Impact of Climate Change on Water Resource in Mongolia

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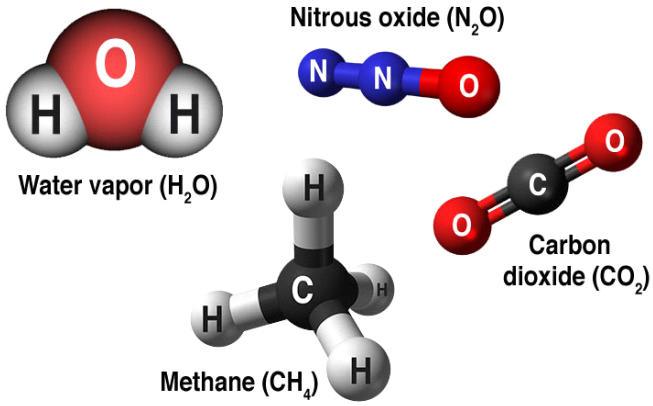
Abstract- The water resources in Mongolia are a vital and sensitive to change of the weather. The results if the climate changes show as the form of ruining of water resources, the lakes and ponds become surprisingly dry. All the surface water runs down to ground water levels, at the summer seasons there is always an extreme heat, as the result of this heat, there is always severe desertification because of the lack of rain precipitation and eventually the drought is eminent, consequences are that of soil change of its characteristics, withering of some species of plants, deterioration of the environment and subsequently the ecosystem in Mongolia. Its truth and fact that water are the vital resources of all the natural resources of which all the living thins depending on, be it surface water, hydrological, streams, the change in the hydrological system in the ecosystem is the change of most of living thing that needs water. The fluctuation of the climate is not only changing the hydrological system, but it also inflicts a serious changes of economic circular, and this change in economic or climate also change the demographic distribution of mankind. Therefore, the expected future change in Mongolia will also affect sustainable environment in the region and Mongolia in particular.

Index Terms- Water Resource, Climate Change, Temperature, Precipitation, Mongolia

I. INTRODUCTION

Climate specifically can be termed as the results of many factors that posed threats to environment, and the degradation of the environment is the result of what we call "Climate change''. It's the main challenge that deprive humanity from enjoying the ecosystem leverages. Climate change is not only changing environment per se, but it changes almost everything that connected with our life ranging from our culture, economic, politics, populations, urban planning, rural recreation, and social habitat. Climate is the carbon emission from the factories, industrials factories, solid waste disposal, and misuse of natural environment to fund economic ambiguity of man, to enrich and fill his micro economic needs, this result into destroying of what was in-situ and use the artificial way, so when these gases accumulate, the block the natural emission from ozone, and ultraviolet, and this cause depletion of greenhouse (Sukh, 2012), (Change, 2007). Greenhouse reflection is a normal and natural way which is essential for life on earth, man keeps changing this greenhouse due to his influence in the environment, emitted energy from atmosphere to earth, and warms its surface is vital to all plants , animals, and micro living organisms as well **(**KY, 2014**)**. Some gas elements in the atmosphere block the heat that needs to escape. There are gases that can stay in the atmosphere for longtime, and don't have necessary active response to alter the temperature to cause climate change. It's obvious that the main cause of climate change is the rise in temperature after the escaping heat from the earth is blocked by some gases from the atmosphere (Change, 2007). The result of changing hydrological flow cycle interaction with terrestrial carbon cycle (Ministry of Nature, 2011)

Fig 1: Gases that contribute to the greenhouse effect

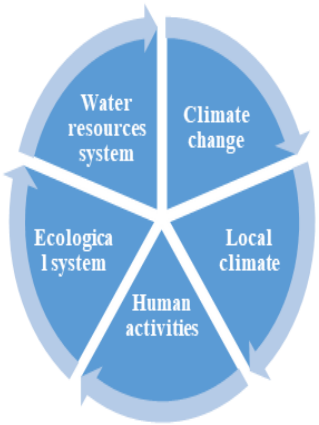


Source: https://climate.nasa.gov/causes/

- **bound between climate change and water resource**

Hydrological nature or cycle is a vital and important link to climate change. The impact of any change in climate on water cycle can be because of water quality alterations which the water resources that caused by climate factors (mostly precipitation, temperature). Climate change can change the world of which we are staying currently and it's all water system principles, and cause negative change in managing and running its hydrological flow and that of rainwater runoff in a given time at a given space and That will also affect evaporation, and that will lead to soil degradation as the result of droughts and severe lack of water. This is shown here below fig 1. (KY, 2014)**.**

Fig 2: Cycle diagram of climate change affects



Source:(KY, 2014)

- **Global Climate and Hydrological Change (standard climate change)**

The climate change, and anthropogenic have influence in pushing the time and space distribution, and intensity. The average of the rains precipitation (i.e. rain belt, temperature, humidity wind speed, and evaporation) all these largely converge in the longest period of time and leads to global, or national level of cycle. (Xia, 2017)**.**

Currently almost a third of the earth population stays at the nations which are living at a certain stress because of lack of water, and this makes the domestic, industrial and farms exceeds 22% of the total water surface. And a billion persons are now in dire need of drinking water, 260% million suffering from the health sickness because of the lack of clean water access and poor water treatment. Every year floods takes thousands lives and displace half million (Hans Joachim Schellnhuber, 2006).thus, it said that climate change can increase the intensity of floods and drought which may be more severely than that of the previous years due to increase in industrialization and economic widens done by the advanced countries (Charles J. Vo¬ro¬smarty, 2000). And the fast developed countries in Asia like China, India and South East Asia countries, U.S and Western countries already did negative impacts on the environment and created a vacuum in the climate change recovery. Sensitivity of the pacific countries to climate change is due to the present of Deltas, Low coral reefs areas so it worries people that their response to this may increase because they keeps exploiting due to their economic expansion (Japan International Cooperation Agency, 2010). addition, some human interactions like exploitation of land, change in cover, deforestation agriculture activities urban planning, use of water, mining activities ,ecological production ,rain water management all these can collectively cause change in evaporation, runoff surface water, precipitation, concentration of the hydrological cycle, and absolute influence (Xia, 2017).

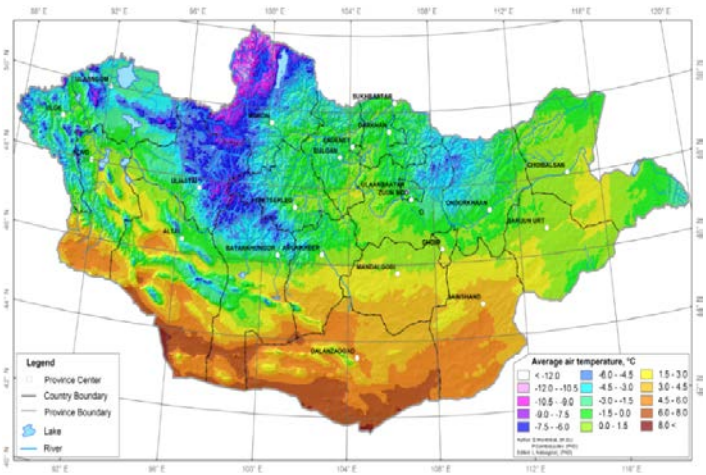
II. Study Area, Geography of Mongolia

Mongolia is a landlocked nation in the North of Asia located at exactly latitude 40^0 35'N and 52^0 09'N and Longitudes 87^0 44'E and 119^0 Mongolia has a relatively high territory altitude, the height of latitude is 1,590m above sea level almost 82% of the country territory is above 1,000, making it a mountainous area which also making inaccessible and half of the territory is higher than 1,400m.Mongolia is covering 1.5 million square km. with more than 3 million population (M. o. E. a. T. o. Mongolia, 2018)**.** The country is engulfed by high mountains that has relative height of 1500m, and this high range apparently block the window of advection of the air that blow from the North and the warm one that comes from the West .the humid flux transport from Pacific and through Indian oceans is blocked here because the uniqueness of this place (Ministry of Environment, 2015)**.** Mongolia is a semi desert and geographically steppes, Mongolia is only 3 regions North, South, and Central these regions differs in their terrains, Climate, Precipitation and minerals. West of the county is covered by many huge forests. Central Mongolia is a home, major characteristics steppes, and south is desert. (Sato).

2.1 Climatic condition

Climate in the country is categorized into four seasons, based on their temperature variety, and low rainfall. Usually, the geographical area of the region shows and help in the climate of the area, the temperature of the air reach up to -5^{0c}c in the Altai, Khangai, Khentii even at Khuvsgul mountainous terrain -6-8°C, also along the valley of big rivers, 2°C at the steppes region or desert it goes up to 6°C but in the Southern parts of Mongolia it even exceeds that number according to the report (Ministry of Environment, 2015). We acquire on daily bases an average of 233-260of Sun energy day, which is enough to nutrients our plants, grow our seeds, and sustain our land from degradation as result of lack of activated living organisms. The sand dusts blow for almost 30 to 100 days a year.

Fig 3: Spatial distribution of annual mean temperature, 1961-1990

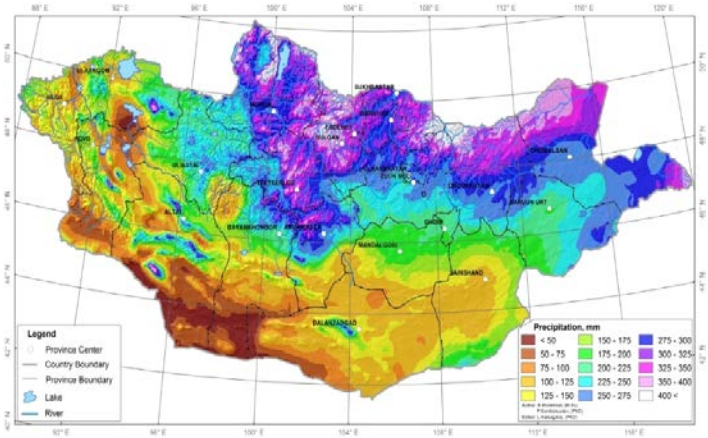


Source: (M. o. E. a. T. o. Mongolia, 2018)

Because the country (Mongolia) is located in a ride area ,that cause the precipitation to be low, the yearly precipitation is ranging from 50-400mm and 83% always deducted from its rainfalls in this hot arid when its having intense rain occurred from the convection system (Ministry of Environment, 2015). The yearly bases precipitation may and can exceed that 400mm only in the highest mountainous plateaus meanwhile its 300-

400mm in Khangai, Khuvsgul and Khentii mountainous, and that of Khalkh basin river at the eastern part of the country, 240-300mm in Mongol Altai. And forest-steppe, 130-240 mm at steppe and 40-160 mm at Gobi and of that desert area from the South inner side of Altai, the precipitation is only 55mm (M. o. E. a. T. o. Mongolia, 2018)**.** The favorite month for precipitation every year is April of which 85% of total precipitation occur up to September among which 50 to 60% only falls when its July and August. Snow and mist do happen in the winter times and are relatively low because basically the all surrounds are desert and mountains covered. Precipitation during cold season is about 30 mm in the mountain places while 12mm at the Gobi region and it is more lessen than 10 mm (Information and Research Institute of Meteorology, 2015)**.**

Fig 4: Spatial distribution of annual mean temperature, 1961-1990



Source:(M. o. E. a. T. o. Mongolia, 2018)

2.2 Current climate change and future scenarios in Mongolia

The climate change mercilessly affects the ecosystem in Mongolia, the temperature is estimated to be increasing by $2.^{0}14c$ at its annual means, since 1940s (Ministry of Nature, 2011). As the result of this change in the environmental change of Climate. Mongolia has been going through extremely cold and hot weather. In the cold weather, precipitations hiked to 12.6% and 119.4%. As a result of climate change, Mongolia experiences extremely cold weather in winter period and the weather declined to 11.3% to 2.5% at its warm weather, the precipitation drop**s**. In summer, most areas or regions experience 13% to 90% increasing in evapotranspiration (Sisira Withanachchi, 2014). As observed in the last 70 years, Mongolians has cattle, and love to take care of their herds, but for climate changes issues, animals started to suffer, the meteorological observers scattered over Mongolia shows that the earth temperature has increased since 1940s, it keeps increasing in the future, but less increase in temperature has been shown in Gobi desert and steppe regions (M. o. e. a. g. d. o. Mongolia, 2014).

Fig 5: Changes in annual mean temperature in Mongolia between 1940 and 2014

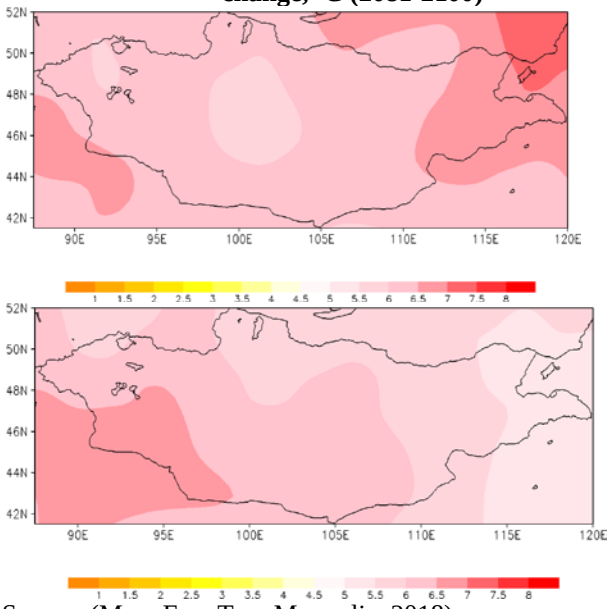
Source:(M. o. E. a. T. o. Mongolia, 2018)

Fig 6: **Changes in annual precipitation in Mongolia between 1940 and 2014**

Source:(M. o. E. a. T. o. Mongolia, 2018)

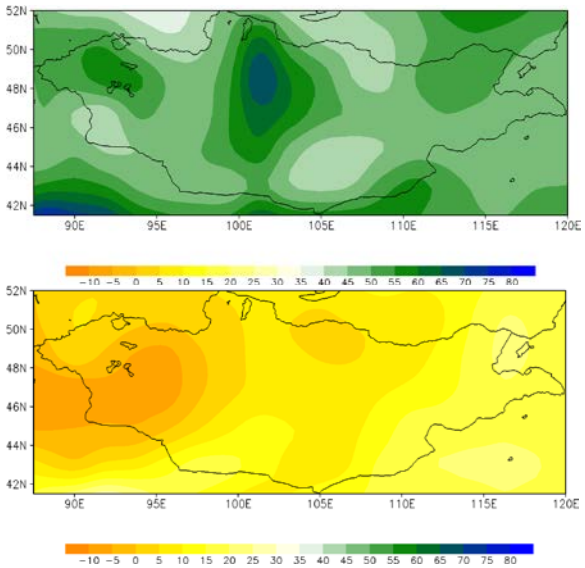
In the future climate prediction, we are aware that the air temperature will increase and it's suspected to be $3.4^{0}c$ than its current percentage by 2046 to 2056 time in contrast to 1985-2005. Moreover, the average annual precipitation shall increase by 13.6 percent and more expectation to increase at winter season precipitation (up to 20-38 percent) again reduction in increase is expected to commence in summer rainfall. The high temperature warming by $6.0\text{-}6.5c^{0}$. (Figure 7) in western region at in summer time in near future, Winter shall be increased with 50-75% in the center part of Mongolia (Figure 8), at the sometimes summer rains can be decreased by5-10% in the West part and slightly hikes up to 10% in the rest of territories of the country (Figure 8). Spatial patterns of air temperature and seasonal precipitation fluctuate in near (2016-2035) and in the mid future of (2046-2065) are the same but only differs each other by low intensity comparing to far future change (M. o. E. a. T. o. Mongolia, 2018).

Fig 7: Spatial pattern of a) winter b) summer temperature change, ^{0}C (2081-2100)



Source: (M. o. E. a. T. o. Mongolia, 2018)

Fig 8: Spatial pattern of a) winter b) summer precipitation change, % (2081-2100)



Source:(M. o. E. a. T. o. Mongolia, 2018)

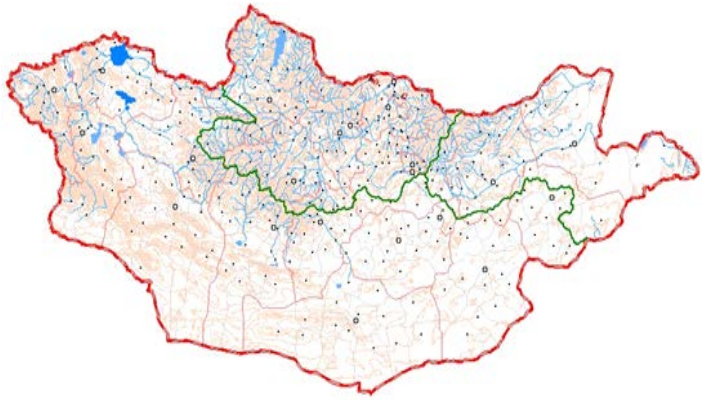
III. Surface Water Resource in Mongolia

The surface water composition in Mongolia is mainly compose of rain water stored in lakes, streams500km^3/year and the glaciers of 19.3km^3/year,32.5km^3/year is r river water which as 1.8% as basic flow, 4.4% are indirect run of rainfall. This amount of 32.5km^3/year has rivers flow formed in Mongolia, and the water that surface inflow water which is 4km^{3}km/year comes from nearby countries like Russia and China (B. Myagmarjav, 1999).

3.1 Rivers

The total of all rivers in Mongolia drains to three different rivers basins in Mongolia, the so call Arctic Ocean Basin, Pacific Ocean Basin and Central Asian Drainage Basin. The main suppliers of this drainage is water from the rain, and winter that provides snow, and the last is ground water and glaciers at the West of Mongolia. In the flow index classification, it is found Mongolians rivers systems are divided into three categories, wit which rivers spring and summer rains are the flooding regime, that of Spring –summer are acting as snow melting flooding and final is rivers which as only summer rains regime (Information and Research Institute of Meteorology, 2015).

Fig 9: River basins in Mongolia



Source: (Information and Research Institute of Meteorology, 2015)

3.2 Lakes

We have over 300 lakes whose surface area are more than 0.1km^2 of which only 4 lakes are having surface that are larger than 1,000km^2 ,17 lakes have larger surface area that is more than 100km^2, 27 have larger than 50km^2. The average amount of water resources in all these lake 500km^3 within which 314km^3 of this total water comes from Kuvsgul Lake. 34 % of these lakes located at the mountains, the rest in the steppe and Gobi (Ministry of Nature, 2011).

3.3 Glaciers

262 glaciers in Mongolia, they occupied an area of 65.9 km that means air temperatures of -8C, and yearly precipitation of about 380 mm, these Glaciers are distributed into an area between 46C25`-50C50` N, 87` 40`-100 50` E, in an altitude of 2750-4374 m. Spatial distribution is irregular and keeps decreasing from north-west to sought-east (Ministry of Nature, 2011). The largest valley glaciers at Tavanbogd Mountains, the Potanin and Aleksandra glaciers (M. o. e. a. g. d. o. Mongolia, 2014).

3.4. Groundwater resource

As it is mentioned before, that ground water recharge is estimated to be 10.8 km$^{3/}$year (M. o. e. a. g. d. o. Mongolia, 2014). But the, distribution of hydrogeological ground water aquifers varies from basins to other, the highest recharges to ground water is 40-60 mm/year and it can be found at sands deposits of alluvial. These aquifers are distributed in rivers valleys and lakeshores (Ministry of Nature, 2011).

Table 1: Potential groundwater resources per unit area (1 km^2) and whole territory of Mongolia

Classification of exploitation resource per unit area		Water for unit area	Area of distribution		Groundwater resource
		10^3m^3/year	êm^2	106m^3/year	106 m^3/year
1	Area with small resources	< 3	770225	1032.9	9.6
2	Area with from small to moderate resources	3- 10	571780	3032.7	28.1
3	Area with moderate resources	10-30	139825	2182.8	20.2
4	Area with large resources	> 30	65790	4538.0	42.1
Total		1547620	10786.4		100

Source: (S.Chuluunkhuyag)

IV. Climate Change Impact on Water Resource in Mongolia

The results of climate change shown the form of change of runoff declined, regime flow change, lakes, ponds have all dried up. Cryo-sphere has reduced or compressed, drop in ground water levels and rapid increase of fast flooding. The runoff of small rivers and that morphometric alteration of small lakes that serves as evident of climate change in those steppe and Gobi area, and these bodies that contains water are the most vulnerable for climate warming and human impact (Information and Research Institute of Meteorology, 2015).

4.1 Impacts on surface water

River runoff: 56-75% of water runoff in rivers draining from Khuvsgul, the Khangai and the Khentii mountains are composed mainly from rainfall, while that of rivers originated from Mongol Altai mountain from snow and ice melting water (50-70 %) the other in the warm period a year. Because in most Mongolian river water easily lose in process through evaporation rates, infiltrations into the ground. During winter periods, rivers freezes, hence, the flow rate is either lowered or not there at all. The country has four main seasons, observed in Mongolia rivers, they are Winter low-flow times, this regime period lasts from December to April, second is that Spring runoff time due to melting down of ice which lasts from April to June, third is Summer period because of rainfall, it goes up to June to September, and finally the last one is warm season low period of water, it comes after rain and lasts to winter (Ministry of Nature, 2011).

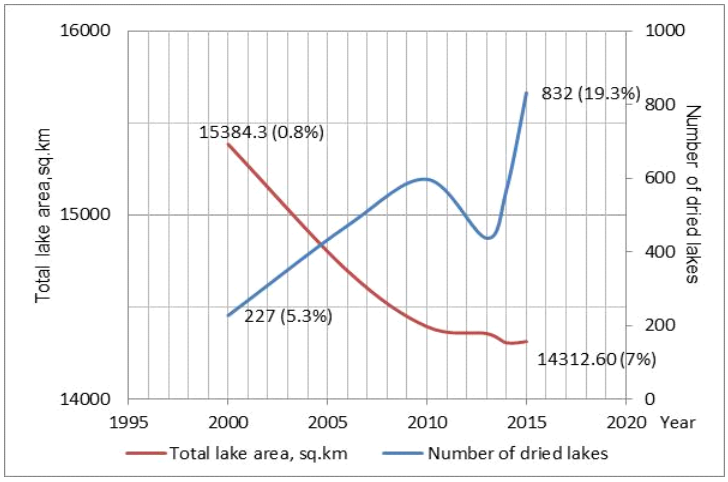
Impact of climate change on rivers reveled in decline of runoff, flow and thermal regime change and reduction of surface water bodies etc. HADLEY model simulation shows that by 2040-2070 shows some small increase of runoff in main three river basins, however such small increase will be much less than (by several times) the increase of basin evapotranspiration. Thus, river basins will continue more dry in the future. Since 1978, the total flow of the river yearly estimated to be 78.4 km^3 in 1993 (M. o. e. a. g. d. o. Mongolia, 2014). Maximum value reached, lasting low flow steadily continues from 1996 and reached the minimum of 16.7 km^3 in 2002 and 22.7 km^3 annual, average river flow was assessed in 2015, which was lower than the long-term means by 11.9 km^3 (M. o. E. a. T. o. Mongolia, 2018).

Fig 10: Annual total river flow variation in Mongolia, km^3/year

Source:(M. o. E. a. T. o. Mongolia, 2018)

Lakes: The area of all total lakes are reduced by 0.8% or 130.3km^2 and 227 lakes are dried since 2000. 5.3% lakes were dried in 2006, 7.2% or 1,121.5 km^2 lakes were dried in 2010, 7.8% or 12,09.1 km^2 lakes were dried in 2014 and by 7.8% or 1,201.9 km^2 and 832 lakes had dried in 2015 respectively, in comparing to those of 1940th .

Fig 11: Changes in total lake areas and number of dried lakes



Source: (M. o. E. a. T. o. Mongolia, 2018)

The water of the big lakes and medium ones had decreased in the last 20 years and that of lagoons and small lakes remain low from the start till now but increased once when there are floodplains (M. o. E. a. T. o. Mongolia, 2018). In a report written by researchers about climate change in Mongolia, the inventory said that, glaciers areas were once 470sq.km until 1990, 451sq.km till 2000, 389sq km in 2011. It reduced by 12.1% from 1940 till 1990, by 4% in 1990 to 2000, and 13.75% in 2000-

2011. In total, glaciers reduced by 29.9% for the last 70 years (M. o. e. a. g. d. o. Mongolia, 2014).

Glaciers: Glacier reduction and shrinking become speedy after 1990th most extensive ablation happened in the last 10 years (Myagmarjav B, 1999). At that period from 1940 to 2000, the glaciers from Bogd area, Turgen massif, Kharkhiraa massif and Tsambagarav massif, these regions are said to have lost 10.2%, 19.3%, 28.0% and 28.8% of their total area accordingly (KADOTA Tsutomu, 2007).

4.2 Impacts on groundwater resource

The impact of climate change on groundwater recharge in Mongolia is unclear. Many factors affect the recharge: alterations in precipitation, evaporation and temperature regime, soil properties and their changes. Climate change will affect groundwater resource throughout the country. It is expected that aquifer recharge is reduced, just as ground water levels are reduced, especially in the shallow aquifers. Higher temperatures and droughts will result in increased evapotranspiration. Recharge will also suffer from more extreme precipitation events, because more water will runoff before it can percolate into aquifers. Thus, even when overall precipitation increases, aquifer levels may decrease, as a result of having less precipitation events that are more extreme (Ministry of Nature, 2011).

V. Conclusion

This review paper information evidence shows us that consequences of climate change reveal in the form change of flow regime and water resources, drying up lakes and ponds in regions without permafrost, dropping of groundwater levels, summer extreme heat, intensifying desertification due to drought in Mongolia. Hydrological systems change does not only affect the biological and ecological system, but also affects the economy, life, so the future climate change effect the sustainable development of regional, national level in Mongolia. These increased vulnerabilities to climate hazards will compound current water governance problems in Mongolia. Thus, governance policy and optimized water use practices will need to adaptation to climate change.

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