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Final Report

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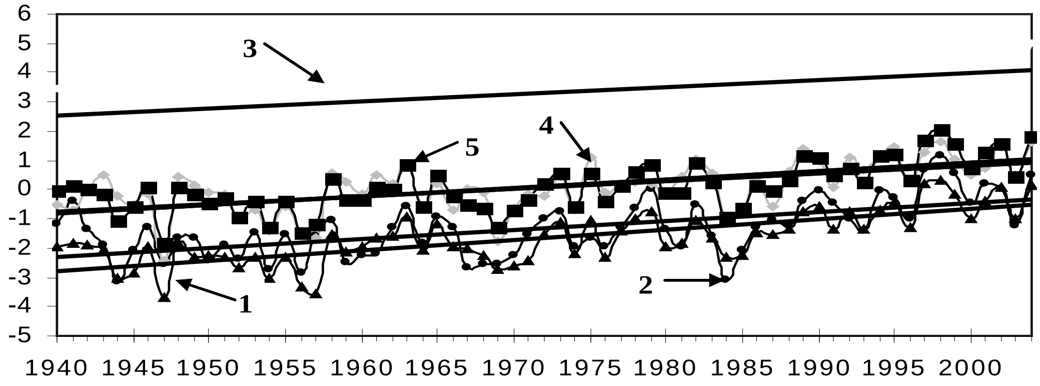
Climate Change – Mongolia

The global warming affects Mongolia stronger in comparison with other regions of the globe. According to the data of 48 meteorological stations evenly spread on the territory of Mongolia, over past 70 years the average annual temperature in Mongolia rose by 2.14º C. At the same time, in the period from 1990 to 2006 a small (-0.119 º C/year) temperature fall has been observed [2].

In the period from 1940-2004 winter air temperature rose by 3.6 º C, air temperature in spring rose by 1.4º C, summer air temperature rose by 0.6 º C and autumn air temperature rose by 1.9º C (Fig. 1)



1. Central; 2. Western; 3. Southern; 4. Eastern; 5 – Countrywide
Fig. 1 Dynamics of region-wise average longstanding air temperature in Mongolia

Climatic forecasts show that the territorial average monthly temperature of a warm season is expected to rise by 1.2-2.3º C in 2010-2039, by 3.3-3.6º C in 2040-2069 and by 4.0-7.0º C in 2070-2099 [6].

The maximum of rainfall in the gross annual rainfall in Mongolia falls out in summer months and varies from 300-500 mm in the mountains to 50-100 mm in the arid zones. In particular, in the Orkhon-Selenge basin the annual volume of rainfall is about 250-300 mm. At the same time a high evaporating capacity is characteristic of all regions of Mongolia. In the highland regions it is higher than the volume of rainfall and amounts to 500 mm/year, in the forest-steppe it amounts to 550-700 mm, in the steppe – 650-750 mm and in the desert areas it amounts to 800-1000 mm [2].

Nowadays a gradual increase of evaporating capacity from the ground surface it taking place practically in all natural zones of Mongolia: in semi-arid and steppe and desert zone by 3.2-10 per cent, while in the highland and taiga areas by 10-15 per cent. The total rainfall in different seasons is shown in Tab. 1

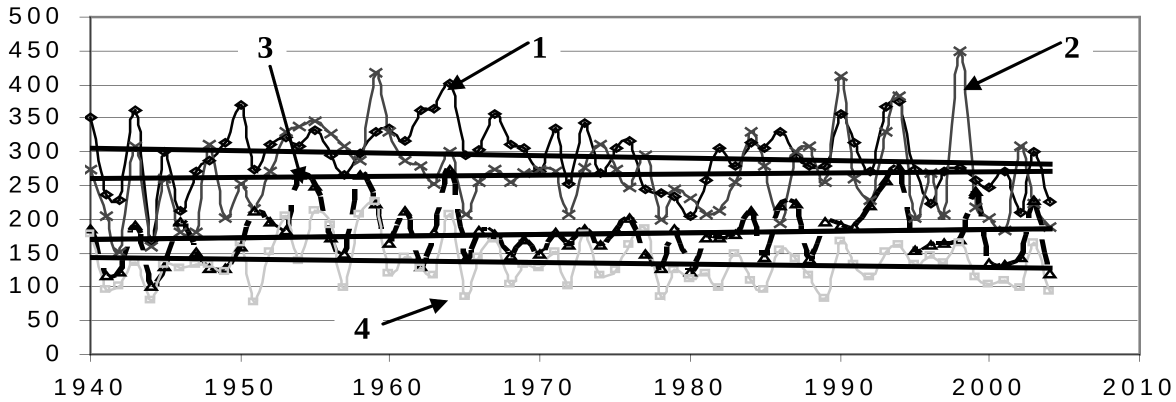
Tab. 1. Coefficient results of linear equation of total precipitation of different seasons

	Equation of Linear Trend a-Coefficient			
	1940-2006	1961-2006	1981-2006	1990-2006
Spring	-0.032	-0.027	0.416*	0.554*
Summer	-0.127	-0.475*	-1.433	-5.288**
Fall	-0.059	-0.087*	-0.485*	-0.712*
Winter	0.009	0.025	0.106*	0.129

Year	-0.206	-0.564*	-1.416*	-5.572**
Warm season	-0.250	-0.617*	-1.523	-5.518**

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

About 95 per cent of total rainfall falls out in a warm season and less than 3 per cent – in winter. Over the last 65 years the gross precipitation amount region-wise decreased by 8.7 – 12.5 per cent. Simultaneously, an annual redistribution of precipitation by seasons occurred. According to Tab. 1 data the winter precipitation amount rose while the precipitation amount in the warm season insignificantly fell. The amount of autumn precipitation rose by 5.2 per cent, winter precipitation rose by 10.7 per cent, while summer and spring rainfall, contrastingly, fell by 3.0 and 9.1 per cent respectively (Fig. 2). This dynamics of humifying and the increase of the average annual temperature contributes to climate aridization.



1- Central; 2- Eastern; 3 – Western; 4 – Southern

Fig. 2. The Long-time Average Annual Region-wise Dynamics of Rainfall in Mongolia.

Changes in rainfall will fluctuate approximately within ± 4% or 6-17 mm in the course of 2010-2039 with the expected rise by 7-8 per cent (27-33 mm) in 2040-2069 [6].

Climate change affects not only temperature, but landscape too. The number of droughts and rainstorms rises, changes occur in ecosystems, including plants and phytocenosis.

A comparison of pictures from 1992 (Fig. 3.1) and 2002 (Fig. 3.2) made with the help of satellite data with a 10-year difference from one another displays that the Earth's surface considerably changed: the desert areas grew in size while forested areas shrank. Surface water area shrank by 38 per cent from 1992 to 2002, but in 2006 area of the surface of the bodies of water grew. The surface of lands without grass vegetation grew by 46 per cent from 1992 to 2002 and by 2006 this exhausted area grew almost threefold. Meanwhile over the same period the forested areas decreased by more than 26 per cent [2].

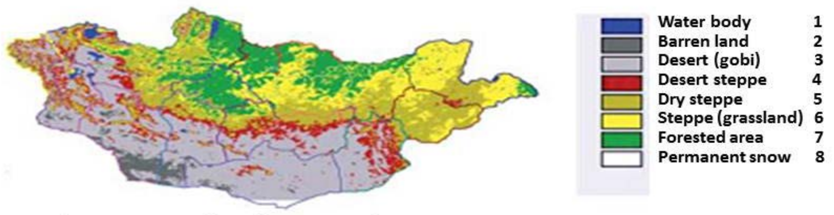


Figure 3.1. Land Surface Image in 1992

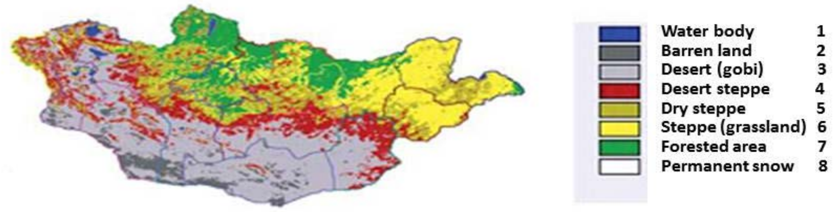


Figure 3.2 Land Surface Image in 2002

As the climate warms the gross amount of annual rainfall also increases. However, despite this fact the semi-arid and steppe zones will continue shifting northward and dryness here has a tendency to increase. These changes will be observed up to years 2070-2099. Vegetation zones with move northward and semi-arid and steppe zones will, most probably, broaden. In this way, the northern part of the country is considered a sensitive part. The northern part of the country has a tendency of transforming into a dry steppe zone, but if the permafrost melts quickly, wetness of the soil will increase. Therefore, the process of drying out will continue for a longer period of time. These processes will start affecting plants when wetness produced by the melting of permafrost decreases. The rise of a total amount of annual precipitation will reduce the aridity of this zone [2].

According to the research data gathered over the recent years changes in ice formation on rivers and lakes are concerned with the dates of ice cover formation and deterioration of condition and thickness of ice.

According to the 2007 inventory of water bodies , out of 5128 rivers and creeks that existed in the country at that moment 852 dried out. Out of 3747 lakes and ponds 1181 dried out and out of 9306 springs 2277 dried out. It was revealed that when the temperature rises the hydrological budget of a territory and the hydrological regime of vegetative ground cover considerably worsens [1].

As shown on Fig. 4 the surface waters volume grew from the mid-1970s to the 1990s, and then sharply declined from 1993 to 1994, experiencing fluctuations at this low level from 1994 to 2005.

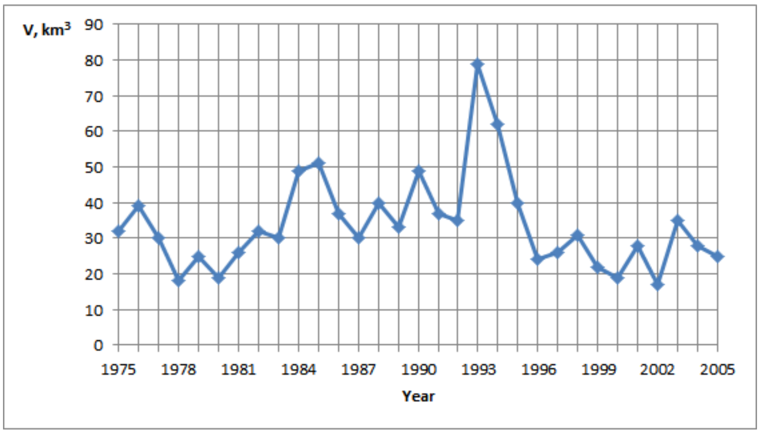


Fig. 4. Multiyear information on Mongolian surface water resources

The value of a seasonal thawing out of permafrost in the active soil layer over the last 30 years increased in the mountain system of Khubsugul by 0.6 – 1.6 cm. The average annual temperature of soil rose by 0.05-0.15º C in the Selenga basin. Besides, over the past 50 years such permafrost phenomena as frost-thaw processes, solifluction and thermal erosion. As a result of permafrost thawing out hollow spaces are formed in the ground. The growth of frost-thaw processes takes place approximately by 5-10 cm a year and in some places reaches 20-40 cm a year [2].

Regions where the size of permafrost shrinks will have wetter soil and this may have a positive effect on pastures. When a definite level of ground wetness is reached, a further thawing out of permafrost will negatively affect pastures and buildings. Besides, with the rise of soil wetness the level of underground and surface waters will rise too, which will result in the admission of water by rivers and creeks. However, later, when the water evaporates from the surface soil layers, the volume of surface and underground waters will decrease and this will lead to negative consequences, such as droughts.

As a result of such extreme natural phenomena as thunderstorms, floods, hailstorms and so on, the number of deadly cataclysms followed by death of people and economic losses considerably increased over the past 20 years. Natural disasters are now twice as frequent as they were 20 years ago. According to the data collected from the year 1970 Mongolia survived about 25-30 large natural phenomena and about one third of them resulted in disasters and the economic losses of 5 to 7 trillion tögrög [2].

The satellite monitoring of the Institute of Geo-ecology shows that 78.2 per cent of Mongolia’s territory are exposed to middle and high-speed aridization. This led to a 20-30 per cent decrease in the growth of grazing lands and a significant growth of animal husbandry’s vulnerability. In the connection with the climate change and a growth of very hot summer days summer conditions of grazing cattle modified. Over the past 20 years the number of days when people limit grazing time by over three hours increased by about seven days. Research results show that the recent effects of the climate change on grazing are, by most part, negative. They result in production losses in cattle breeding and affect the economic efficiency of animal husbandry. If today the length of grazing in summer takes 25 per cent of all grazing period, by 2020 this time will decrease almost twice.

Despite a prognosticated small growth of annual precipitation, there will ne negative natural changes in Mongolia concerned with the climate warming (an increase of aridity, migration of arid and steppe zone plant vegetation northward).

An increased number of extremely hot days during blooming and pollination of crops, which takes place in July with the agricultural crops, when the air temperature rises to +26° C and higher is a factor of yield depression.

A tendency of shrinking of boreal forest area continues in the total forested area. Under the influence of many factors including the climate change, insufficient wetness, droughts the forest ecosystems change toward weakening of ecological functions, including water regulation and soil protection. The current climate change exerts a negative influence on the growth of forest resources.

Arid Mongolian steppes are in the zone of insufficient wetness. The average annual precipitation is 235-240 mm. Over 60 per cent of this amount accounts for summer. Intensive droughts continued over 10-12-year periods, less intensive ones took place more often. At present a long period of drought is observed (2000-2007). In 2006 there were a little over 90 mm of precipitation and over the first six months of 2007 there were only 21 mm of precipitation or 1/10 of the average annual standard norm. This led to a sharp deterioration of the living conditions of dominants and co-dominants of plant complexes and a production loss and diminishing of nutritive properties of animal feed. In the connection with an increased pasture load and paucity of precipitation the species diversity here dropped from 24 to 13 species and harvesting capacity fell tenfold [5,6].

As it pertains to the creation of a legal and regulatory framework in the field of climate change and the reduction of climatic disaster risks, the Government of Mongolia ratified the Kyoto Protocol in 1999 and carried out the following measures within the Framework Convention on Climate Change:

- A National Action Plan on Climate Change was developed (NAPCC, 2000);
- Millenium Development Goals were formulated for Mongolia (MDGs-based CNDS, 2008);
- The First National Communication (2001) and the Second National Communication (2010) on climate change were prepared;
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Besides, over the past years the National Water Program (2010), National Program Against Aridization (2010), National Forest Program, National Global Climate Change Program (2011), National Natural Disaster Protection Program were developed. Also a document under the title “The Evaluation and Development of a Strategic Measures Program for the Adaptation to Climate

Change Consequences and Survey and Analysis of Relevant Activity in the Current Policy, Goals in the Nature Protection Planning."

Fig.5 shows the total volume of greenhouse gas emissions (GHG) in the Carbon Dioxide Equivalent in Mongolia in the period from 1990-2006. Calculations indicate that pure greenhouse gas emissions in 1990 amounted to 22532 thousand tons in Carbon Dioxide Equivalent and were limited to 14850 thousand tons in 1995.

The decrease in greenhouse gas emissions occurred mainly due to an economic downturn in industry during the transition period from socialism to market economy. Yet it is in this period that methane emissions elevated due to the growth of livestock population [2].

The energy production sector (including stationary sources of energy, transport and unorganized emissions) is the main source of greenhouse gas emissions and provides 65.4 per cent (10.213.09 thousand tons) of the total greenhouse gas emissions volume (Fig. 6). The second largest source of greenhouse gas emissions is the agricultural sector (41.4 per cent). Other relatively small sources are industrial production emissions and wastes.

In land use and forest management in 2006 the total volume of carbon dioxide absorption was larger than the total volume of carbon dioxide emissions by 2.082.6 thousand tons (13.3 per cent) in the connection with the growth of derelict land area and shrinking of the newly cultivated lands.

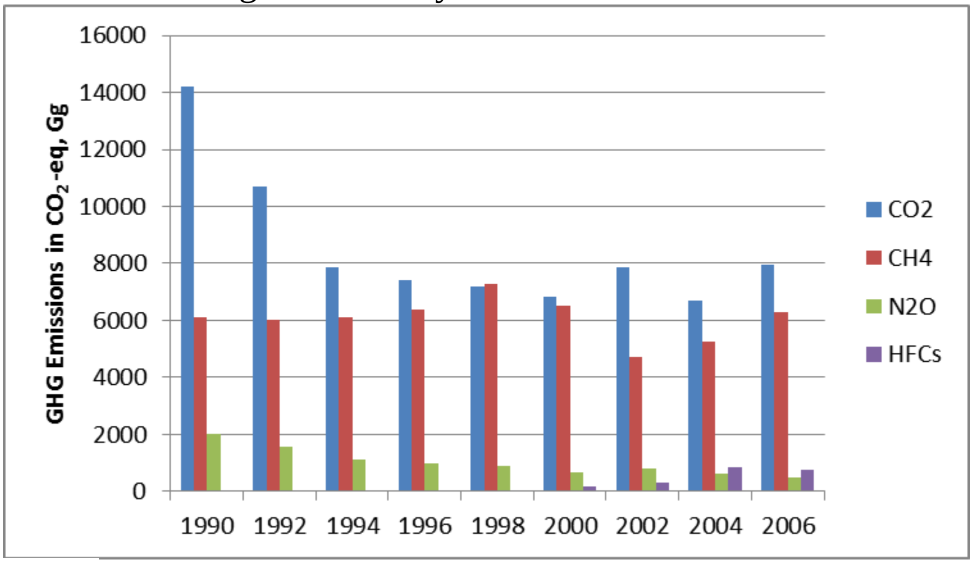

Fig. 5 Total GHG emission in the CO_2 –eq by gases of the period 1990-2006

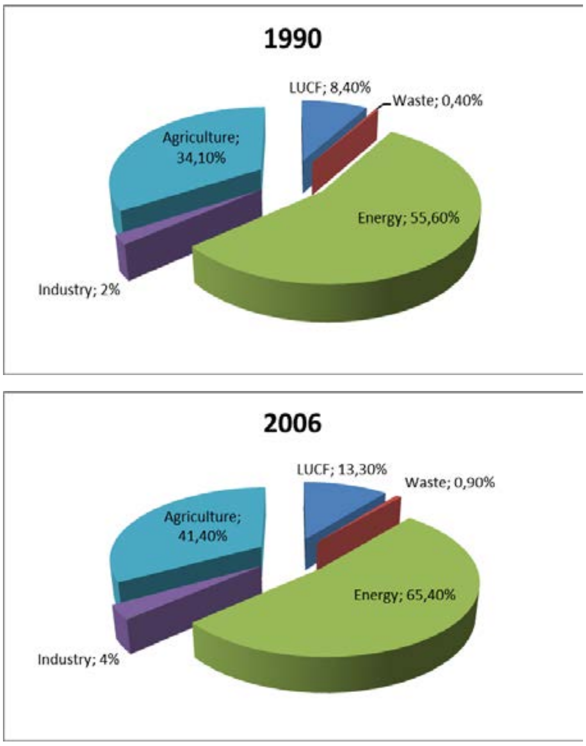

Fig. 6. Contribution of CO_2 –eq emission by sector for 1990 and 2006

Though the GHG emissions volumes in Mongolia are relatively low, still the indicator "greenshouse gas emissions volume per capita" (6 tons of Carbon Dioxide Equivalent) is relatively high in comparison with other developing countries.

Among the sources of energy coal is the main fuel in Mongolia. Its share in 2005 amounted to 66.3 per cent. Oil follows with 22.7 per cent, hydroelectric power stations and other renewable sources of energy make up only 11 per cent.

Forecast calculations shows that by 2020 the total emissions volume in Mongolia will increase more than fivefold.

One of the permanent measures to limit the GHG emissions is the enhancement of coal quality since it does not comply to minimal standard requirements and the efficiency upgrading of burning of fossil fuels on account of equipment modernization.

- electric power loss recovery during its transmission and distribution by installment of more energy efficient equipment on supports and in electrical substation by changing old and ineffective electric transformers;
- provision of strict control and prevention of electric power theft;
- improvement of thermal insulation of buildings;

- change of inefficient incandescent electric lamps by energy-efficient fluorescent tubes consuming approximately 70 per cent less electric power;
- development and use of renewable energy sources, such as hydroelectric engineering, wind driver generators and solar batteries, and the use of biofuels;

The main measures to mitigate the consequences of GHG emissions in the forestry complex are:

- reduction of woody tissue and other forest biomass consumption;
- forest reclamation;
- natural forest restoration;
- agricultural afforestation.

The Global Warming Influence on the Climate of Lake Khubsugul

An analysis of dynamic changes of Lake Khubsugul is made on the basis of data obtained after deciphering of high resolution space images taken over three time periods (1992-2000, 2000-2008 and 1992-2008). In particular, Landsat TM space images from 1992 (1-5.7 spectral channels) and Landsat ETM from 2000 and 2008 (1-5.7 spectral channels) were used. Reliability of the results is 90.1 per cent for 1992 and 93.2 per cent for 2008 [8].

On the maps presented below (Fig. 7) it is visible that the area of Lake Khubsugul grew in the recent years. On the one hand, global warming processes exert influence on this process. They result in thawing out of permafrost and glaciers. On the other hand, there are man-induced factors. In the north of Cis-Khubsugul area two small contemporary glaciation centers were exposed and its whole territory is located in the zone of insular permafrost. A belt of continuous outspread of permafrost is associated with the highland areas surrounding the lake.

In the transitional area between the Siberian taiga and the Central desert area the warming is very sharply manifested. The average annual temperature of this region according to Khatgal station data equals – 4.5° C. According to the data over the past 43 years the temperature rose by 1.7° C. In winter it rose by 3.1 ° C, in spring by 2.1° C, in summer by 1.4° C and in autumn by 0.9° C [7].

In Dalbai valley where there is no grazing of domestic animals the depth of thawing of the permafrost is 1.4 meters and in Turaga valley where there are numerous herds of grazing animals this indicator reaches 4.8 m. Due to overgrazing the pastures are exposed to degradation of the soil cover and this results in the thawing of permafrost. When comparing the areas with plant vegetation cover and without vegetation it turned out that the soil temperature of thickly covered areas in lower by 2.2° C, under bushes and light forest by 3.6° C, under thick forest by 4.9° C and on areas with advanced moss carpet it is by 6.4° C lower than on bare spots [3]. In the lower part of northern slopes, where the thawing of seasonal permafrost is not so deep and on the lake shores when the moss carpet disappears, the thawing of the permafrost layer is more active [4]. Therefore among the reasons of permafrost thawing the man-induced factors play a very important role. In sum, it results in the increase of water level in Lake Khubsugul and in other nearby lakes.

1992 – water area 2732.3 sq km, length 436.25 km

2000 – water area 2782.7 sq km, length 446.27 km

2008 – water area 2792.1 sq km, length 454.11 km

Changes 1992-2000: area increased by 50.4 sq km

Shore line increased by 10.02 km

Shore line increased by 17.86 km

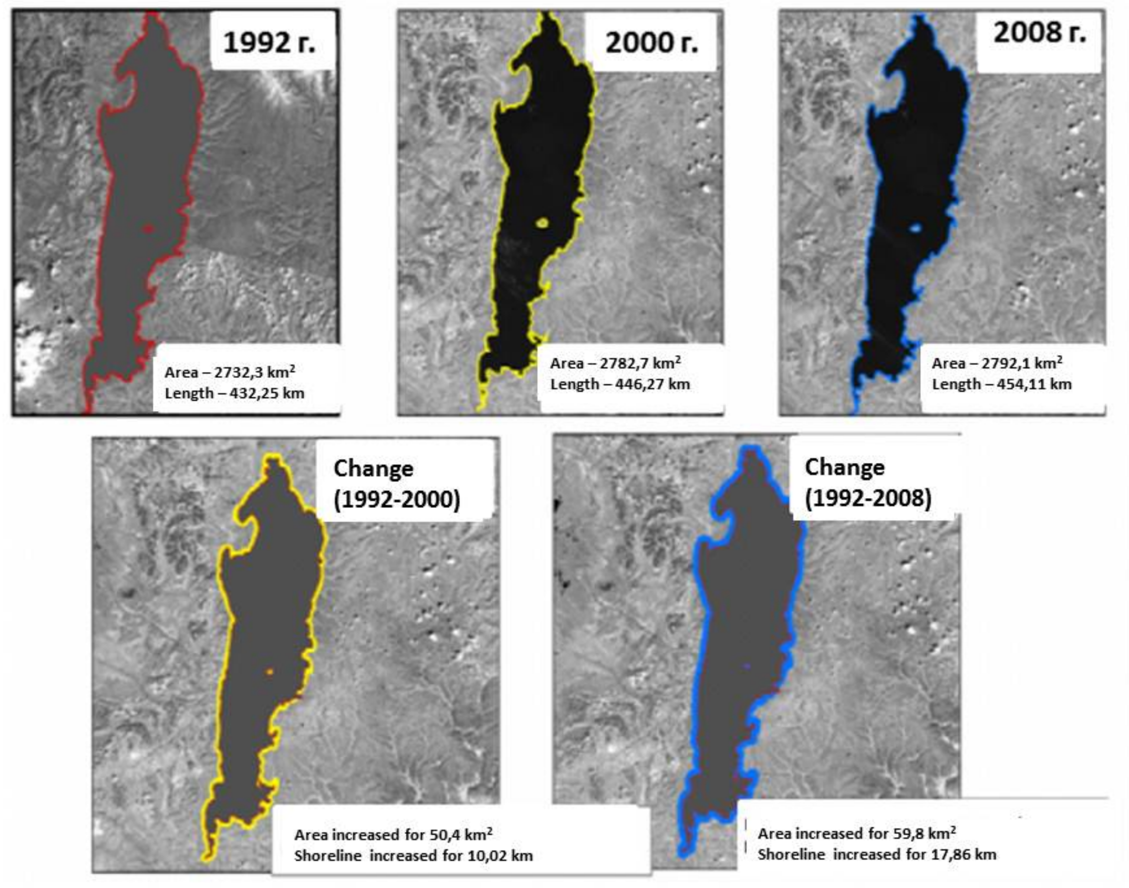

Fig. 7. The dynamics of Lake Khubsugul water area change

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