem

Mongolia is a forest-poor country (at the end of 2006 forest cover area was about 8.14 percent). Mongolia has a total land area of 157 million hectares (FAO 2006). Forest reserve lands comprise 18.3 million hectares, with 12.9 million hectares of forest-covered area; this includes 10.5 million hectares of coniferous and hardwood forests, which is equivalent to 67 percent of the forest reserve. The country spans the major transition zone between the deserts of Central Asia and the boreal taiga of Siberia, which comprises six broad biogeoclimatic zones. The climatic zones are desert, desert steppe, steppe, forest steppe, boreal forest and mountain. The forest steppe, boreal forest and mountain zones all exhibit varying depths and distributions of permafrost. Figure 2-4 shows forest resource locations in Mongolia. Forest resources are not evenly distributed with most forests in the north, while the south and west mainly comprise steppe and desert ecosystems. [12]

The amount of forest covering the land is very low in Mongolia. In 1994, the total designated forest area of Mongolia was 17.5 million hectares, including 12.7 million ha of closed forest or 8.1 % of the total land area. Based on their basic functions, forests in Mongolia are subdivided into 3 types: special forests, protected forests, and industrial forests. Nowadays Mongolia faces the same forestry problems with others developing countries, namely deforestation. There are three main factors that bring about deforestation in Mongolia: [9, 11]

1. Increasing livestock numbers
2. Increasing demand for fuel and industrial wood
3. Forests fire impacts

Deforestation due to the demand for fuel is mainly occurring from mining sites in Mongolia. For example, since one of the biggest coal mine area the *Baganuur* was established in 1968, approximately 50 % of vegetation has decreased. Undesirable side effects of this activity include a decline of the underground water level and destruction of plant cover in fragile areas, etc.

There is one factor whose effects can’t be predicted which has caused deforestation in Mongolia. It was the use of wood by local people to build the *ger* frames and also furniture for the interiors. Even in Ulaanbaatar, the capital city of Mongolia, we can see the influence

of the *ger* is still rich. A typical Mongolian house is surrounded by a fence made from wood. This factor might be one of many factors causing deforestation in Mongolia. [2]

Figure 5: The Ger in Gobi [12]

According to some statistics, the forest area in Mongolia has decreased by 1.2 million hectares over the last 20 years. To prevent deforestation, reforestation is needed. However, Mongolia does not have a long history regarding plantations and reforestation. Since 1970, Mongolian forestry and timber-harvesting companies have been instructed by the state to follow a 5 year plan to harvest wild seeds, breed seedlings and conduct reforestation activities. Also, between 1997 and 2000 the government of Mongolia has also supported significant efforts at reforestation. [4, 9]

Many people in Mongolia believe that water is their most important resource, and perhaps that's why many Mongolian researchers have a tendency to focus on water. However, it's important to remember that forests also play any important roles in our lives, as soil erosion preventer, for biodiversity preservation, and also regulating the water regime, etc.

Climatic influences, especially reduced precipitation over the past 20 years have increased the susceptibility of forest fires. The fire risk is high approximately 75 percent of the time, and 80 percent of fires are caused by careless human activities which degrade the forest quality, through degraded species composition, damage by insect infestations, and the

deterioration of forest soils. To protect forests against fire, early-warning systems need to be developed to enable rapid responses to extinguish fires before they become serious. [13]

Approximately 40 percent of Mongolia's forests are already suffering from degradation as a result of detrimental human activities, insect damage and fire. For example, around 50,000 hectares of saxaul forests – known in Mongolia as "*zag*" (Haloxylonammodendron) a desert plant – have been heavily degraded or destroyed due to overharvesting. In dry land *Aimak*, *Sum*, and *Bag* (administrative unit, sub-district) woody plants, shrubs and switch plants on common lands are often overexploited for firewood. [11]

3.2.3 Water supply

There are more than 3,800 rivers and streams with regular run-off in Mongolia. The total length of the river network is about 6,500 km. There are 186 glaciers with a total volume of 62.5 km^3 and 3500 lakes covering total surface area of 15,600 km^2 (surface area of each exceeding 0.1 km^2) with a total volume of 500 km^3 and 8,000 river lets. Table 1 presents the details of surface water resources in Mongolia. [10]

Table 1: Types of Surface water in Mongolia [10]

Surface water	Number	Length(km)	Area covered(sq.km)
Rivers	3811	67080	
Lakes	3500		15640
Glaciers	187		540
Sprongs	6899		
Mineral	250		

The potential water resources of the country are estimated to be about 36.4 km^3. Of this, the surface water resources are 22.0 km^3 and the usable groundwater resources are 12.6 km^3. About 78 % of the river run-off is formed on 36% of the territory in northern, western, and north-eastern mountainous areas and 22 percent is formed on 64 % of the territory in the south of the country.

Water balance is as follows:

- Total annual precipitation 360.0 km^3
- Total annual runoff 36.6 km^3 of which:
  - Surface runoff 24.6 km^3
  - Ground water flow 12.0 km^3
- Total soil moisture 202.0 km^3
- Total evaporation 190.0 km^3

On an average, the annual amount of water resources per capita is 17,300 m^3. However, it ranges from 4,500 m^3 per capita in the Gobi area to 46,000 m^3 per capita in northern and central areas. [14]

The total mean annual precipitation over Mongolia is estimated to be 360 km^3 of water or 230 mm per year (nationwide average); about 90 % of this is lost through evapotranspiration, 4 % infiltrates to aquifers, and 6 % contributes to surface flow. [15]

2000 (77 % of probability) 19 km^3 of water was formed in the territory of Mongolia. Mongolia's annual surface runoff has increased since 1988 and reached its maximum of 78.4 km^3. Figure 6 shows the annual surface runoff in Mongolia.

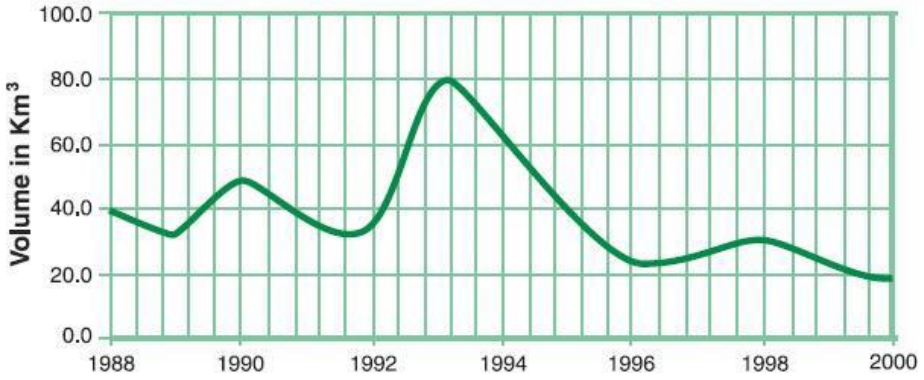

Figure:6: Mongolia's annual surface run-off (km3/year)[15]

Annual water use in Mongolia is estimated to be about 500 million m^3, the distribution of which is shown in Figure 7.

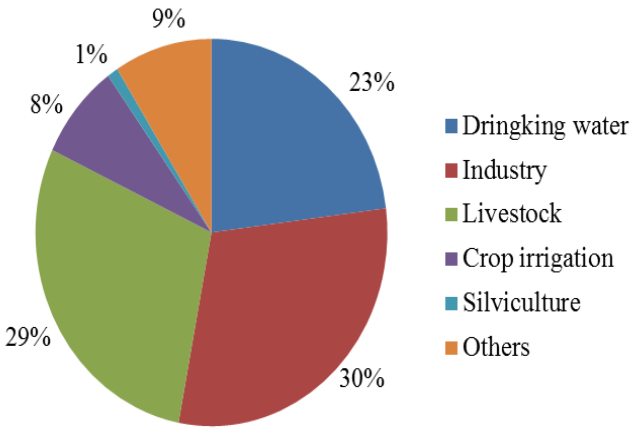

Figure 7: Water uses distribution [16]

Water supply from the underground sources is about 80 % of total water consumption. 30.8 % of the population of Mongolia is supplied with water from centralized water-supply system, while 24.8 % are supplied from water transportation service, 35.7 % from water supply points and 9.1 % are from springs, rivers and snow water respectively. Drinking water is supplied from different sources as shown in Figure 8.

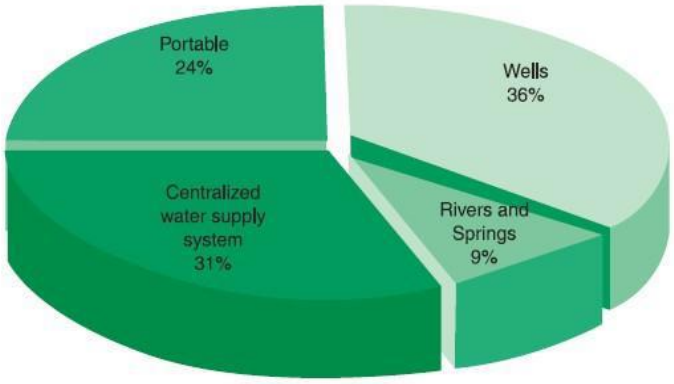

Figure 8: Drinking water supply sources [16]

Of the drinking water supply sources, the largest proportions are wells. In the *Ger* area in the north part of Ulaanbaatar city, some residents have wells drilled by themselves. This kind of well can provide drinking water for domestic use from spring to autumn. Due to low temperatures, the wells do not work in winter. Therefore, production wells play a very important role, especially during winter when many household wells are frozen. The depth of the production well is 58 m, and the total construction cost is around 5000 USD. Some families buy drinking water from the production well, especially the rich who do not have

wells themselves. The water is not expensive. It costs only 4 Mongolian Tugrik per litre. [17]

In recent years, improvements in groundwater wells have been the most widespread structural measure for the exploitation of water resources in Mongolia.

Although the rivers and springs only provide 9% drinking water, the role of springs are also very important. The people of the *Ger* area can use spring water for drinking and domestic use at no cost. Spring streams originating in the high mountain areas normally carry relatively clean water, but with the development of mining industry, the quality of some spring water has been polluted. For example, the nitrate concentration (60 mg L-1) in this spring water has exceeded the maximum level (44.3 mg L-1) promoted by USEPA. [15]

Water consumption per capita in Mongolia is 3 to 4 times lower than the world average. According to studies, water consumption of the population living in the *Ger* districts, large cities, *aimak* centers, and big settlements is about to 8-10 litres per person per day; which is 4-5 times lower than the acceptable standard. However, water consumption in Ulaanbaatar exceeds the average of that in the developed countries. It shows that there is a significant waste of water. There are irregular repairs and maintenance services in the municipal water supply line of the capital. If drinking water continues to be wasted in this way, the capital city's drinking water supply is likely to face severe problems in the near future. [15, 16]

At the present time water pollution is serious problem in Mongolia, especially in urban areas and in the gold placer mining locations. Recently, the exploration of natural resources, e.g. gold mining and gravel extraction has been rapidly increasing. Accordingly, the threat from mining pollution has also been increasing. As a result, over half of the population of Mongolia is at an immediate risk from air and water pollution. Mongolia is home to some of the earth's largest untapped gold, copper, and uranium reserves. There are officially 1,083 active mine sites in Mongolia, only 419 of which are legal. There is no official data on the scope of illegal mining, but both legal and illegal mining are wreaking terrible damage on Mongolia's environment. The "gold rush" in Mongolia is leading to irreversible environmental degradation and excessive river pollution. According to the Mongolian government, 900 streams and small rivers have gone dry or have completely disappeared in the last 15 years from outdated gold extraction methods such as dredging and river

diversion. Due to mining activities, the water sedimentation has increased by 8 times that of the permitted standard. Mongolia's water resources are very susceptible to the pressures of over-utilization for human activity. The increasing water consumption has resulted due to an expansion of population, production, and enterprise activities. A considerable waste in the use of water in some regions of the country has also put pressure on the water resources. The deterioration and pollution of water sources near the large cities and settlements has negatively impacted the living environment of the human population. Water runoff in the *Tuul, Haraa* and H*erlen* rivers are decreasing and the rates of pollution in these rivers have exceeded the permissible limits by several times. This has been mainly due to the intensive timber work carried out in the water-feed zone of these rivers without proper management. [16]

It has been reported that groundwater tables are lowering over time and some wells and springs are also drying up. These effects are also observed seasonally, for example in Ulaanbaatar, which typically experiences an insufficient supply from the municipal water system in March or April each year due to lowering of groundwater levels at supply wells. Also, a water quality has also been a problem in recent years.

3.2.4 Human and natural factors

With the collapse of socialism and central planning the number of herders' households increased from 140,000 to now 280,000. Mongolia, since experiences the 'tragedy of the commons', private livestock grazing the vast common steppes and increasing steadily in numbers. Large herds with a high number of goats (46% of all the animals, compared to a traditional percentage of 20%), uncoordinated herding patterns, and the development of mineral resources are threatening species diversity and are leading to increased soil erosion and weed infestation. Never in history in Mongolia grazed more animals on the wide steppes (43.2 million by the end of 2008). According to an assessment by the Agency for Land Affairs, Construction, Geodesy and Cartography conducted between 1999 and 2004, pasture carrying capacity was exceeded by 32.5%, which is equivalent to an excess of 16 million sheep units. [13]

Figure 9: OvootTolgoi coal mine [5]

Abandoned croplands, mining activities and unpaved multi-track roads also directly contribute to land degradation. According to the UN Ecological Assessment report of Mongolia 2000, desertification has the biggest detrimental impact on the wellbeing of rural people and makes them more vulnerable and insecure. The Government of Mongolia is aware of this double threat to its environment ever since. In 2007 the National Security Council recognized desertification as a key security issue for Mongolia. [13, 18]

3.2.5 Vegetation degradation

Vegetation biomass values for five different years are given in Table 2. As seen from the table, the maximum and mean values of vegetation biomass decreased through time.

Table 2: Areal percentage of biomass classes [13]

Plant biomass classes, kg/ha	Years				
	1973	1990	1991	2002	2005
0-15	0	0	0	15	12
15-30	0	0	0	48	51
30-45	0	10	0	22	22
45-60	15	26	5	9	5
60-75	21	36	9	9	4
75-90	43	10	22	7	6
90-95	3	7	21		
95-222	18	11	43		

Comparing 1990 and 1991, the biomass of 1991 was slightly higher in terms of mean and maximum plant biomass. It is attributed to the fact that the 1990 image was acquired in September, corresponding to the end of growing season, whereas the 1991 image was acquired in July, the peak of growing season. The plant biomass estimates decreased along the time periods, and average biomass estimates were almost half in 2005, what they were 15 years earlier. Standard deviation rapidly increased through the time period, from 13 kg ha^{-1} in 1990 to 38 kg ha^{-1} in 2005. The highest vegetation biomass appears to represent non-degraded natural vegetation. Vegetation biomass for 1973-2005 has a wide range of values ranging from 1–222 kg ha^{-1}. The years 1973 and 1990 contain more vegetated areas compared to the later years. The years 2002 and 2005 include small portions of high-biomass vegetation, around 10% displays high vegetation. The rest of the areas are low vegetation, where the plant biomass ranges from 1-60 kg ha^{-1}. The 15-30 kg ha^{-1} plant biomass was virtually non-existent in the images of 1973 and 1991. It looks as if the vegetation biomass was the highest in early years, but decreased in later years due to climatic and human factors. The largest areas for differing years were the following: 51% for 15-30 kg ha^{-1} in 2005, 48% for 15-30 kg ha^{-1} in 2002, 43% for 95-22 kg ha^{-1} in 1991, 36% for 60-75 ha^{-1} in 1990, and 43% for 75-90 kg ha^{-1} in 1973. Almost 90 % of the areas supported 45 - 222 kg ha^{-1} plant biomass for 1973-1990, while 90 % supported 1-45 kg ha^{-1} plant biomass between 2000 and 2005. As mentioned earlier, the highest plant biomass in 1990 and 1991 was attributed to those years had the highest rainfall in a 32 year period (1970-2002). In addition, the monthly rainfall pattern for those years show that both dates of 1990 and 1991 images were acquired after the highest rainfall of 80 mm. [19]

4 Research

Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.

4.1 Investing in improved resource management

A healthy environment underpins human life and well-being by providing food, clean water, disease control, and protection from natural disasters—and is thus necessary to achieve each Goal. But the environment is under threat in all parts of the world because of

rising pollution, soil degradation (including rapid desertification), deforestation, destruction of coastal and freshwater fisheries, rising water scarcity, and declining biodiversity. Anthropogenic climate change, already causing environmental change, is projected to threaten agricultural productivity in many parts of the Gobi,.

Environmental degradation and the effects of climate change are therefore major development issues. Most countries cannot wait until they reach higher incomes before investing in better environmental management. The degradation of the environment threatens the very basis of sustained economic growth, particularly where agriculture accounts for a large share of national income. Achieving environmental sustainability will require interventions at the national, regional, and even international level.

Unfortunately, the concept of environmental sustainability does not provide clear operational guidance for choosing policies and outcome targets. The first step is thus to decide which environmental objectives are to be achieved and beyond. Many agree that it is necessary to take the lead in ending unsustainable patterns of production and consumption. Perhaps most important, urgent action is required to stabilize greenhouse gas concentration by reducing emissions and promoting carbon sequestration.

Developing countries such as Mongolia, in turn, need to concentrate on integrating environmental strategies into all sectorial policies and more specifically on promoting direct investments in environmental management, considering the effect on the environment when designing sector strategies, promoting regulatory and market reforms to reduce environmental degradation, and improving environmental monitoring. In each of these intervention areas, countries will need to consider the growing need to adapt to climate change. This includes changes in agricultural practices, improved environment monitoring and reporting systems, investments in local climate modeling and projections, and measures to stem the impact of rising soil degradation.

4.2 Direct investments in environmental management

Examples of direct investments in environmental management include planting trees to combat deforestation, improving farming and land management practices to combat desertification, treating wastewater to reduce nutrient loads in freshwater ecosystems,

curbing chemical pollution to protect human health and ecosystems, and preserving critical ecosystems to protect biodiversity.

4.3 Sector strategies to benefit the environment

Targeted sectorial investments are instrumental to improving the environment. Investing in modern cooking fuels to shift away from biomass will not only lower ambient and indoor air pollution, but also reduce pressure on fragile ecosystems. Likewise, improving access to water and sanitation will improve environmental quality. Of particular importance to the environment are improved agricultural practices and investments in soil health and sustainable water management for agriculture, which can stem soil degradation and biodiversity loss. To this end, agricultural extension workers should be trained to promote environmentally friendly practices that can raise yields while minimizing the use of environmental resources. In addition, goals are need to be set by initiating the design of strategies for integrated water resources management as soon as possible.

4.4 Regulatory and market reforms to reduce environmental degradation

Reforms to land tenure regimes and an improved regulatory environment to combat pollution are required to minimize the adverse impacts of sectorial policies on the environment. To this end, there is a need to invest in strengthening the capacity of environmental protection agencies or equivalent government bodies. In most cases this will require a substantial scaling up of their human resources, equipment, and operating budgets.

4.5 Environmental monitoring

No strategy for environmental sustainability can be successful without better monitoring. Yet, monitoring systems for water flows and quality, air quality, deforestation, and other land degradation are woefully inadequate in many developing countries. Sustained investments in strengthening environmental monitoring systems will thus be essential. An important mechanism for implementing national strategies is the set of multilateral environmental agreements and conventions, such as the Convention on Biological Diversity, the UN Convention to Combat Desertification, the Ramsar Wetland Convention, and the UN Framework Convention on Climate Change. More funding and targeted technical support need to be made available to implement these agreements.

5 Results and Conclusion

5.1 Reforestation

The MNE prepared a report forecasting new areas of planting to 2010. The report provided a medium-term forecast describing the five years out from the year 2000. The report estimated new planting to be between 6 000 hectares and 8 000 hectares per year during this period, with a best estimate of 7 000 hectares. In the longer term, from the year 2005 to the year 2010, the report expected new planting to be between 8 000 hectares and 40 000 hectares with a best estimate of 24 000 hectares per year. [19]

Even if some areas regenerate naturally after logging, the situation is not satisfactory. Without artificial regeneration, the share of birch and aspen will increase, and some areas may be converted into grassland in the harsh climate. [18]

The most common planted species are pine and larch. The survival rate of seedlings is reported to be only 30-65 percent.

The low survival rate is due to the following reasons:

- Harsh and dry climate
- Poor quality of seedlings produced in nurseries
- Inadequate site preparation and poor planting techniques
- Neglected maintenance of plantations
- Uncontrolled grazing

As the areas requiring reforestation are much larger than the available resources, optimum working methods need to be developed. In the first phase of this development, the whole regeneration system should be thoroughly analysed. [18, 19]

5.2 Green Wall programme

The government programme to establish a “Green Wall” has been approved and implemented since 2005. Each year, the programme constructs and replants forest green belts in the desert and steppe ecosystems of Mongolia.

Mongolia is encountering the challenge of combating the adverse impacts of global warming and climate change that are significantly affecting the country’s economy, social

life and people's livelihoods. The country has recognized the potential environmental benefits of reforestation in the face of intensifying sand movement, dust and sand storms and desertification. [20]

Figure 10: Green wall programme in Gobi [19]

The goal of the programme is to create a "Green Wall", which totally covers the transitional area between the Mongolian Gobi and steppe regions, in an effort to reduce the present intensification of loss of forest reserves, desertification, sand movement and dust and sand storms, caused by climate change and inappropriate anthropogenic activities. The long-range programme will be realized in a step-by-step process involving the local community, harmonizing environmental and socio-economic development policies, and measures that take into account specific features of the respective areas. [20]

The Green Wall national programme has three phases and will be implemented over a 30 year period. The Green Wall or Ecostrip will be built, crossing the Gobi Desert and steppe regions with a total length of up to 2 500 kilometres and a width of not less than 600 meters. The total area covered will be 150 000 hectares. In addition, a sub-strip covering 50 000 hectares will also be planted in adjacent areas of the Gobi and steppe regions – synchronously with the main ecostrip with the purpose of preventing sand movement and desertification. The Green Wall national programme will be implemented in three phases as follows:

- First Phase (2005-2015): Not less than 20 percent of the planned programme shall be completed on the basis of forming legal coordination and capacity, and acquiring implementation methodologies and technologies.

- Second Phase (2015-2025): Not less than 30 percent of the planned activities shall be completed on the basis of assessing the First Phase progress and strengthening the national capacity. Outcomes shall be improved.
- Third Phase (2025-2035): Not less than 50 percent of the programme shall be completed on the basis of improving ecological and socioeconomic efficiency of the programme, and mastering methodologies and technologies for reducing adverse impacts of desertification and sand movement.

To support this whole programme, practical activities of reforestation will be implemented, expanding the range of afforestation in the Gobi and steppe regions, by planting trees and bushes and establishing nurseries in desertified areas. [18,20]

The funding required for the programme will be obtained from the central government and local government budgets, donor governments, loans from international organizations, technical assistance, gratis aid, donations from institutions, economic entities, and others. A detailed plan for programme implementation will be reviewed and approved by the Cabinet every two years and planned activities will be reflected in the "Annual Basic Trends in Socioeconomic Development" report/plan. Local citizens, organizations and economic entities will be encouraged to develop project and action proposals that reflect their local features in accordance with the format for planting trees, bushes and vegetation and building protection zones in the Gobi and steppe regions. The proposals will be reviewed for compliance with relevant procedures. Projects and action proposals for building the green strip and afforestation in Gobi regions shall also be reflected in bilateral and multilateral agreements to be made with foreign countries and international organizations. Afforestation components shall be included in relevant projects, in harmony with the overall programme, to create synergies. [17]

The expected outcome of the program is increase in Mongolia's forest reserve by 1.6 percent and positive changes in the Gobi and steppe ecosystem. In addition, saxaul forest reserves will be conserved, areas of deciduous forest expanded, a favorable microclimate will be established, and ecological balance will be maintained. The legal environment that protects the cultivated forest and forest strip in the Gobi and steppe regions will be improved and strengthened as a result of the successful implementation of the Green Wall programme. [18,20]

In the first three years, since the approval of the programme, the main belt and supporting ecostrips have been established on 951 hectares in 80 sum of 18 *aimak* with financing of 500 thousand USD. From 2005 to 2007, the average survival rate of the Green Wall strip was 70-75 percent. For the first three-years, implementation of the annual objectives of the Green Wall national programme was 50-60 percent of the target. From 2007, the programme has been implemented with the involvement of other donor countries. For example, the Green Wall programme is being implemented in collaboration with the Korean government for 10 years, with total budget support of 10 million USD.

An important feature of the programme is to increase the effectiveness of new forest establishment in all eco regions of Mongolia, in particular steppe and desert zones. Through the implementation of the programme, there are expected to be benefits through improved participation of citizens and working units in planting trees and greening the environment. In 2006, studies to determine appropriate tree species, to select areas for establishing green strips and to identify land where desertification and sand movement might be combated, were implemented in 78 Sums of 18 provinces. Field studies were conducted on four major topics, with the involvement of scholars and researchers. [16]

In the future, improvements in agro technological and scientific bases of planting will be required, to ensure establishment of the main belt and supportive strips in accordance with the overall plan.

5.3 Water Supply

In 2001, there were 107 guards and 17 stations acting at 70 rivers, 1 spring and 9 lakes. Guards and stations undertake studies on water regime, quality and composition. They take measurements on water biology with 54 indices, evaporation with 8 indices and water pass-over with 81 indices. In fact, these measurements are three times lower than the world average. Through the accumulated data by years, the changes of water regime and water quality could be determined.

Mongolia's goal is to develop a market-oriented agriculture sector with minimal state intervention. According to the 'Mongolia irrigation rehabilitation project' the objectives are:

- to restore to full productive capacity around 1 550 ha of irrigation schemes in the north-central region;

- to strengthen the capacity of government and private institutions involved in irrigation development;
- to form WUAs and train farmers in the O&M of irrigation systems and irrigated crop production;
- to develop irrigated crop production technologies adapted to the new production systems, especially to smallholders, and to identify and promote new irrigated crops adapted to Mongolian conditions.

In order to alleviate the problems of the water resources, some solutions should be made as follows:

1. Strictly enforce the legal framework (Water Law, Water Use Fees Law, etc.) on water supply, disposal and wastewater treatment, and further update on some of these laws.
2. Increase investment and rehabilitate existing water supply networks for the domestic water supply.
3. Raise public awareness about saving water, build water recycling plants, and improve the management of water supply utilities.
4. Do more to improve water quality, particularly through the rehabilitation of wastewater treatment plants. This should include the introduction of practices to reuse and recycle wastewater. [14]

5.4 Mongolia's Policy for Combating Desertification

Mongolia supports and endorses the Millennium Declaration adopted at the UN Millennium Summit. The objective of MDG-based Comprehensive National Development Strategy is through strengthening human capacity and intellect achieve MDGs, creating a knowledge based economy whose growth is ensured through high-technology-based economy, environment-friendly production and services. A new program to combat desertification was developed with purpose "to protect environment, improve economic security, and increase living standards of the people through combating desertification and decreasing vulnerability to climate change". [20]

The UNCCD's "The 10-year strategic plan and framework to enhance the implementation of the Convention (2008–2018)" and Comprehensive National

Development Strategy of Mongolia based the Millennium Development Goals (2007-2021) are basis of this new program. Actions and mechanisms to incorporate economic sector, involve local governments and citizen, and increase financial support from the central Government have included in the new program to combat desertification. [19, 20]

In April 2010, Mongolian Government adopted newest of policies for combating desertification aligned with UNCCD and National Policies. This program, together with the National Programs on Biodiversity (1996) and on Climate Change (2000) is the major policy documents relating to the Rio Convention.

The government and its external partners need to increase the country's resilience towards environmental and external shocks and with coping mechanisms for societal and climatic changes. Land degradation and desertification threaten to destroy not only the country's environmental assets, but even its nomadic culture. [15, 16]

Following main outcomes are expected in the first stage directly relevant to reduce rural poverty and combating desertification.

As a result of active and rapid economic growth many new jobs will be created, poverty halved and education and health sectors will be reached to success, hereby Millennium Development goals will be realized. [20]

20-30 thousand households in *ger* districts of the capital city connected to the central public utility systems; nationwide average of 10 thousand households will be improved their housing conditions annually. [20]

Livestock breeding quality improved by using biotechnology and genetic engineering, harvest of crops increased

Average annual wheat production will be increased fourfold, average annual production of potatoes and vegetables will be increased 1.5 times

The size of territories of special significance for preservation of the ecosystem balance of Mongolia will be enlarged to no less than 20 percent of the total territory, i.e. more than 30 million hectares and ecologically unsustainable conditions will be reduced rapidly. [18, 20]

6 Discussion

To prevent, cope with and revert desertification and land degradation in Mongolia to ensure environmental sustainability, improve livelihoods of the rural population and generate environmental services of global importance. [11, 21]

This will be achieved by:

- strengthening institutional capacity
- improving the legal and policy framework
- enhancing science, technology and e
- investing in advocacy, awareness raising and education
- intensifying concrete actions at the grassroots level, increase investment

Three strategic objectives have been formulated to which will provide a significant contribution.

These are:

1. To improve the living conditions of the rural population

It is recognized that poverty is one of the root causes of degradation of natural resources and desertification in Mongolia. Therefore, it is crucial that the measures of NAP CD are taken in a way that benefits directly the local populations and mainly the poorer segments among them. Two complementary strategies will help to achieve this objective. One is to increase the benefit from management of the natural resources by the local households and communities. The other, not less important, is to create alternative income opportunities for the people living in rural areas.

2. To improve the condition of affected ecosystems

The ongoing degradation of the natural resource base of Mongolia is part of a vicious circle in which the causes and the effects of degradation reinforce each other, leading to an ever increasing pace of devastation. This is most visible in the desert steppes of the Gobi region and the Great Lakes' depression which turn into desert and are not able anymore to feed the animals of the herders who move more and more towards north and the center of the country. It is imperative to reverse this trend and to safeguard the environmental conditions which are the basis for social and economic development.

It is difficult to determine how much of the ongoing degradation process in Mongolia is due to the effects of climate change and how much is due to human induced factors.

However, there is no doubt that climate change increases the vulnerability of ecosystems and amplifies the effects of mismanagement of the natural resources. Therefore, NAP CD invests mainly in addressing the man-made causes of land degradation and desertification and tries wherever possible to reduce the risk of collapse of ecosystems and livelihood systems.

3. To generate environmental services of global importance

The increasing global awareness regarding climate change opens new opportunities to address land degradation and desertification. Already now, and probably even more in the future, important financial resources are invested worldwide for carbon sequestration in order to achieve the targets on greenhouse gas emissions set by the countries. It is expected that Mongolia could profit from these financing mechanisms under the condition that the trend of environmental degradation is reversed and its vegetation cover and soil quality is improving. This in turn would improve the natural resource base for the economic development of the rural population. There are two major challenges Mongolia has to overcome in this regard: it has to make sure that the major beneficiaries will be the rural managers of the natural resources and that the measures taken will bring lasting changes. These measures need to be implemented in synergy and complementarity with other conventions like the Conventions on Climate Change and Biodiversity.

It is important to bring fundamental changes by addressing land degradation and desertification in a different and much more resolute way than in the past. The following guidelines describe the recommended strategies and approaches which will be applied throughout the different components:

- Increasetheunderstandingof the root causes and trends of desertification and possible ways to address them (at policy and decision maker level as well as for the general public).
- Addressdesertification not as a special additional program but as an integral part of the ordinary planning, budgeting and implementation of all concerned ministries and organizations.
- Reorganizetherelationshipbetween local government and population.
- Encourageresourceusers' participation in the implementation of NAP through incentivesrather than disincentives.

- Invest primarily in areaswhich are not yet too much degraded, where there is a good potential to bring tangible improvements with limited resources. Invest less in extremely degraded areas and only where there is a need for it and where there will be tangible benefits for the population (e.g. protection of vital infrastructure and settlements from sand movement).

It is understood that desertification is by far the most important environmental issue of Mongolia. It endangers the nomadic and semi-nomadic lifestyle and the cultural identity of Mongolia. It threatens the livelihoods of the rural population which is about 40% of the total populace of the country and it increases the risks for serious conflicts among the population. Therefore, it is recommended to formally treat desertification as topic of national security. [21]

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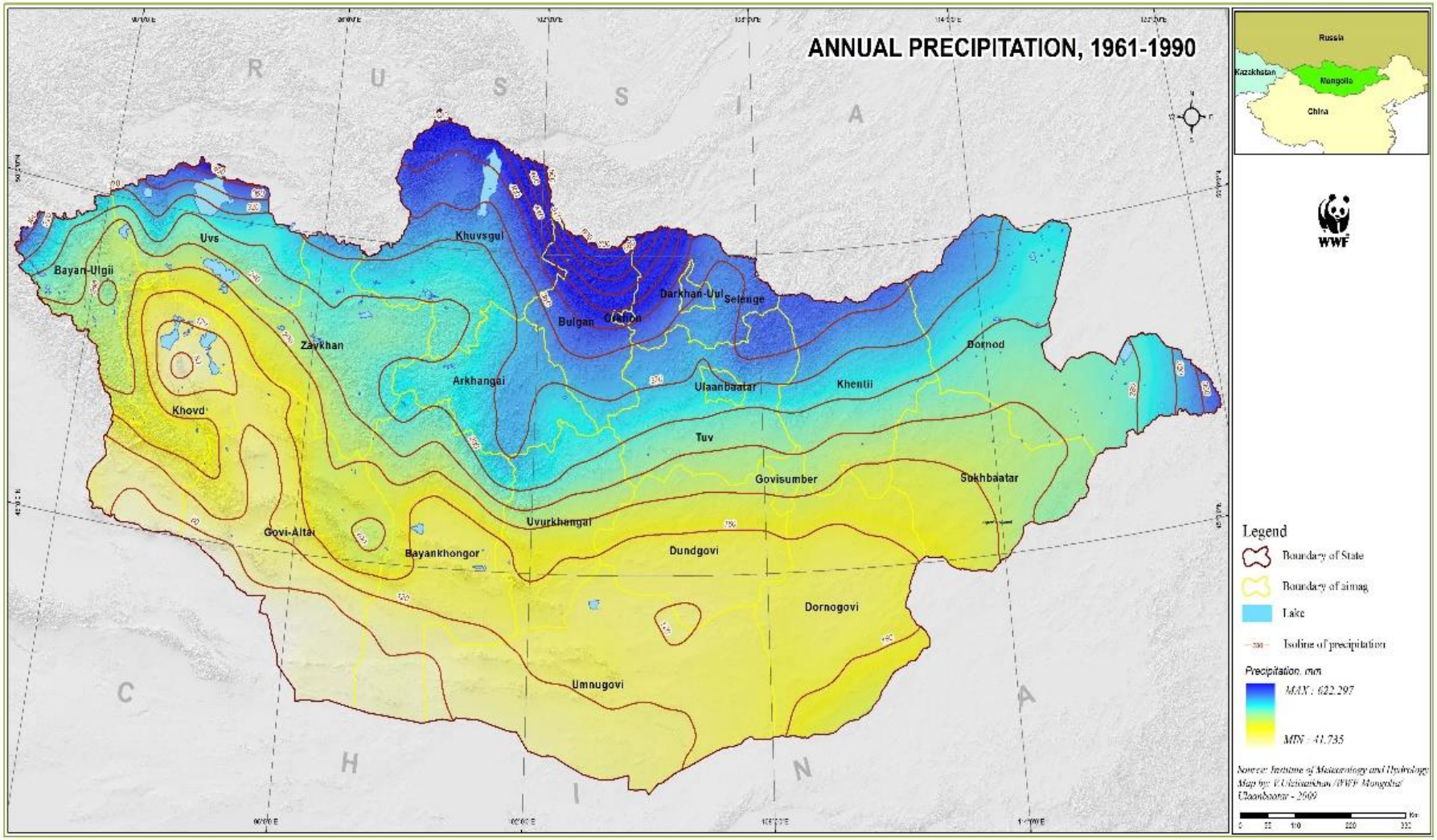
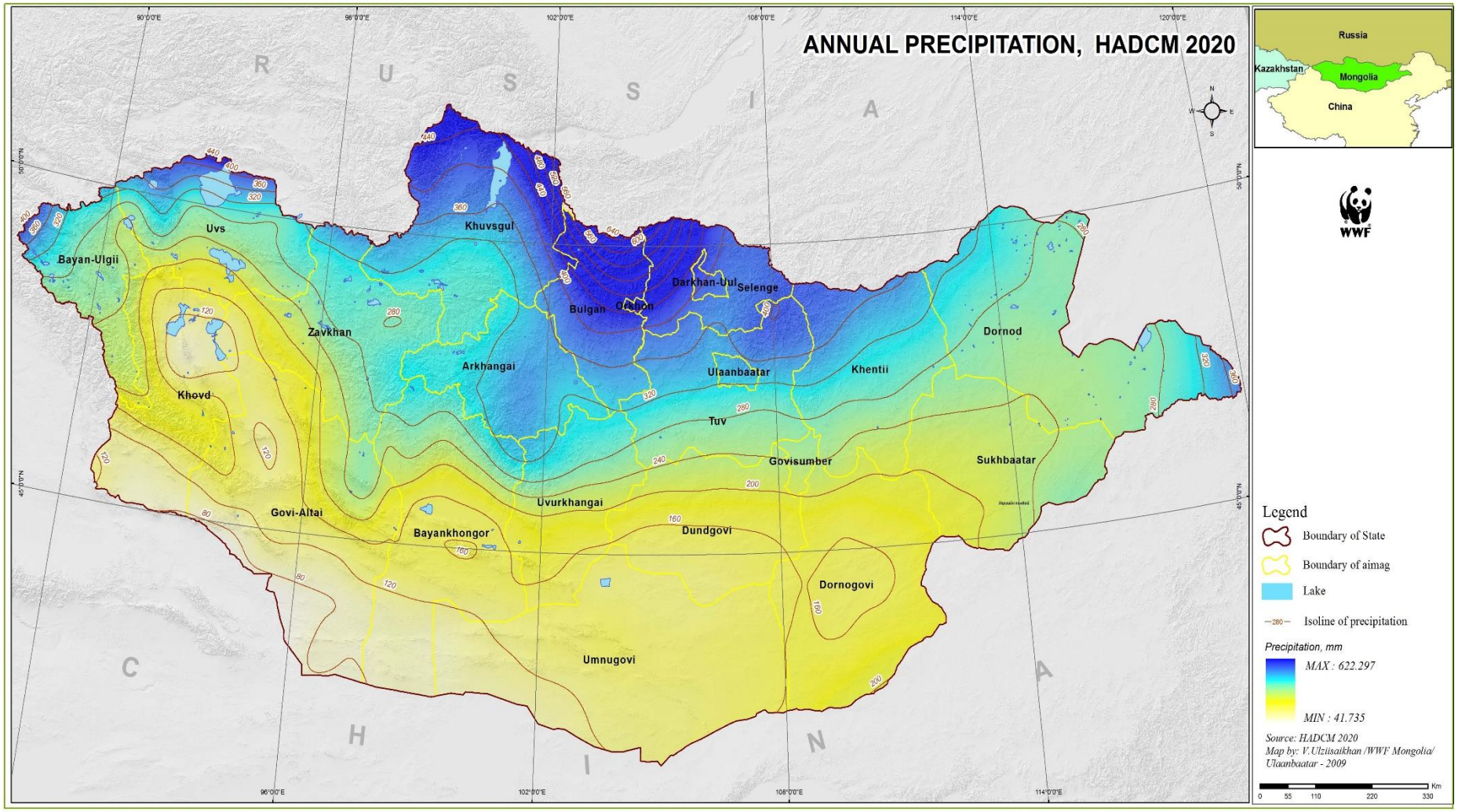
8 Annexes

Photo documentation

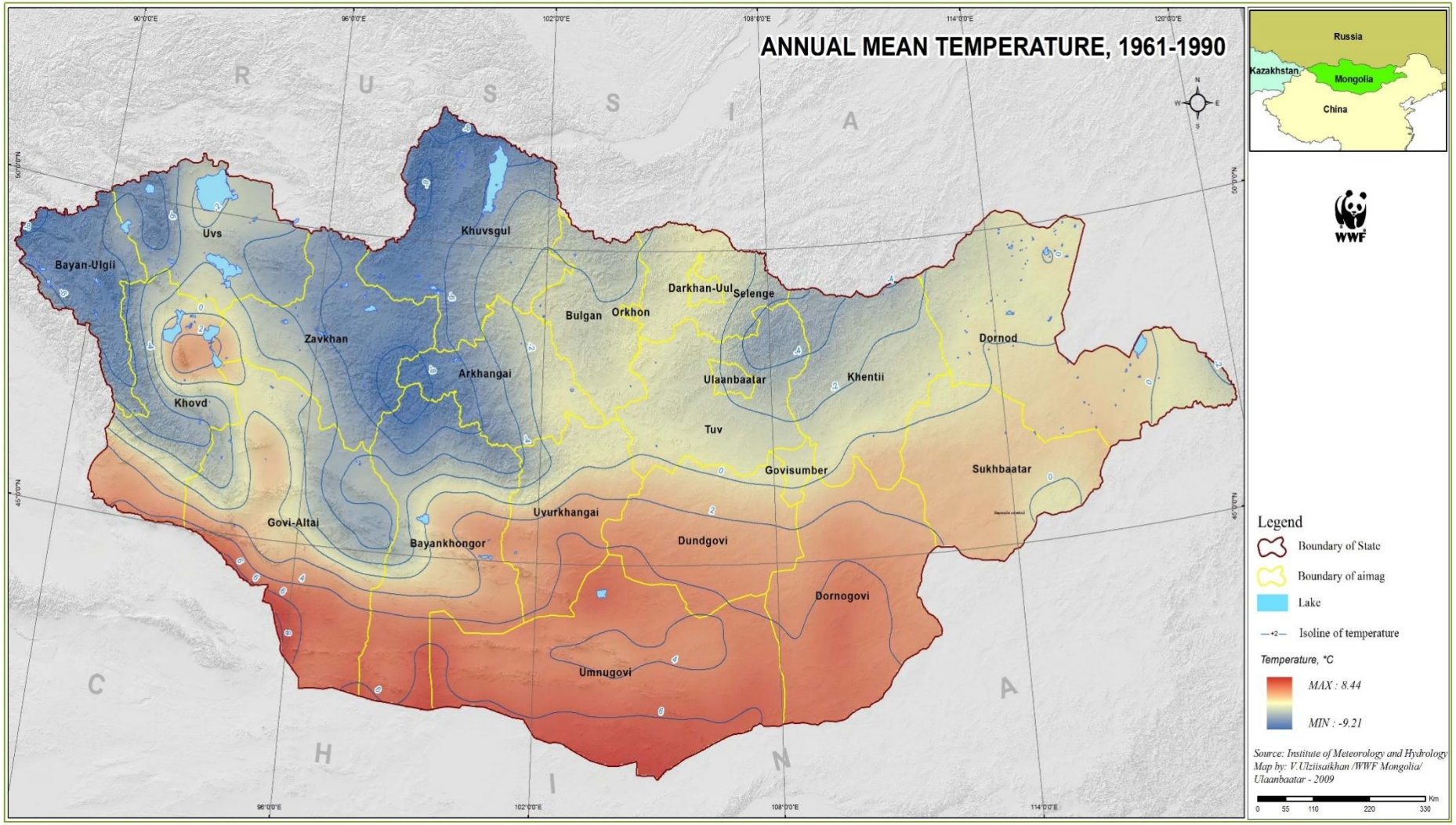
Content of pictures



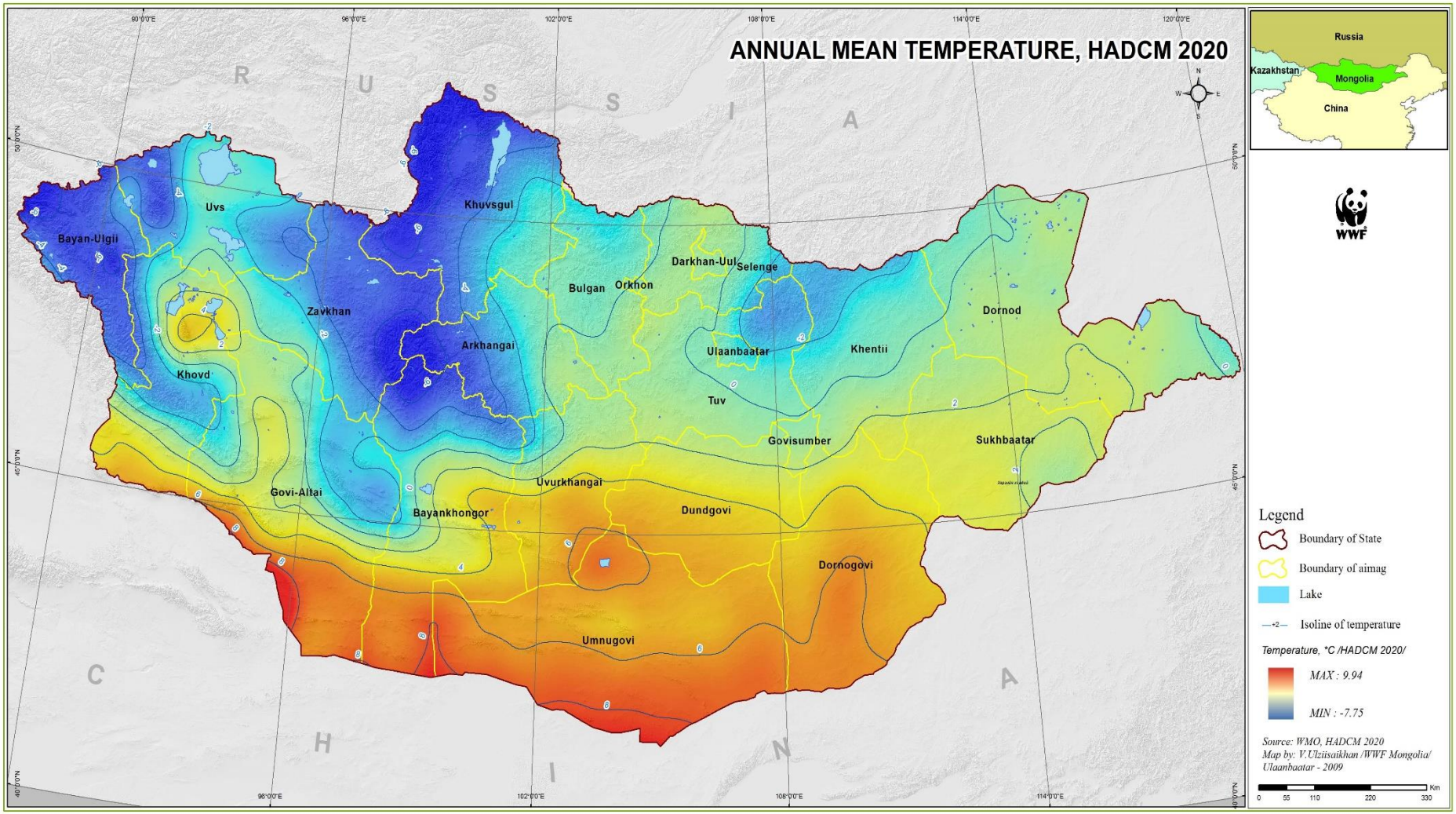
Picture 1: Annual precipitation, 1961 – 1990



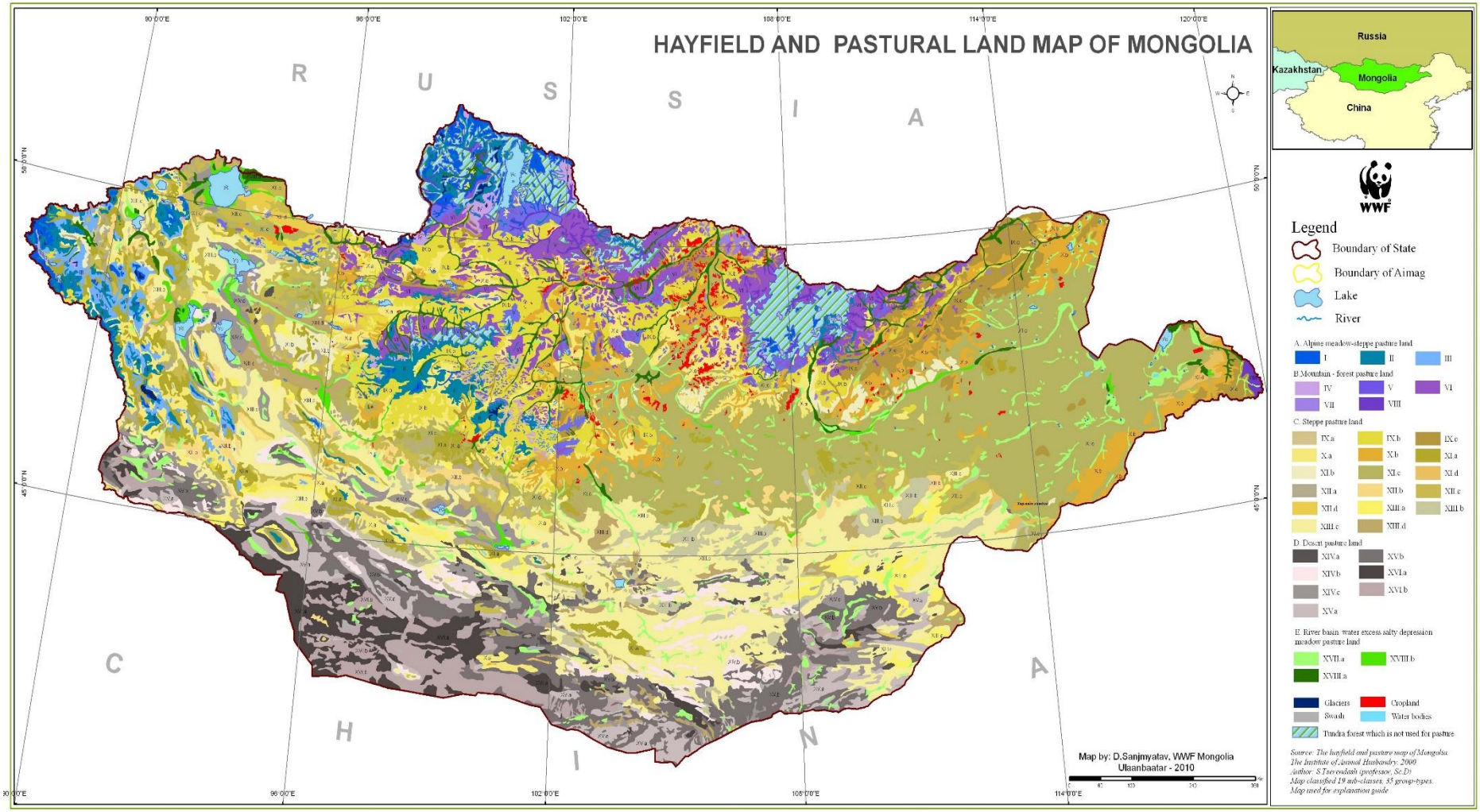
Picture 2: Annual precipitation, 2020



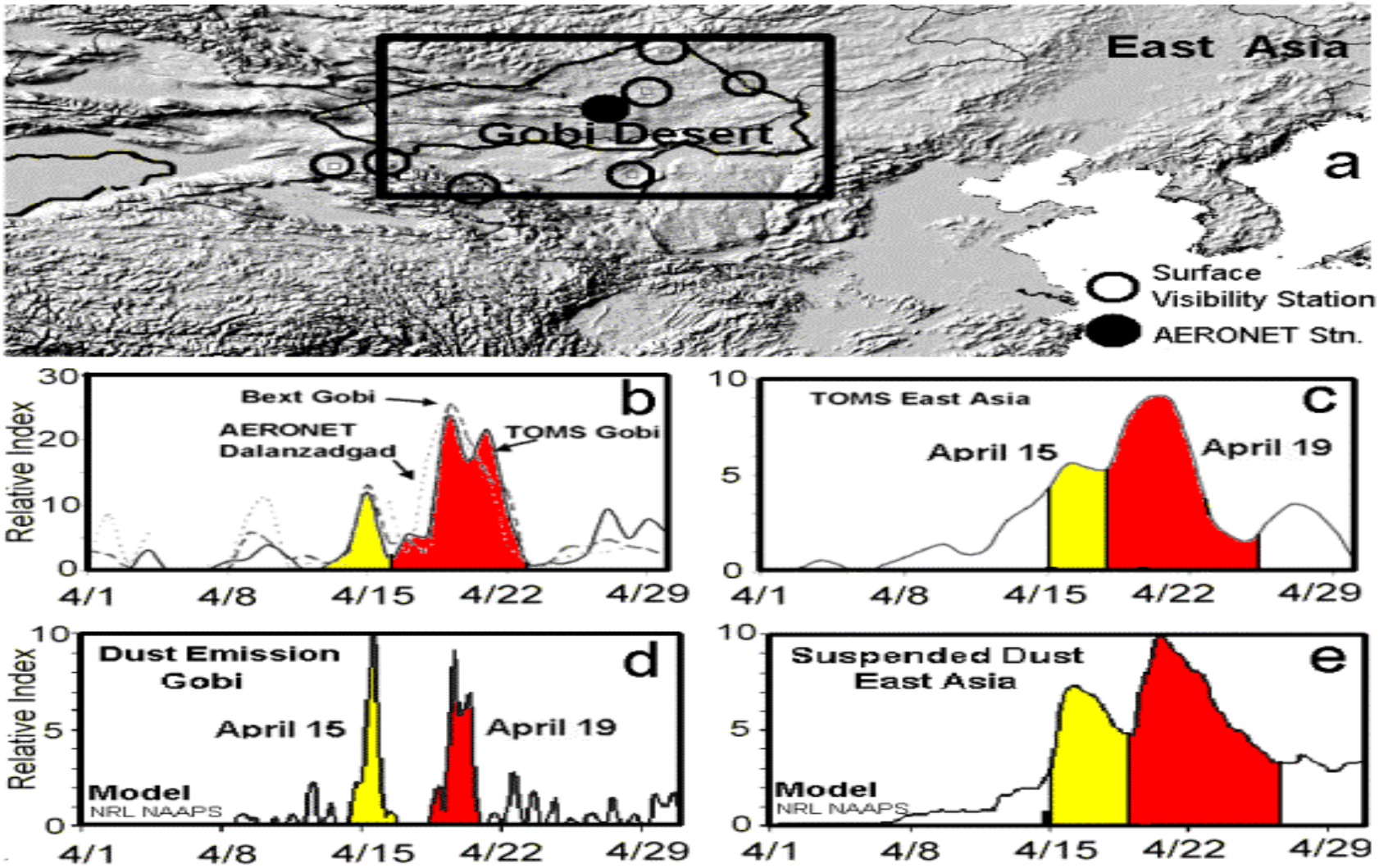
Picture 3: Annual mean temperature, 1961 - 1990



Picture 4: Annual mean temperature, 2020



Picture 5: Hayfield and pastural land map of Mongolia



Picture 6: Daily variation of aerosol during April 1998

Picture 7: Asiatic Ibex (Capra sibirca)

Picture 8: Jerboa (Jaculusorientalis)

Picture 9: Plate-tailed Gecko (teratoscincusprzewalskii)

Picture 10: Takhi (Equusprzewalskii)