



Natural hydrological risks and their prevention in Kazakhstan

Plekhanov P.A.

Expert on natural emergency situations and disaster risk reduction, LLP Institute of Geography, Kazakhstan

Email: plekhanov50@mail.ru

Abstract

Insufficient real data on extreme hydrological events, lack of their classification and of official damage assessment methods are the reasons for no conduction of a full-scale research on hydrological risks in Kazakhstan. The paper aims to define possible qualitative characteristics and common patterns of hydrological risks in Kazakhstan based on a synthesis of published research studies and materials on extreme hydrological events available from the Committee for Emergency Situations of the Ministry of Internal Affairs of the Republic of Kazakhstan and the National Hydrometeorological Service of the Republic of Kazakhstan. The obtained results are to be used during the development of long-term strategies and development programs.

Keywords: hydrological risks, monitoring, Kazhydromet, Kazakhstan.

Introduction

Worldwide, there is a widespread opinion that natural disaster risks might have a significant negative impact on sustainable development of countries and their regions. Herewith, water-related disaster risks are considered to cause the most significant social and economic damage. However, such inferences are, very often, based on emotional and qualitative judgments without conducting an objective comparative analysis.

For instance, insufficient real data on extreme hydrological events, lack of their classification and of official damage assessment methods are the reasons for no conduction of a full-scale research on hydrological risks in Kazakhstan. Therefore, a negative impact from hydrological disasters on sustainable development of the country and its regions has not been considered in the current long-term strategies and development programs.

The paper aims to define possible qualitative characteristics and common patterns of hydrological risks in Kazakhstan based on a synthesis of published research studies and materials on extreme hydrological events available from the Committee for Emergency Situations of the Ministry of Internal Affairs of the Republic of Kazakhstan and the National Hydrometeorological Service of the Republic of Kazakhstan. The obtained results are to be used during the development of long-term strategies and development programs.

Natural hydrological risks and the extent of emergency water-related situations

The Republic of Kazakhstan is located in the moderate continental belt of the central part of the Eurasian continent between 40°35'N–55°30'N of northern latitude and 46°30'E–87°20'E of east longitude. The maximum length of the country from north to south is about 1600 km, from west to east more than 2900 km, the total area is 2724,9 thousand square kilometers [1].

Kazakhstan has an 'extreme' continental climate, with warm summers and very cold winters. Astana is the second coldest capital city in the world after Ulaanbaatar. Precipitation varies

between arid and semi-arid conditions, winter is particularly dry [35]. The percentage of steppes, deserts and semi-deserts, forests, snow-glacier zone are 35, 36, 18, 6 and 5, respectively. The percentage of flat plain and mountain landscape is about 70 and 30. Diversity of natural conditions of the Republic predetermines its vulnerability to different hydrological risks. Causes of natural hydrological risks are extreme hydrological events (EHE), a list of which in Kazakhstan includes about 30 types. Formally, this list could be divided into three groups: 1. extreme hydrological events occur over land water objects; 2.

extreme hydrological events occur over sea water objects; and 3. extreme hydrological events occur on groundwater objects.

However, only few types of EHEs from the list might lead to significant damage. These are: rainfall and thawed freshets, spring floods on plain rivers, mudflows, and wind surges over large water bodies, river congestions, river ice jam, low water level, high level of surface- and groundwater that are a result of weak surface runoff of melt- and rainwater, snow avalanches and etc.

All types of dangerous extreme hydrological events might have a wide range: from local to global (catastrophic). The government of the Republic of Kazakhstan approved criteria and categories to define the scale of emergency situations, including those connected to EHEs extreme hydrological events [3] (Table 1).

Table 1. Criteria and categories of natural and man-caused emergency situations in the Republic of Kazakhstan

Emergency situation criteria	Categories of natural and man-caused emergency situations			
	Facility-related	Local	Regional	Global
People's deaths (N –number of people)	$5 < N < 10$	$5 < N < 10$	$50 < N < 200$	$N > 200$
Violation of living conditions (N –number of people)	$50 < N < 100$	$100 < N < 500$	$500 < N < 1500$	$N > 1500$
Size of material damage	$MCI < 15\ 000$	$15\ 000 < MCI < 100\ 000$	$100\ 000 < MCI < 200\ 000$	$MCI > 200\ 000$

* – MCI – Minimum Calculation Index (year 2017 – 2 269 Tenge, or \$7, 3 – as of 20.04.17)

An indicative example of water-related catastrophic risks, for instance, the year 1993, when during the spring period, 669 local communities, including 41 local regional centers, 11 cities, 5 towns, 612 working settlements and villages were affected by floods, simultaneously. The total area of destroyed residential housings was 635 thousand square meters. According to the official data of the Kazakh Committee on Statistics, the total direct economic damage was estimated at 57.7 billion rubles (prices of the former Soviet Union) [2], what is approximately equals to at least USD500 million.

Water regime of rivers, causes of floods and freshets

There are four major types of rivers water regime typical for Kazakhstan:

- 1) *Kazakhstan type* is typical for steppe and semi-desert rivers located in the northwestern, northern and central parts of the Republic. The regime is characterized by a very sharp and high flood wave (from 2-3 weeks to 1 month), estimated to up to 90% of the entire annual runoff. In addition, by an extremely drought flow, when the streamflow is very low, up to total drying up of rivers.
- 2) *Tien Shan type* is typical for rivers of southeastern and southern Kazakhstan, sources of which are located in the zone of eternal snows and glaciers. Floods on this type of rivers are

characterized, mainly, by successive melting of seasonal snow cover at all high-altitude belts of mountain landscape and glaciers in highlands.

3) *Altai type* is typical for rivers of the mountain regions of eastern Kazakhstan, river basins of which are located, mainly, in a medium-altitude mountains zone. These rivers are characterized by spring floods that last during 1-2 months, higher summer runoff and low winter drought flow.

4) “No outflow” type (conventional) is typical for small temporal watercourses in central and western desert and semi-desert parts of the Republic, where streamflow occurs only during short spring periods on closed local territories, where a hydrological network is characterised by drying out riverbeds of watercourses.

Causes for floods and waterlogging in Kazakhstan are:

- *Kazakhstan type river basins* – melting of seasonal snow cover on plains and in low mountain areas, ice jams, liquid precipitation that occurs during floods and freshets that occur as a results of lakes and/or artificial reservoirs break;
- *Tien-Shan type river basins* – intensive melting of seasonal snow cover in mountain areas, storm precipitation during spring-summer period, mudflows, freshets that occur as a result of ice lakes and/or reservoirs break;
- *Altai type river basins* – melting of seasonal snow cover, steady rains during warm periods of a year, river jams, lakes and/or artificial reservoirs break;
- “*No outflow*” *type basins* – floods are also possible, but very rare, only during strong intensive rainfalls.

Territories vulnerable to floods and maximal levels of terrain flooding

In Kazakhstan dangerous floods and natural minor flooding, mainly, occur in big and average rivers valleys during floods and freshets, in coastal zone of the Caspian Sea during wind surges of sea water as well as in closed low areas of terrain that characterized by unsatisfactory filtration qualities of underlying surface.

The highest increase of water level during floods (5-10 m and higher) occurs in valleys of the biggest plain rivers of Kazakhstan: Ural, Tobol, Turgai (Torgai), Esil, Ertis and their tributaries. On average size plain rivers a water level increases at least up to 3-5 m during spring period. A water level increases in mountain river valleys of the Tien Shian and Altai regime types of a flow – up to 1-3 m, where relatively significant inclinations of terrain are [4].

In the coastal zone of the Caspian Sea, maximal water surges are not higher than 2-3 m according to actual observations [4]. The size of terrain flooding area can be different – units, dozens, hundreds, and even thousands of square kilometres. It depends on landscape characteristics, characteristics of river watercourses, and previous and current hydro-meteorological conditions.

Economic, social and environmental damages caused by floods

There are no approved assessment methods of economic, social and ecological damages from adverse water impact in Kazakhstan. Nevertheless, several reviews on disasters have been conducted. For instance, in 2014, the Republic governmental enterprise “Center VTTISA” of the Committee for Emergency Situations of the Ministry of Internal Affairs of the Republic of Kazakhstan conducted several studies on vulnerability of the Republic of Kazakhstan to natural emergency situations and their impact during the years 2004 – 2013, based on its own data. Based on the results of these studies, the author of this article inferred that 93 extreme hydrological events occurred in Kazakhstan during that period. These lead to 58 floods, 9 freshets, 5 terrain flooding, 15 wind surges, 3 mudflows, 1 river jam, 1 dangerous sloping runoff, and 1 high increase of a groundwater level. Total damage from such disasters included 45 deaths and 13055 injured, and direct economic loss estimated to 41, 36 billion Tenge (or USD \$275, 7 million) [5]. Probably, the size of this loss is significantly underestimated in comparison to its real value, since only in 1993; the damage from floods was twice bigger (see above). There is no possibility to discuss ecological damage caused by floods, as yet; no research has been conducted in Kazakhstan.

Generally, based on the existing data, it might be concluded that the negative economic effect from floods in Kazakhstan has relatively small size, i.e. about one percentage of the Republic’s annual average GDP.

Climate and its impact on hydrological risks

Undoubtedly, climatic conditions are the main factor that determines spatial and temporal patterns of a streamflow regime on the territory of the Republic, as well as occurrence of extreme hydrological events.

The climate in Kazakhstan as the climate on the planet is changing. According to the RSE Kazhydromet, during last 75 years the observed temperature in Kazakhstan has increased by 0.280 degree Celsius, at average, and the amount of precipitation has decreased by 0.2 millimeters, every 10 years [6]. As a result, increased evaporation and decreased amount of precipitation lead to a decreased streamflow on the plain rivers of the Republic. On the mountain-glacier rivers, the situation is opposite. Degradation of glaciation adds leads to a temporal increase of a streamflow [7]. Based on these facts, experts talk about possible activation of extreme hydrological events, including floods [8]. During last 2-3 years, a number of experts from the RSE Kazhydromet were investigating this problem. For instance, according to Dolgih S.A., in Kazakhstan, during the years 1960-1990 and the years 1991-2012, extreme hydrological events included freshets – 50/89 (increase by 78%); high floods – 65/50 (decrease by 23%); jams – 11/20 (increase by 82%); mudflows – 11/18 (increase by 64%). Kojahmetov P.G conducted a similar study. He identified similar ratio of extreme hydrological events during the years 1967-1990 and the years 1991-2015. For mountain rivers: extreme hydrological events included freshets – 54/96 (increase by 78%); mudflows – 11/20 (increase by 82%), jams – 8/17 (increase by 112%). For plain rivers: high floods – 49/39 (decrease by 20%), jams – 3/7 (increase by 130%).

Results of the abovementioned studies show that during last 50 years, the frequency of freshets, mudflows, and jams has increased, and the frequency of high floods has decreased. However, these conclusions should be considered as preliminary, and only regarding the frequency of events and not their scale.

Prevention of hydrological risks

In Kazakhstan prevention of hydrological risks is implemented according to the Kazakh legislation on land and water relations, ecology, civil protection, according to the legislation of local public authorities and etc.

Prevention and liquidation of consequences of hydrological risks approaches have drawbacks and gaps. For instance, many settlements and facilities are located in the flood-prone areas, with ineffective flood protection constructions. The network of hydrological monitoring and forecasting of extreme hydrological events requires significant expansion and automation. Population in Kazakhstan almost does not participate in self-protection from extreme hydrological events and have little knowledge on appropriate behavior before, during and after emergency situations. Early warnings of possible extreme hydrological events are almost not implemented, and insufficiently considered in strategic planning and in programs for regional development at different governmental levels.

To reduce disaster risks in Kazakhstan in 2018, an updated “Plan for preparation of the Republic of Kazakhstan to natural emergency situations” and a methodological basis “National situation analysis of security from natural and human induced disasters on the territory of the Republic of Kazakhstan” [9] have been developed in cooperation with UNDP and implemented into the state system of civil protection [5].

Currently, in accordance with the Sendai Framework for Disaster Risk Reduction 2015 – 2030, the Committee for Emergency Situations of the Ministry of Internal Affairs of the Republic of Kazakhstan together with the Center for Emergency Situations and Disaster Risk Reduction are working on bringing the latest international experience in the field of innovative technology for disaster risk management and for engineering protection from floods.

Conclusion

1. In Kazakhstan the most significant hydrological risks are associated with occurring of:
 - rainfall and thawed floods, mudflows in mountain and foothill areas of southern, south-eastern and eastern regions of the Republic during spring-summer period;
 - high floods on plain territories in western, central, northern and north-western regions during spring time;
 - snow avalanches in mountains in southern, south-eastern and eastern regions of the country during winter and spring periods.
2. According to the available data:
 - direct economic loss from hydrological risks is approximately not higher than 1% of the country’s GDP;

- social loss: number of deaths – from several to 10 and more people a year; number of injured people, including those, who lost their properties – from hundreds to several thousand people a year.
3. Climate change (warming or desiccation) in Kazakhstan characterized by an increase of a freshet and mudflow frequency on mountain rivers and by a decrease of a high floods frequency on plain rivers.
 4. There are no official methods to record data on extreme hydrological events and on assessment of losses in the Republic; therefore, there are no exact inferences on their risks and trends.
 5. A potential negative impact of hydrological risks is not included in long-term strategies and development programs of the Republic of Kazakhstan.
 6. It is recommended urgently to conduct a research on patterns of extreme hydrological events in Kazakhstan and based on the obtained results to organize constant monitoring and to record extreme hydrological events at appropriate level.

List of references

- [1] National Atlas of the Republic of Kazakhstan. Volume 1: “Natural conditions and resources”. Almaty, 2010. – 150 pp. (in Russian).
- [2] Information on economic loss from floods in the regions of Kazakhstan (as of 01.07.93). Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan (brief as of 19.06.93, implementation of the decision of the Emergency Situation State Committee No. 38-10/71 as of 29.04.93 paragraph 2.2) (in Russian).
- [3] Decree No. 756 of the Government of Kazakhstan as of July 22, 2014 "On setting of classification of natural and human induced emergency situations". (in Russian).
- [4] Atlas of natural and human-induced dangers and risks of emergency situations of the Republic of Kazakhstan. – Almaty, 2010. – 264 pp. (in Russian).
- [5] Plan to prepare the Republic of Kazakhstan to natural emergency situations. – Committee for Emergency Situations of the Ministry of Internal Affairs of the Republic of Kazakhstan – UNDP Kazakhstan, Astana, 2015. – 304 pp. (in Russian).
- [6] Annual digest of monitoring change and climate in Kazakhstan: 2015. - Ministry of the National Economy of the Republic of Kazakhstan (Kazhydromet). Astana, 2016. – 55 pp. (in Russian).
- [7] Nasanbaev E.N., Medey A.R., Tursunova A.A. water resources of Central Asia: challenges, threats, problems of use. – Water resources of Central Asia and their use. Almaty, 2016. – pp. 4-8. (in Russian).
- [8] Assessment report on climate change on the territory of Kazakhstan. Kazhydromet. Astana, 2014. – 55 pp. (in Russian).
- [9] National situation analysis of security from natural and human induced disasters on the territory of the Republic of Kazakhstan (methodological basis). - Ministry of

Internal Affairs of the Republic of Kazakhstan – UNDP Kazakhstan, Astana, 2015 – 92 pp. (in Russian).