Climate Change and Agriculture

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Global climate change is appearing in clear and unique ways in Mongolia and influencing on ecosystems, natural resources and socio economic sectors such as agriculture, health and others of Mongolia. Therefore, adaptation to climate change and mitigation of greenhouse gases are strategically important for Mongolia as a developing country.

Fragile ecosystems, lifestyle of people and economic system of the country are considered very vulnerable to climate change. In the last 40 years, ecosystems of Mongolia is experiencing significant changes which are revealed in intensified desertification, increased damages of natural disasters, deterioration of water resources and biological diversity as well as negative impacts on economy, environment, and livelihood due to climate change and human factors.

Since 1940, the annual mean air temperature of Mongolia has increased by 2.24^0C. Air temperature has decreased in winter, the average summer temperature has been increasing noticeably during 1990-2010.

In terms of precipitation, there is an increasing trend of winter precipitation and a decreasing incidence of summer rainfall. Accordingly, winter climate is becoming milder and more snow fall, on the contrary summer is being hotter and drier as a result of climate change.

There are the following consequences of climate change in Mongolia depending on geographical distributions.

- Change of hot and cold days
- In the most area, especially in the Gobi desert, drought condition is extending and water resource is decreasing.
- Frequency of drought and zud is increasing
- Occurrence of dust and sand storms is raising
- Flood threats are increasing
- Cry sphere and permafrost are deteriorating.
- Land degradation and desertification are being intensified

Data analysis of pasture observation confirms that the pasture biomass edible for livestock has decreased. For example, the pasture biomass has dropped by approximately 20-30 percent in the last 40 years according to pasture monitoring data from the National Agency for Meteorology, Hydrology and Environmental Monitoring (NAMHEM). Biomass changes for the period of 1960s to 2007 showed that in most areas the biomass is tended to decrease (Table 1).

Due to climate change, the increasing number of very hot summer days has a potential influence on the summer conditions of animal grazing. For instance, an average daily interruption of livestock grazing occurred in June-July by 0.8 hours (48 minutes) and this has increased by 0.2 hours (12 minutes) during the past ten years in comparison with the previous ten years. In addition, the number of days with more than three hours interruption of grazing time has increased by about seven days during the past 20 years. In particular, it has significantly increased since the beginning of summer in 1990.

Table 1. Linear trend coefficient of pasture biomass changes (100kg/year) on fenced plot from 1965 to 2007

Natural zone	Number of sites	Time series	Date of measurement									
			6_04	6_14	6_24	7_04	7_14	7_24	8_04	8_14	8_24	9_04
The high mountains	10	33-42	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	0.00	-0.02
The forest steppe	16	21-41	0.03	0.03	0.02	0.01	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03
The steppe	17	27-41	-0.02	-0.01	-0.02	-0.03	-0.03	-0.02	0.00	0.00	-0.02	-0.03
The desert steppe	10	24-40	-0.03	-0.04	-0.05	-0.01	-0.01	-0.02	-0.02	-0.04	-0.05	-0.05
The desert	3	35-41	-0.06	-0.06	-0.06	-0.11	-0.03	-0.14	-0.11	-0.12	-0.10	-0.01

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Based on multi year observations on animal in different natural zones, live-weight of animal in summer autumn season as well as in winter spring seasons which impact on productivity decrease, earlier wool, hair and cashmere gathering time.

The analysis of monthly ewe weight measurement for 21 years at the zoo meteorological station in Tsetserleg soum of Khuvsgul and Orkhon soum of Bulgan aimag demonstrated that sheep weight has decreased by 4 kg and goat weight - by 2 kg on average in the forest steppe regions. The rate of the decrease has been significant especially since 1990, as seen as in Figure 1.

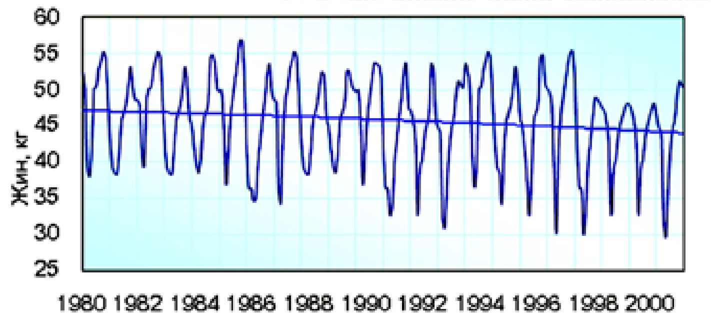

Figure 1. Ewe weight dynamics trend

According to measurements, the weight of a matured cow has dropped by 13.8 kg from 1980 to 2001.

These negative changes in animal productivity and meat production will lead to biological and economic losses. The survival rate of animals during lean and severe winter and spring conditions would be reduced because of an insufficient accumulation of energy and weight of livestock in the summer-autumn period. Consequently, this leads to long term weight loss because of diminished ability to gain weight in the summer-autumn seasons.

Multi year measurements in the forest steppe sites also indicate that wool production of ewes dropped by 90 g or 4.3 g per year. As a result, the total wool production in the country could be reduced by 60 metric tons of wool. Therefore, goat cashmere and cattle hair productions are tending to decrease. In particular, cashmere production per goat decreased by 4.1 g or 0.2 g per year over the past 20 years. The total national production of cashmere is estimated as 2 tons assuming there are 11 million goats in the country. These results show that recent climate changes have a primarily negative affect on pastoral livestock, which leads to a reduction in livestock productivity and impacts on the economic efficiency of animal husbandry.

The hot air temperatures during the summer-autumn period significantly impact on the sheep grazing, which ultimately affects livestock reproduction, fat and productivity. Animal stimulus lessens and the daily pasturage duration decreases due to the reduction in animals grazing on pastures under very hot temperatures.

When average air temperatures rise more than 22 ^{0}C, then pasture grazing of Mongolian sheep is interrupted and their grass intake decreases. Consequently, intensified warming impact on grazing has been studied by researchers under different climate change scenarios.

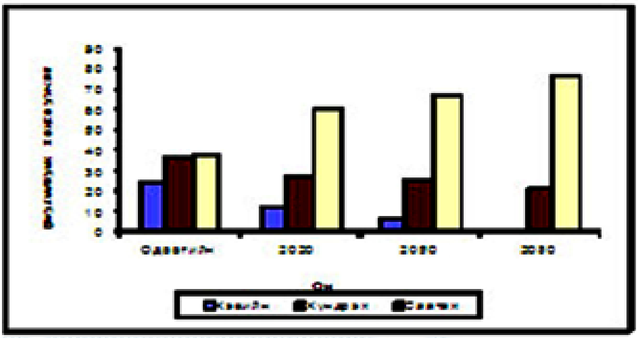

Figure 2. Impact of climate change on sheep grazing in summer season

For instance, while the duration of normal grazing time in summer occupies 25 percent of total pasture time, it will decrease by almost twice as much in 2020. However, the present interruption time of gazing on pasture is 38 percent, which will be significantly increased to 53-58 percent in 2011-2030.

Summer hot days will be extended in many areas which have negative impact on summer grazing. Such area has been estimated as 60% of the country in 2020, 70 % in 2050 and 80 % 2080.

If air temperature in future is considered despite snow thickness, grazing time in winter will be extended.

In the future, Mongolian sheep live-weight in the summer-autumn period will decrease in most areas because of warming in summer and dryness, as shown in Table 2.

Table 2. Sheep live-weight changes in summer-autumn period by HadCM3 model under SRES A2 emission scenario, (%)

Regions	2020	2050	2080
The forest steppe	-10.68	-34.40	-57.75
The steppe	-12.85	-31.67	-39.50
The high mountains	-2.92	-3.05	-9.03
The Gobi desert	2.02	3.87	-0.18

The drop rate will be more from the south to the north west of the country. In other words, sheep weight gain will be less in the forest steppes than in the steppes and the *Gobi* desert areas.

In Mongolian agricultural areas, precipitation variation is high during the growing season , which leads to big fluctuations in crop yields from year to year. Figure 3 shows the multiyear national average yield of spring wheat for Mongolia.

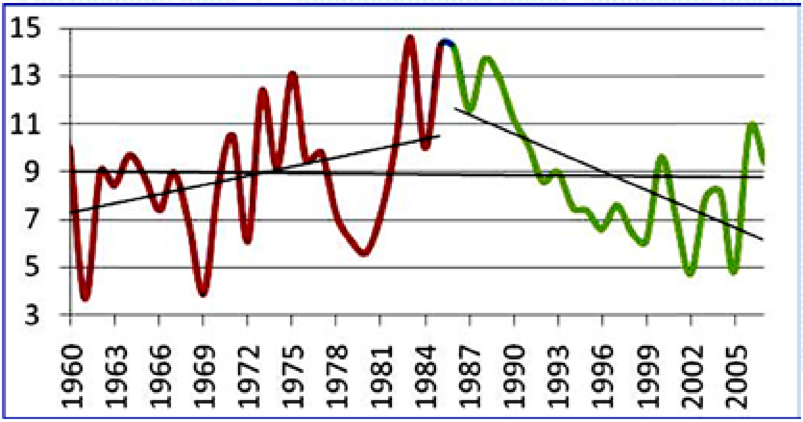

Figure 3. Multiyear trend of spring wheat yield /national average/

As presented in the above table, the wheat yield per hectare (ha) showed an increasing tendency and lower variation coefficient from 1960s to 1980s during the extensive cultivation in the country. However, in the last 20 years the trend has begun to decrease. Obviously there have been many factors that have affected this tendency. Firstly, soil fertility has been depleted after long term crop rotation of black fallow-wheat–black fallow. From the 1990s, a significant amount of agricultural land was abandoned due to a deficit of investment and financial resources. The frequency and magnitude of drought and aridity intensified in the late 1990s.

Measurement of crop fields by the Agricultural Institute in *Khongor soum*, *Darkhan-Uul aimag* showed that the spring wheat yield has decreased by 0.28 centner/ha per year during the period of 1986 to 2007.

Another factor affecting yield decline is the rising number of hot spells during crop flowering and pollination stages. The study revealed a significant correlation between the number of days with temperatures higher than 26 ^{0}C and the critical period – July - for wheat crops (Figure 4).

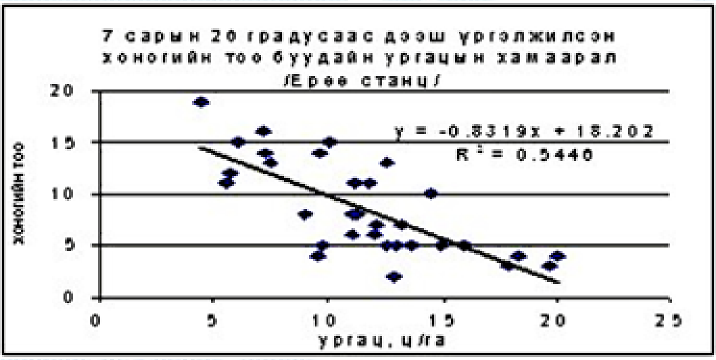

Figure 4. Correlation between wheat yield and hot spells above 26 0C in July at Eroo site

This is also reflected in changes to the development stages. In theory, when temperatures rise, the crop development stage will be shortened. However, higher temperatures above certain thresholds will possibly delay the crop stages. Observation data confirmed that all wheat stages were shortened except the stage from tilling to heading. For example: at 6 sites out of 10, development stage from tillering to heading have been extended which is mainly can be explained by unfavorable condition of hot July.

Future climate change scenario analysis showed that spring wheat yield would be decreased by 19-67 % in the central agriculture, and insignificantly increase in other regions. There was no noticeable changes in potato yield.

The study of climate change impact on agriculture show that agriculture production in the central region will be negatively affected by climate change.

In the current situation of experiencing negative consequences of climate change and the future predictions of climate change, adapting to climate change is important to overcome challenges with the least damages and losses.

The identified adaptation measures and prevention actions should be taken in the country.

Conclusion:

- In the last 40 years, ecosystems of Mongolia is experiencing significant changes which are revealed in intensified desertification, increased damages of natural disasters, deterioration of water resources and biological diversity as well as negative impacts on economy, environment, and livelihood due to climate change and human factors.
- Pasture biomass has decreased by 20-30 % in the last 40 years.
- Negative changes in animal productivity and meat production will lead to biological and economic losses. The survival rate of animals during lean and severe winter and spring conditions would be reduced because of an insufficient accumulation of energy and weight of livestock in the summer-autumn period. Consequently, this leads to other productivity loss and earlier wool, and cashmere cutting time.
- Wheat production has decreased in the last 20 years due to decreased land fertility and intensified drought and dryness. Also it is affected by hot spells during flowering and pollination period of cereals.
- For instance, while the duration of normal grazing time in summer occupies 25 percent of total pasture time, it will decrease by almost twice as much in 2020. However, the present interruption time of gazing on pasture is 38 percent, which will be significantly increased to 53-58 percent in 2011-2030. Summer hot days will be extended in many areas which have negative impact on summer grazing. Such area has been estimated as 60% of the country in 2020, 70 % in 2050 and 80 % 2080. In the future, Mongolian sheep live-weight in the summer-autumn period will decrease in most areas because of warming in summer and dryness.
- Future climate change scenario analysis showed that spring wheat yield would be decreased by 19-67 % in the central agriculture, and insignificantly increase in other regions.
- As a conclusion, adapting to climate change is inevitable for us under changing climate.

Reference:

1. National communication of Climate change in Mongolia -2009. UB, 2010.
2. Natsagdorj L and Dargavdorj D, Adapting to climate change. UB, 2010.

Land Cover Change And Heatland Phenomena In Urban Area : Greater Jakarta Case Study

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Abstract

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Background

At present time, as the population in the city became denser, the land use change is grow very fast. The change of vegetation area to building area will increase the air temperature of the city area. For instance, the concrete and asphalted road will have albedo smaller than vegetation and it will absorb a lot of sun radiation to the earth, while all material with high albedo only absorb small amount of sun radiation and caused the cooler area. All surfaces with low albedo, such as concrete and asphalted road, will accelerate the presentation of heat island phenomena in the fast growing city. This energy will release back to atmosphere during night time, and caused hotter night there. The mechanic, electric, and chemical energy that are produced in the city will worsening the condition

Figure 1 shows the urban area temperature compare to rural area temperature. The highest temperature will be found in central of the city, while temperature in the rural area still low as the high vegetation are still exist there.

Heat island influenced local temperature flow and weather condition, especially for increasing rain days during dry season. It due to hot air over an urban area produces low pressure cell which is formed by cooler air.

Figure 2 shows the land use change I Jakarta area since the year of 1972 to year 2005. The figures explained that during those years the land use change in Jakarta is very significant and it is assumed that those changes created heat island phenomena in Jakarta area.

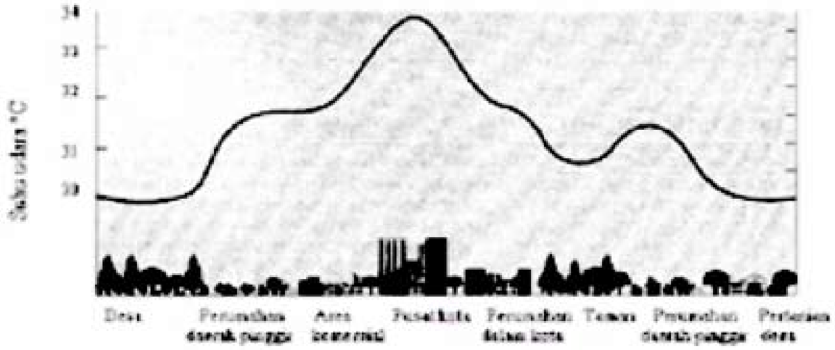
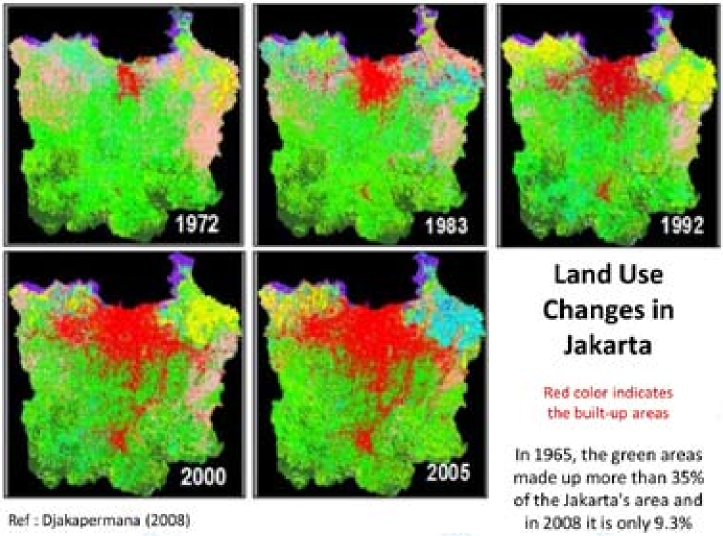


Figure 1. Model of temperature variation between urban area and rural area and its surrounding. (Miller, 1981)



Land Use Changes in Jakarta

Red color indicates the built-up areas

In 1965, the green areas made up more than 35% of the Jakarta's area and in 2008 it is only 9.3%

Ref : Djakapermana (2008)

Figure 2. Land use changes un Jakarta area

Recorded sub-surface temperature in groundwater is an important sources information to recognize climate change or this city heating. Heat flow process of subsurface temperature will be recorded together with heat flow. To reconstruct the development of this sub-surface temperature, the analytical solution will be used. This model is based on one – dimension relationship of heat flow either surface or sub-surface. By assumed that subsurface material is and heat flow process is one dimension conductively, then the temperature fluctuation on surface (z = 0) will follow below function (Goto et.al, 2005):

$$T(z = 0, t_{i-1} < t < t_i) = \Delta T_i \ (i = 1, 2, \ldots, M) \qquad (1)$$

Where, is time at measurement and ΔT_i change of temperature after period of mreasurement between and Response of sub-surface temperature to change of temperature will follow this equation (Carslaw H.S, Jaeger J.C. 1959)

$$T(z, t = 0) = \sum_{i}^{M} \Delta T_i \left[erfc\left(\frac{z}{2\sqrt{kt_i}} \right) - erfc\left(\frac{z}{2\sqrt{kt_{i-1}}} \right) \right] \qquad (2)$$

Erfc function is error function to process non-conductive process that might happened and k is thermal diffusivity value of subsurface material that could be defined as:

$$k = \frac{K}{\rho C_p} \qquad (3)$$

Where ρ and is thermal conductivity, density value and of rock material. Next step is to reconstruct this value by using Bayesian inversion process based on Tarantola equation (1987).

METHODOLOGY

In order to obtain the data, field works were executed several time on the period of August 2008 to Desember 2010. All data were collected from some monitoring well in Jakrata area. Based on the collected data, three wells were chosen for detailed analysis (Figure 2). Those three wells are located at Kamal (J-6), Tambun (J-8) and Parliament Complex (J-28).

The collected data is subsurface temperature using a digital thermistor thermometer of 0.01°C precision and the accuracy is ± 0.03° C which was attached to a 300 m long cable measured the subsurface temperature at 2 m intervals from the static water level to the bottom of the hole. The wells were drilled exclusively to monitor groundwater level and subsidence caused by groundwater withdrawal. They are therefore ideal for thermal studies as they had attained a steady-state thermal condition as the time elapsed since their construction was quite a long period. Before field measurement, the equipment was calibrated at laboratory using measuremen simulation with method at 0.0°C (32°F).

This calibration was done in order to get accurate and reliable data. The diameter of monitoring wells are mostly between 3-6 inci (7.62 – 15.24 cm) with stell pipe construction and have only one .

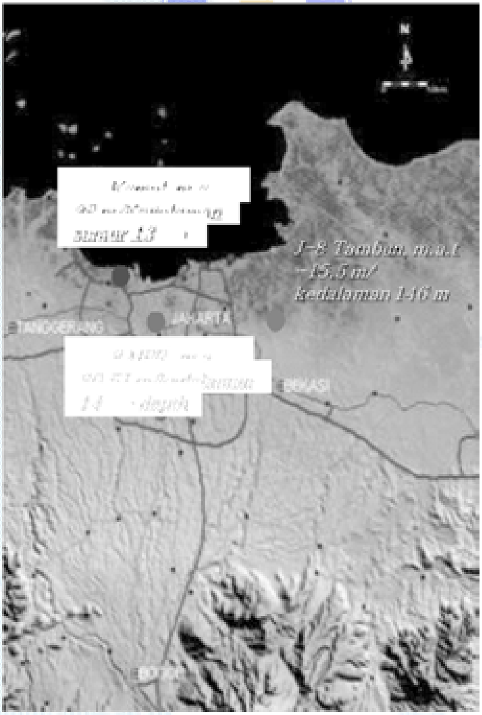


Figure 3. Location of chosen monitoring well I Jakarta area.

RESULT AND DISCUSSION

The result of subsurface temperature measurement of those 3 deep wells are presented on Figure 4. It is showed the temperature increasing with different gradient value.

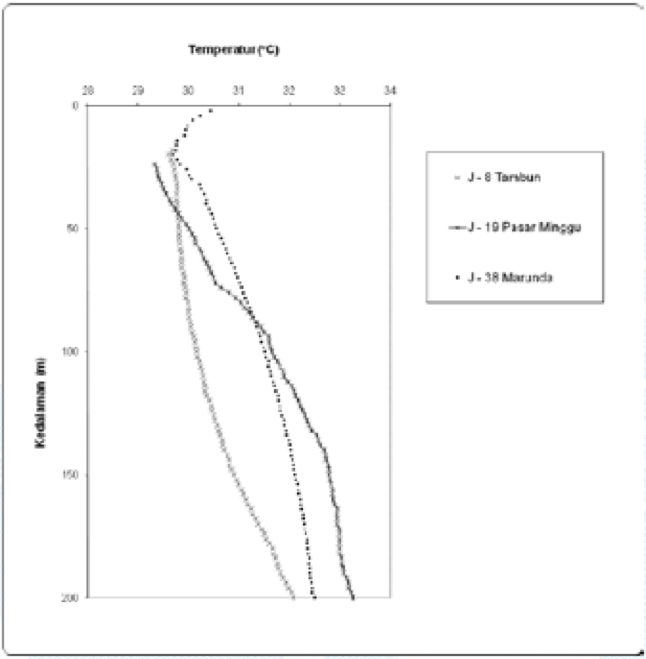


Figure 4. Sub-surface temperature profile at 3 analyzed deep wells.

By using equation (2), the profiles showed that temperature the change of temperatures were varied between 1,4 – 2.4 ^{0}C during period of 100 years tahun (Figure 5). This change is higher than global climate change which is only varied between 0.5-0.8 ^{0}C (Hansen et.all, 1987, Huang et.all, 2000). This changed value can be confirmed by the 100 years recorded data in climate station in Jakarta (KLH, BMG, NOA, 2007) that showed same increasing tendency (Figure 6). This result showed that the increased subsurface temperature in Jakarta is not only due to global warming, but also due to another factors.

Horizontally, the subsurface water temperature showed that the higher temperature were found in the area where land cover has been changed to building area (Figure 7).