

Floods in Mongolia

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Key words: rainfall, spring and flash floods, flood damage, flood frequency and forecasting

Introduction

Recently, besides studies on past and present condition of different natural processes, it is clearly become more important studies on predict future behavior and change of the natural processes and its related consequences. Therefore social-economic development must be closely correlate with possible change of natural system in future and such tendency of development becomes prevailing one in present days. Mongolian people has quite long history on environmental protection, knowledge on water related events such as flooding etc. Several hundreds years ago, people were attempted to know and to study runoff phenomena, river water regime and water resources of Mongolia. Many interesting and very important cases of study, notes were documented in different types sources like as historical, tourist and scientific books, reports etc.

As mentioned we have experiences to study and to reveal water resources and regime of Mongolian rivers quite long years ago and however systematic observation and research studies just began only from mid 1930th. This paper concentrates on floods, its forecasting, flood damages and some measures against flood disaster.

Floods, causes, magnitude and frequency

According to some definitions flood is inundation of surrounding area due to quick and sudden rise of water level due to intensive rainfall or slow snow melting (A.I.Chebotarev). Cause of floods also could be earthquake, landslide, ice blocking, dam break etc.

In Mongolia, depending on natural and climatic conditions can be identified 3 types of floods. Rise of water level and over bank flow in relatively long period due to snow and ice melting is called spring or snow melting flood. Quick rise of water level and over bank flow caused by intensive rainfall is called rainfall flood. Finally flash flood- high intensive turbulent flow with rocks and sediment and other surface materials due to high intensive rain along the steep dry beds and small rivers. Spring flood starts from mid of April till end of May in most area of Mongolia and about 20-60 percent of annual runoff forms during the spring flood depending geographical location.

In Mongolia most of annual runoff up to 70-80 percent forms during rainfall floods in summer period. Rainfall floods occurs when daily rainfall exceeds 40-110 mm. Intensity of rainfall depends on many factors such as rainfall intensity and duration, relief, vegetation cover antecedent soil moisture condition etc. Rainfall starts from mid of June till mid of September and has several peaks.

Historically mentioned that in 1613, 1623, 1695, 1696, 1701, 1715, 1716, 1830, 1838 and 1868 years in Mongolia have occurred several high (D.Tsedevsuren,1987). For example in 1869 was high floods along the Selenge river and due this flood the water level of Baikal level had risen by 2 meters.

In 1915 there was also big flood along the Tuul river and flood water reached in the left side along the bottom slope of Zaisan hill and right side-Gandan temple area in Ulaanbaatar.

Since systematic and permanent observation for river water regime, in 1966-67, 1971, 1974, 1976, 1982, 1984-1986 years have occurred several huge floods along the Selenge, Delgermuren, Onon, Orkhon, Tuul, Kharaa and Eroo (N.Dashdeleg, 1987). As for recent years-1988, 1989, 1993-94 were high flow years.

One specific peculiarity of river floods in Mongolia is very quick rise and short duration. N.Dashdeleg estimated that duration of rising limb of rainfall floods in the Selenge river basin is 2-6 days and falling limbs may continue until 4-18 days. In some rivers, rainfall flood passes just within 1-3 days and amplitude of water level may reach 100-150 cm within day.

Concerning rainfall-runoff relationship, one single analysis in the Tuul river basin show that 4 days rainfall with amount of 20 mm in upper river basin cause rise of water level by 70-90 cm after 1-3 days in lower basin (D.Oyunbaatar, 2004).

Maximum rainfall discharges can be reached from several hundreds to several thousands cumecs. Flood discharge in Khalkhin gol river in eastern Mongolia in 1985 have reached 300-400 cumec while rainfall floods along the Selenge river 1971-1973 produced flood discharge up to 2000-4000 cumecs. One biggest rainfall in modern era is rainfall flood in 1966 in the Tuul river basin. On 10-11th of July 1966, in Ulaanbaatar area have recorded 103.5 mm rainfall which was about 43 percent of total annual precipitation. Due to this rainfall Tuul and other small tributaries of the river as Selbe, Uliastai rivers have

flooded and over bank flow, inundation of surrounding area. Flood water velocity have reached 4-5 m/sec, flood discharge was 1700 cumec and water level have risen up to 151 cm for 1-2 days. Another example of flash flood also in Ulaanbaatar city. In 15th of August of 1982, was very high intensive rain which gave 44 mm (84 % percent of monthly sum) rain for just 20 minutes. Due to this intensive rain there were huge flash floods along the 42 dry beds and small rivers around the Ulaanbaatar city, mainly from northern side and as consequences of the flood, several tens of people dead and brought big economics losses to the Ulaanbaatar city.

Need and aim of hydrological forecasting, flood mitigation and warning measures

Mankind faces with two distinguished problems related to water, rivers, such as TOO LITTLE water (drought) or TOO MUCH water (flooding) and for whole history of mankind, people always was thinking how to deal with water, by researching, constructing, protecting etc. Achievements in this field were different for each country depending on development level, tradition and culture, geographical location and climate condition. Moreover, as consequences of recent global climate change, frequency of occurrence of floods and their intensity have increased. Due to change of basin ground surface (soil and pasture degradation, overgrazing, agricultural use, urbanization, forest cut etc) intensity and amount of direct runoff has increased and consequently flood hazards occur frequently and extensively.

Another key factor is change of basin surface, such as forest cut, agricultural use, overgrazing and urbanization and make the problem more complex.

In Mongolian case, weak development of runoff forecasting methods and modeling could not satisfy nowadays requirement. Therefore, it is needed to significantly improve studies on runoff forecasting in order to meet present requirement and provide adequate service to the users. Main aim of flood forecasting systems are just to answer for the questions : WHEN, WHERE, HOW MUCH would expect flood events as much as possible accurate?

B.Myagmarjav states that first attempt to establish warning system against flood in Mongolia was establishing of several gauging stations with radio-communication devices along the Terelj and Tuul and Terelj rivers in June of 1960. Due to this system, we much saved during the flood in 1966 along the Tuul river, in Ulaanbaatar city. First hydrological forecasting based on aerospace data was carried out in 1981 for the Selenge, Orkhon and Tuul river.

To have good operating flood forecasting and warning system, need to have excellent gauging network with required density in terms of space and time. Secondly, must have very operative and reliable communication system for operative data transmission and exchange. Finally need to have forecasting models

and methods adapted for Mongolian condition, data quality.

At present days, in Mongolia we have totally 126 gauging stations at more that 70 rivers out of 3565 rivers and streams in Mongolia and only 53 hydrological gauging stations are transmitting operative data for flood control which is certainly not enough to have appropriate flood controlling system. Concerning communication system, we have quite good and reliable VSAT system and so far the system is satisfying our present requirement.



Figure 1. Location of operative information hydrological stations

Recent years we trying to apply and adopt some world wide hydrological models such as unit hydrograph, Maskingum flood routing, linear regression etc (N.Dashdeleg, D.Oyunbaatar, G.Adaybadam, B.Oyunchimeg and S.Dorj).

Flood routing is a procedure to determine the time and magnitude of flood or flow hydrograph at the downstream from known hydrograph at upstream. In broad sense, flood routing may be considered as a analysis to trace the flow through a hydrologic system.

If time difference depends on distance between sites and flood wave velocity then attenuation is result of channel roughness, bank infiltration etc.

One of widely used method for short range forecasting is method of related level or discharge(linear regression model). This method is based on flood wave movement pattern along the river reach. Flood wave observed at upstream gauge will reach downstream gauge after some time with certain transformation (attenuation) rate. The lag time of the model depends on several morphometric and flow characteristics of river reach such as length, water level or discharge, slope and roughness.

Below one of derived forecasting equation for Terelj-Tuul river system with 1 day lag time and the Figure 2 is presented results of short range forecasting for the Tuul-Ulaanbaatar.

$$Q_{Tuul,j+1} = 2.39Q_{Trlj,j} + 5.21$$

Forecasting equations derived for mean flow cases provide better results with coefficient correlation of 0.72-0.96 and error of forecasting varies on average 12.5-35.0%. Forecasting accuracy is estimated as

absolute error between observed and forecasted hydrographs in percent and forecasting efficiency within permissible values. Past experiences show that mean forecasting efficiency is about 70 percent for selected Mongolian river systems.

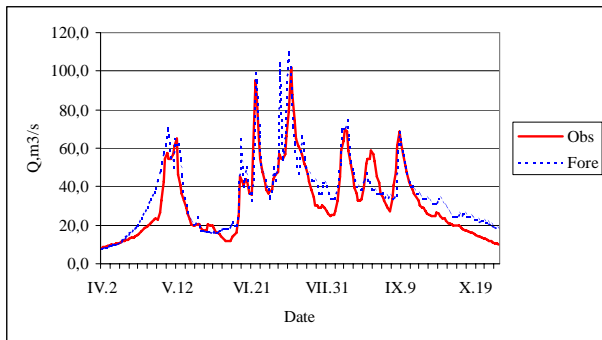


Figure 2. Observed and forecasted hydrograph, Terelj-Tuul Ulaanbaatar

Conclusions

- Recent demographic growth, socio-economic development, nature and climate change's consequences show strong need of development of runoff forecasting methods and modeling in our country
- Under limited condition on hydrological forecasting and modeling studies and lack of adequate data, the system approach is best way for calibrating of runoff models in our cases, at present time
- Need to improve density of gauging sites in upper basins of rivers where forms main runoff portion and falls more rainfall. For flash flood control need to develop radar data based system with application GIS data and rainfall-runoff models

- In cities like Ulaanbaatar it is important to keep clean and free of garbage different flood structures protection and diversion systems. This must be one of important duties of different administrative, municipal and professional related organizations. In some cases one causes of flood damages is inappropriate use of flood protection structures and causes artificial floods.

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