The agroclimatic resource change in Mongolia

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Introduction

At the present climate change is taking much more attention of scientists from different countries of the globe. There is significant change in land cover due to an increasing of anthropogenic forcing, such as desertification and deforestation may affect climate by changing the hydrological cycle and surface energy balance. Therefore we have to better understand the climate change at the regional and global levels and its impact to social and economics.

The vegetation plays an important role in the transfer of matter and energy from the Earth's surface to the atmosphere. Interactions between the land surface and the atmosphere, and the resulting exchanges of energy and water have a large effect on climate (Sukla & Mintz 1983). Its leaves square, height, development, vegetation cover, leaf orientation angle etc characterize a vegetation canopy.

Mongolia is a landlocked country, which has dry and continental climate because of high altitude and big distance from seas and ocean and surrounded by high mountains. On the other hand, Mongolian traditional animal husbandry is heavily dependent on pasture, which completely defined by weather conditions of a year.

Pasture biomass and phenological stages determined by heat and moisture conditions during the whole growing season/period between any two stages of plants. Any plant biomass and phenology occur in agro climate conditions.

One of the most significant sectors of Mongolian economy is agriculture. Since 1960-s the agriculture in our country has started to develop more intensively and widely. Recently Mongolia has 1.3 million hectares of arable land that can produce environmentally clean and friendly products.

According to above mentioned we have calculated and compared the annual air temperature, the crossing date for 0^{0}C, 5^{0}C and 10^{0}C, precipitation, soil moisture and their change in the last 30-40 years in Mongolia. Also we have tried to do some statistical and time series analyses. This research is based on meteorological and agrometeorological observational data at the stations of Mongolia.

Used data and methods

In the recent study we have used the meteorological and agrometeorological data from 1961 to 2004. In this paper mostly used the time series analyses and statistical methods.

Results

Temperature is one of the mean factors for the growth and development of agricultural crops. Most useful characteristics of temperature are the crossing date, sum of active and effective temperature above the biological minimum of plants.

The annual air temperature has increased by 1.9^0C in Mongolia for the period from 1940 to 2004 [P.Gomboluudev, IMH, Mongolia].

Firstly, we have analyzed the annual air temperature for the period between 1961 and 2004 for different natural zones of Mongolia. Due to the annual air temperature warming the crossing date of air temperature through the 0^0C and 5^0C in the spring and in the autumn have changed.

Table 1. The crossing date of air temperature through the 0^0C and its duration

	National zone	Periods	In the spring	In the autumn	Duration of period
1	The high mountains, forest steppe	1961-1990	4/20	10/9	172
		1991-2004	4/15	10/11	179
		Difference	By 5 days early	By 2 days later	By 7 days longer
2	The forest steppe	1961-1990	4/10	10/16	189
		1991-2004	4/4	10/18	197
		Difference	By 6 days early	By 2 days later	By 8 days longer
3	The steppe	1961-1990	4/9	10/19	193
		1991-2004	4/3	10/20	200
		Difference	By 6 days early	By 1 day later	By 7 days longer
4	The desert steppe	1961-1990	4/2	10/24	205
		1991-2004	3/30	10/25	209
		Difference	By 3 days early	By 1 day later	By 4 days longer
5	The desert	1961-1990	3/25	10/31	220
		1991-2004	3/22	11/2	225
		Difference	By 3 days early	By 2 days later	By 5 days longer
6	The high mountains, desert steppe	1961-1990	4/7	10/18	194
		1991-2004	4/4	10/20	199
		Difference	By 3 days early	By 2 days later	By 5 days longer

The number of days with temperature above 0^0C and 5^0C are increased in the study area. Recently 188-202 days or 51.5-55.3% of a year are days with temperature above 0^0C in Mongolia.

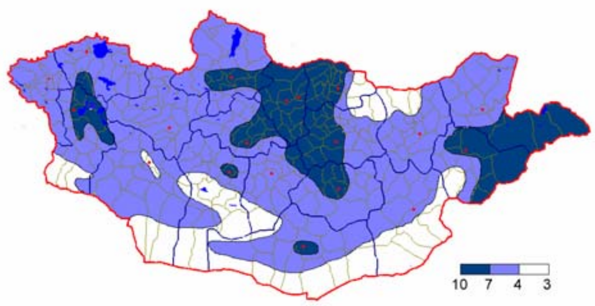

Fig 1. Change of days with temperature above 0^0C

Figure 1 shows the change of days with temperature above 0^0C. In the last 14 years number of days with temperature above 0^0C is changed by 3-10 days depending on natural zones and locations, by 3-4 days in the Govi, 7-10 days in the Great Lakes Depressions, big rivers basin and by 4-7 days in the rest of areas.

Table 2. The sums of effective and active temperatures above 0^0C, 5^0C and 10^0C

	National zone	Period	Active sum temperature			Effective sum temperature	
			0	5	10	5	10
1	The high mountains, forest steppe	1961-1990	1573	1420	1045	771	223
		1991-2004	1742	1570	1240	900	320
		Difference	169	150	195	129	96
2	The forest steppe	1961-1990	2149	2051	1757	1289	600
		1991-2004	2344	2250	1960	1453	735
		Difference	195	199	203	164	135
3	The steppe	1961-1990	2381	2295	1987	1489	766
		1991-2004	2552	2456	2163	1761	883
		Difference	171	161	176	272	117
4	The desert steppe	1961-1990	2620	2528	2241	1684	908
		1991-2004	2783	2689	2425	1831	1034
		Difference	163	161	184	147	127
5	The desert	1961-1990	3134	3044	2771	2112	1246
		1991-2004	3314	3231	2934	2273	1380
		Difference	180	187	163	161	134
6	The high mountains, desert steppe	1961-1990	2249	2154	1832	1361	661
		1991-2004	2406	2322	1995	1501	777
		Difference	157	168	163	139	116

In the last 14 years the sum of active and effective temperature above the biological minimum is increased by 55-210^0C (Fig 2 & 3) for the growth period in the region, but ranging cross over the country. The increase was 55-100^0C in the Mongol Altai ranges and some of Khentii Mountains, 101-120^0C in the Khangai and Khuvsgul mountains and the steppe and 121-210^0C in the rest of the area.

For each phenological phase of pasture plant growth require specific temperature condition and this situation depend on plant species, climate and geographical location etc. Study in last 15 years shows that sum of active temperature above 5^0C and 10^0C have been in the mountain area and steppe regions by 96-112^0C degree and desert and Govi region by 127-147^0C.

It says that, the heat provision is good for agricultural crops in Mongolia. Due to increasing of active and effective temperature growth period is delayed by 3-10 days.

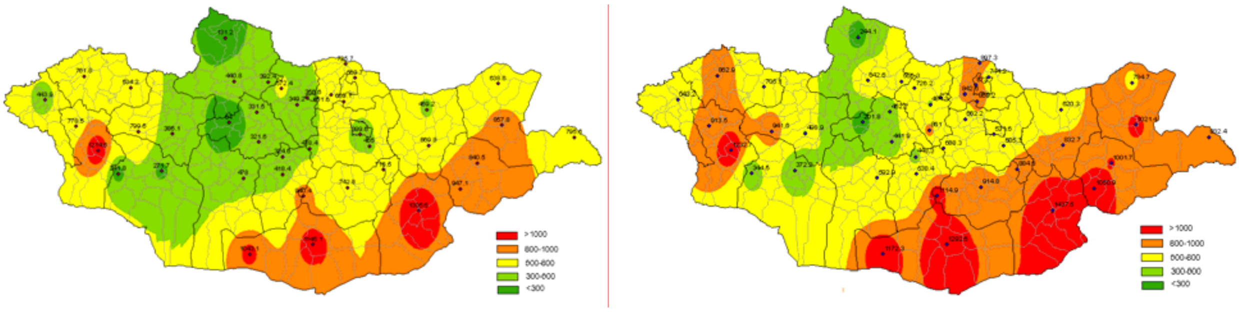

Fig 2. The change of sum of active temperature above 10^0C, 1960-1990 & 1991-2004

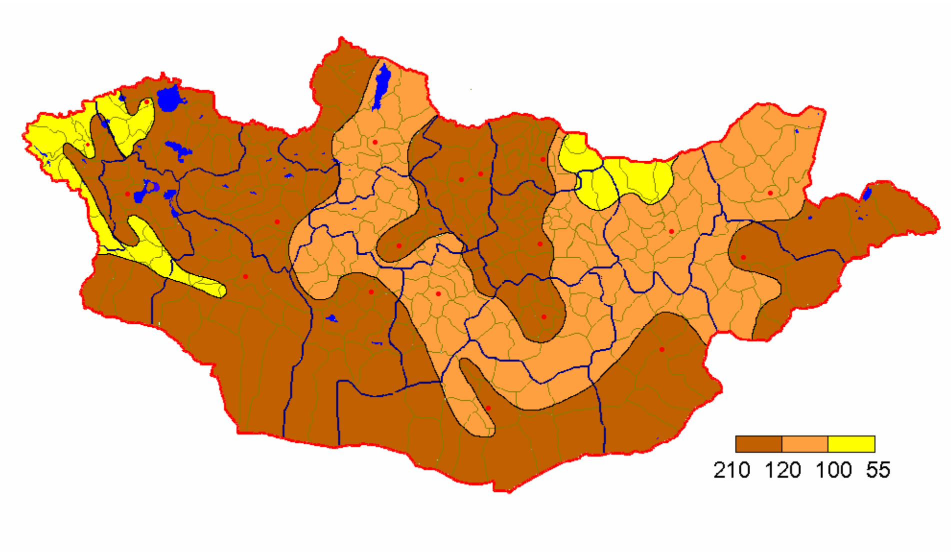

Fig 3. The change of sum of effective temperature above 5^0C

The duration of non-frosted period in the agricultural regions of Mongolia is increased by 7-27 days in the last 14 years.

The number of days with temperature higher than 26^0C in the period of May-July in Mongolia has increased by 2-7 days. An another study shows, that number of days, where air temperature exceeds 30^0C has increased by 1-2 days from June to August in mountain and steppe, steppe and desert steppe regions. In case of ground surface temperature, number of days, where temperature exceeds 40^0C also has increased by 1-5 days.

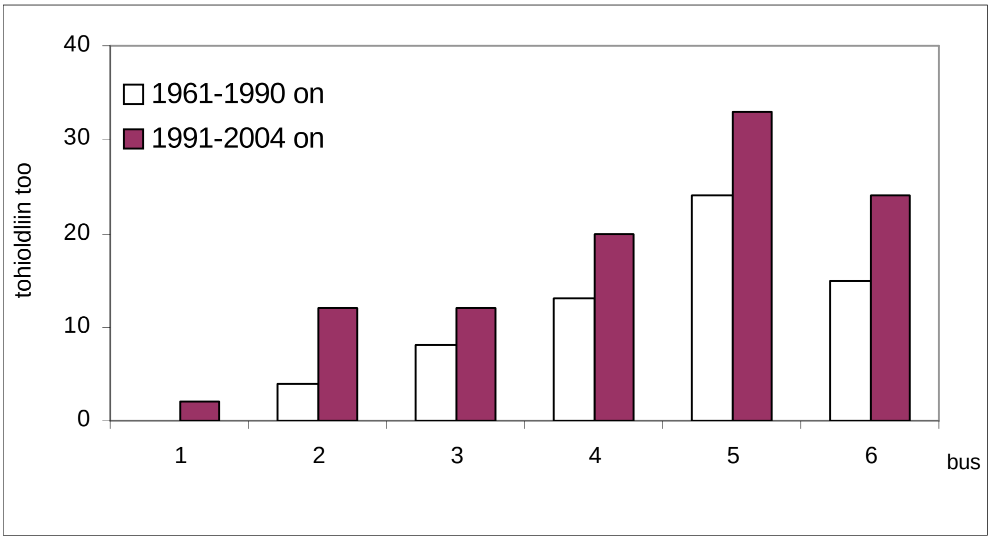

Figure 4. Number of hot days with temperature exceeded 30^0C during growing season

Comment: 1-the high mountains, forest steppe, 2-the forest steppe,
3-the steppe, 4-the desert steppe, 5-the desert, 6-the high mountains, desert steppe

According to the above figure, hot days occurred 4-8 times in the forest steppe and the steppe, 13-15 times in the desert steppe and the high mountains desert steppe and 24 times in the desert for the period of 1961-1990. Although, last 15 years, number of hot days has grown by 2 days in the high mountains forest steppe, 4-8 days in the forest and the steppe and 7-9 days in the desert steppe, the desert and the mountains desert steppe.

Annual precipitation in Mongolia normally is low. Annual mean precipitation in Khangai, Khentei and Khovsgol mountains ranges vary 300-350 mm and in Mongolian Altai, steppe and desert regions 250-300, 150-250 and 20-150 mm, respectively. Precipitation amount increase with elevation and relief has important role in precipitation distribution. Generally, precipitation amount decrease from north to south and from west to east direction. About 85 percent of annual amount fall within warm months from April to September and from them 50-60 percent fall just within two months, July and August.

In the research, number of days with 0 mm and more 5 mm precipitation was analyzed and shown in Table 3.

Table 3. Number of days with 0 and 5 mm more than precipitation

1	National zone	Years	Month						Sum
			4	5	6	7	8	9	
Number of day with 0 mm precipitation									
1	The high mountains, forest steppe	1961-1990	5	7	12	17	14	8	63
		1991-2004	5	8	13	16	14	8	64
		difference	-	1	1	-1	-	-	1
2	The forest steppe	1961-1990	5	6	11	14	12	7	55
		1991-2004	5	7	12	15	13	8	60
		Difference	-	1	1	1	1	1	5
3	The steppe	1961-1990	4	5	9	12	11	7	48
		1991-2004	4	6	10	13	11	6	50
		Difference	-	1	1	1	-	-1	2
4	The desert steppe	1961-1990	2	3	6	9	7	4	31
		1991-2004	3	4	6	9	8	3	33
		Difference	1	1	-	-	1	-1	2
5	The desert	1961-1990	2	2	4	7	6	4	25
		1991-2004	2	3	5	7	7	3	27
		Difference	-	1	1	-	1	-1	2
6	The high mountains, desert steppe	1961-1990	3	4	7	10	8	4	36
		1991-2004	3	4	6	10	7	3	33
		Difference	-	-	-1	-	-1	-1	-3

Due to the global warming during the last 14 years amount of precipitation for the growing period has decreased and precipitation amount of the cold period has increased by 5%.

Depending on precipitation amount for the growth period in Mongolia the soil moisture is also decreasing in the last 30 years.

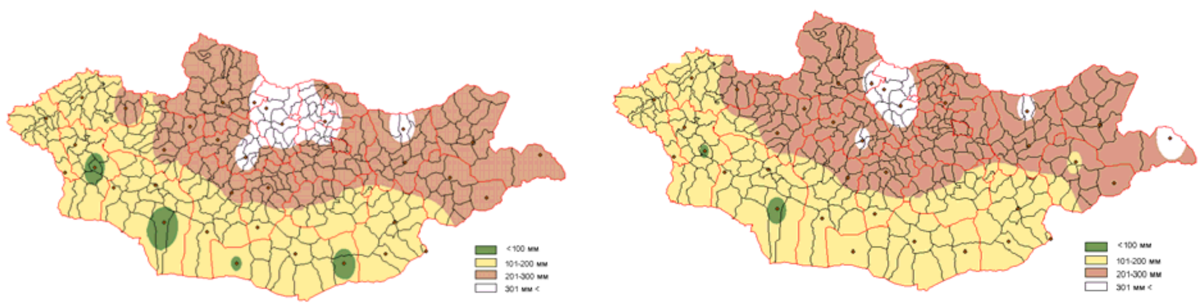

Fig 5. The precipitation change, 1960-1990 and 1991-2004

Number of rainy days with 0 mm has increased by 1-2 in the mountains forest steppe, the steppe, the desert steppe and the desert and 5 days in the forest steppe and in contrast to that rainy days dropped by 3 days in the mountains desert steppe.

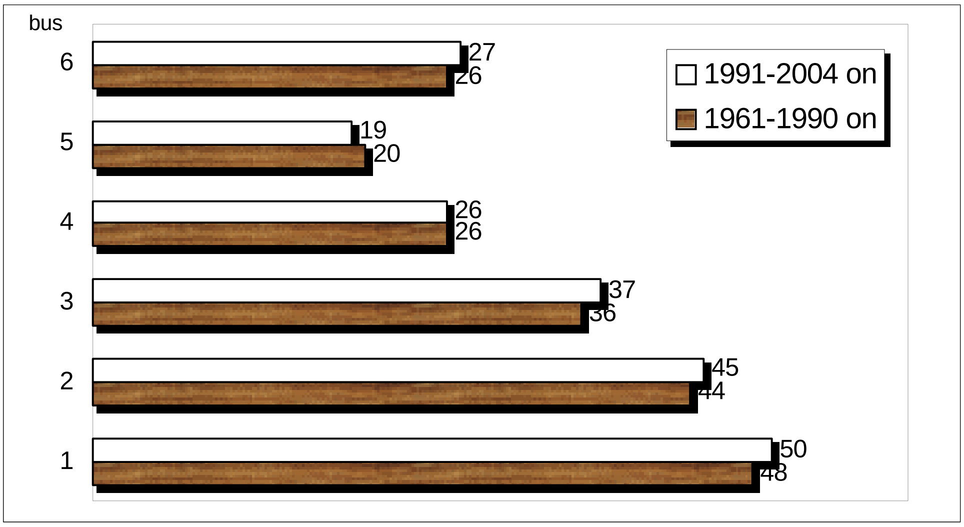

Figure 5. Number of rainy days with more than 5 mm during the growing season

Comment: 1- the high mountains, forest steppe, 2-the forest steppe,
3-the steppe, 4-the desert steppe, 5-the desert, 6-the high mountains, desert steppe

Figure 5 present that in the last 15 years number of rainy days with more than 5 mm has increased in almost all area except the desert and the desert steppe which means heavy rain occurance is tend to be more frequent.

Conclusions

The air temperature is warming in Mongolia. Due to this warming crossing date of air temperature through the 0^0C and 5^0C in the spring and in the autumn are changed. The number of days with temperature above 0^0C and 5^0C are increasing in the study region. Recently 188-202 days or 51.5-55.3% of a year are days with temperature above 0^0C in Mongolia.

In the last 14 years $55\text{-}210^0$C increases the sum of active and effective temperature above the biological minimum for the growth period in the region.

The duration of non-frosted period in the agricultural regions of Mongolia is increased by 7-27 days in the last 14 years.

The number of days with temperature higher than 26^0C in the period of May-July in Mongolia has increased by 2-7 days.

Due to the global warming during the last 14 years amount of precipitation for the growing period has decreased and precipitation amount of the cold period has increased by 5%. Number of rainy days with 0 mm has increased by 1-2 in the mountains forest steppe, the steppe, the desert steppe and the desert and 5 days in the forest steppe and in contrast to that rainy days dropped by 3 days in the mountains desert steppe.

Depending on precipitition amount for the growth period in Mongolia the soil moisture is also decreasing in the last 30 years.

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