ӘЛ-ФАРАБИ АТЫНДАҒЫ ҚАЗАҚ ҰЛТТЫҚ УНИВЕРСИТЕТІ
КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ УНИВЕРСИТЕТ ИМЕНИ АЛЬ-ФАРАБИ
AL-FARABI KAZAKH NATIONAL UNIVERSITY

ГЕОГРАФИЯ ЖӘНЕ ТАБИҒАТТЫ ПАЙДАЛАНУ ФАКУЛЬТЕТІ
ФАКУЛЬТЕТ ГЕОГРАФИИ И ПРИРОДОПОЛЬЗОВАНИЯ
FACULTY OF GEOGRAPHY AND ENVIRONMENTAL SCIENCES

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МАТЕРИАЛЫ

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студентов и молодых ученых

«ФАРАБИ ӘЛЕМІ»

Алматы, Казахстан, 6-9 апреля 2020 года

MATERIALS

International Scientific Conference
of Students and Young Scientists

«FARABI ALEMI»

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ГЕОГРАФИЯ, ЖЕРГЕ ОРНАЛАСТЫРУ ЖӘНЕ КАДАСТРДЫҢ ӨЗЕКТІ МӘСЕЛЕЛЕРІ СЕКЦИЯСЫ
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SECTION ACTUAL ISSUES OF GEOGRAPHY, LAND MANAGEMENT AND CADASTRE

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МЕТЕОРОЛОГИЯ
METEOROLOGY

IMPLICATION OF CLIMATE CHANGE ON MUDFLOW ACTIVITY IN THE CENTRAL PART OF ILE ALATAU, KAZAKHSTAN

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Mudflow phenomena in high mountains are typically initiated by the sudden input of considerable quantities of water into channels which in turn mobilize stored sediment. In addition to triggering by extreme rainstorms, mudflows have also been reported to be released by rapid snowmelt, rain-on-snow storms, the sudden emptying of glacier water bodies (water pockets, proglacial/supraglacial lakes), on through the rupture of landslide dams [1,2].

Global warming is unequivocal, but the effects of global warming and the related changes in climate, on geo-hydrological hazards (e.g., floods, landslides, droughts) remain difficult to determine and to predict. There is the need to understand and measure how climate variables and their variability affect geohydrological hazards [3], including mudflows.

Climate change is also expected to have a range of secondary effects, with indirect linkages to mudflow activity. Changes in subsurface temperatures and distribution of permafrost are expected to promote in certain zones its down wasting in the medium to long term [4], which in turn is likely to liberate additional sources of unconsolidated material for mass transfers [5]. As a result of the temperature increase of the twentieth century, the lower permafrost limit has already risen by 150–250 m in the Swiss Alps, thus increasing the probability for slopes and rock walls to become more unstable and to provide sediment into torrential systems [6]. Conversely, increasing temperatures are also thought to allow vegetation to grow at higher altitudes and to stabilize loose material [7], provided the ground is sufficiently stable for plant colonization.

While many of the above considerations point to a potentially enhanced debris-flow activity in a future climate, changes in activity are so far difficult to detect in observational records. Uncertainties also remain considerable due to error margins inherent to scenario-driven global projections, and due to the coarse spatial resolution of available downscaled model data in mountain environments. A series of studies have addressed possible consequences of climate changes on permafrost bodies and the associated occurrence of debris flows, with a research focus on the European Alps [8].

With ongoing climate change, the air temperature has increased considerably in the last few decades, such that they were warmer than in any comparable period in Kazakhstan during at least the last 100 years. This warming trend is expected to accelerate during the latter half of the century, for which an average decadal increase of 0.6°C is projected [9]. Changes in precipitation, in particular heavy precipitation, have been demonstrated to affect the occurrence of mudflows, and a significant increase in high-intensity precipitation has been documented over Kazakhstan for the recent past [10]. Projections for future precipitation are consistent with past changes, but future changes tend to be less uniform and more hidden in natural variability and model errors. Nevertheless, several studies indicate that future heavy precipitation might increase in fall and winter, whereas models portray a less consistent picture for future summers.

Such changes in temperature and precipitations are likely to alter the nature of mudflow-triggering precipitation events in many ways. A warmer climate is likely to result in higher 0°C isotherms, allowing for more precipitation to fall in its liquid form and thus potentially increasing the area contributing effectively to direct runoff.

The mudflows in the central part of Ile Alatau mountain, according to their genesis, can be formed due to storm origin and as a result of the breakthrough of moraine-glacial lakes, both by surface and through intra-moraine flow channels. Since the 70s of the last century, the number of mudflows has increased significantly, the reason for this is the warming of the climate and the degradation of glaciers in the Ile Alatau high mountain areas.

More frequently, however, high-elevation mudflows occur as a result of high-intensity, convective rainstorms of short duration, or low-intensity adjective precipitation events over several days.

The results also revealed that the effect of climate change on mudflows was not straightforward to identify and the close interaction between rainfall magnitude/intensity, temperature, and soil moisture should be analyzed in depth.

Climatic changes that spanned the entire globe are accompanied by an increase in the number of extreme natural processes and phenomena, primarily hydrometeorological. An increase in the number of mudflows in the Republic of Kazakhstan, including in the central part of Ile Alatau, which is characterized by increased mudflow hazard, has been noted by many authors, as well as confirmed by the data of Mudflow Protection services.

The mudflow activity in the central part of the Ile Alatau Mountains is due to complex seismic and hydro-meteorological conditions. Mudflow phenomena are among the active exogenous processes that in a short period produce significant changes in the shape of the valley and channels in the mountain river basins.

The central part of Ile Alatau is the most mudflow activity region of Kazakhstan, where the damage caused by mudflows requires timely protection from them.

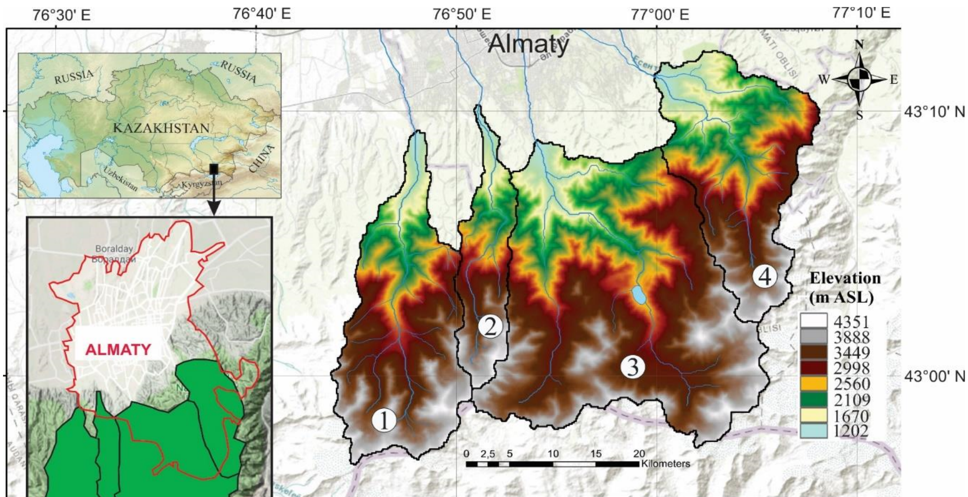
Almaty city is located in the center of the mudflow activity area. Its suburb and occasionally town center are subject to mudflow hazards. The district where Almaty is situated in the most hazardous in the republic. Four mountain rivers Kishi Almaty, Ulken Almaty, Kargaly and Aksay, flowing across the central parts of the city, are characterized by a high mudflow formation activity (Fig. 1). The basins of these rivers are extremely susceptible to mudflows. Their mountains part (of the water catchment area measuring 1 083 km2 respectively ~totally) is located on the northern slope of Ile Alatau Range. Their sources are in the glacier zone at a level of 3,300-3,400 m. The basins are mainly made up of hard rocks – granites, porphyries – mostly covered with Quaternary sediments, which are a predominant component in the mudflows [11].

Steep slopes of mountain riverbeds enable the mudflows to descend considerable distance and into the piedmont plain. The Kishi Almaty river seems to be more dangerous due to a steeper bed slope and also because the largest part of Almaty is situated in the area of its alluvial cone [12].

About fifty cases of mudflows were recorded during the twentieth century in the Kishi and Ulken Almaty river basins, five of which were catastrophic, causing considerable damage. The most severe occurred in 1921 on the Kishi Almaty as a result of heavy rainfall. It caused enormous damage to Almaty, whose population at the time was 45,000 people, killing about 500 people. The total volume of the flow was 10 million m3, and its maximum discharge was about 900 m3 s-1. A record amount of hard mud forming material (over 3,000,000 m3) was carried down [13].

On the Ulken Almaty river the most remarkable mudflow occurred in 1950; also resulting from heavy rainfall, it caused severe damage to structures and buildings in the river basin. The maximum estimated discharge of the flow was 1,000 m3 s-1.

Almaty is a modern city with a population of over 1,854,556 and a developed economy. Zones favorable for life and economic maintaining of the population are usually located in mountainous and foothill areas. These areas are attractive for their favorable climate, rich in water resources and minerals, as well as mountain and foothills, are centers of formation and passage of catastrophic mudflows.



№	River basin	Gauged area			Catchment elevation		
		Total	Glacierized				
		km²	km²	%	Min	Max	Mean
1	Aksay	245	9,3	3,8	1110	4160	2953
2	Kargaly	92	2,3	2,5	1079	4104	2687
3	Ulken Almaty	519	19,4	3,7	1202	4351	3005
4	Kishi Almaty	227	5,7	2,5	1208	4374	2561

Figure 1 – Study area

The first information about mudflow phenomena in Kazakhstan is contained in the I.V. Mushketov's publications, describing the events caused by the earthquake of 1887. Then, several researchers published descriptions of the catastrophic mudflow formed in the Kishi Almaty river basin in 1921. This event served as an impetus for the organization of the mudflow observations network in general. They began to acquire a more streamlined character since 1929, first with the establishment of the Kazakh Meteorological Bureau under the Kazakh Autonomous Soviet Socialist Republic and its subsequent merger with the Hydrological Bureau in 1931. The activities of the hydrometeorological service focused primarily on observations, research, and warning of mudflows. During 1970-80s the area of mudflow research conducted by Kazakh National Institution of Hydrometeorological Researches, the observation network in the Hydrometeorological Service system significantly expanded and Main Service for mudflow protection (KazGlavSeleZaschita) was created. Extensive material on monitoring mudflows, examining traces of past mudflows and summarizing information about them was drawn up in the form of scientific and technical reports and left in organizations creating them for interdepartmental use. Following the collapse of the Soviet Union, the 1990s are characterized by a sharp decline in mudflow research. The network of mudflow observations in Kazhydromet was being reduced. Since the beginning of the 21st century, the mudflow monitoring network continues to function in an abbreviated form and only in the State Agency "KazMudflowProtection" (KMP) system [14].

Historical data of mudflows occurrences in the river basins of Almaty city provided in Anthology of mudflow phenomena and monitoring data of KMP were analyzed for more than 100 years. This record was complemented with data from field studies of the last 30 years. The previous data were mostly available in Soviet archives and primarily included localized in-situ data. During the investigation period from 1931 to 2018, a total of about 280 rainfall generated mudflow events were observed in the study area (Fig. 2).

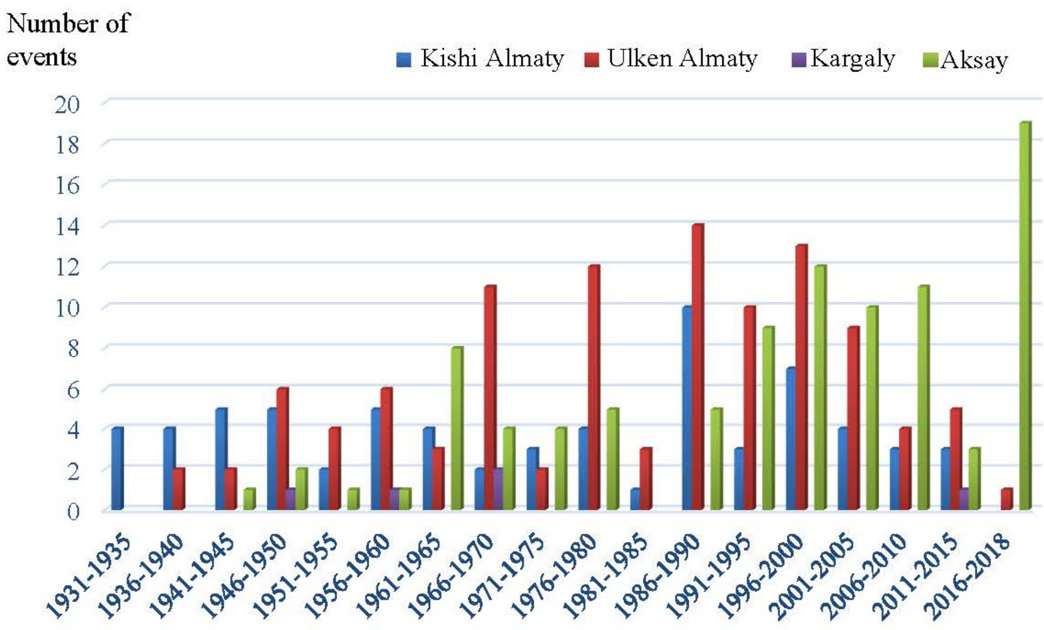


Figure 2 – Distribution of mudflow events across the river basins of Almaty city in the period from 1931 to 2018

The impact of climate change reflecting in the intra-annual distribution of mudflows is given in Fig. 3. According to actual data, mudflows were recorded only in the May-August months in the period from 1931 to the 1950s. In the next three decades, mudflows were formed from April to August. In recent years, mudflow events have been observed from March to September and their repeatability over the months is almost evenly distributed. These data show that in the late decades' air temperature is increased in the highlands and liquid precipitation begins to fall in early spring.

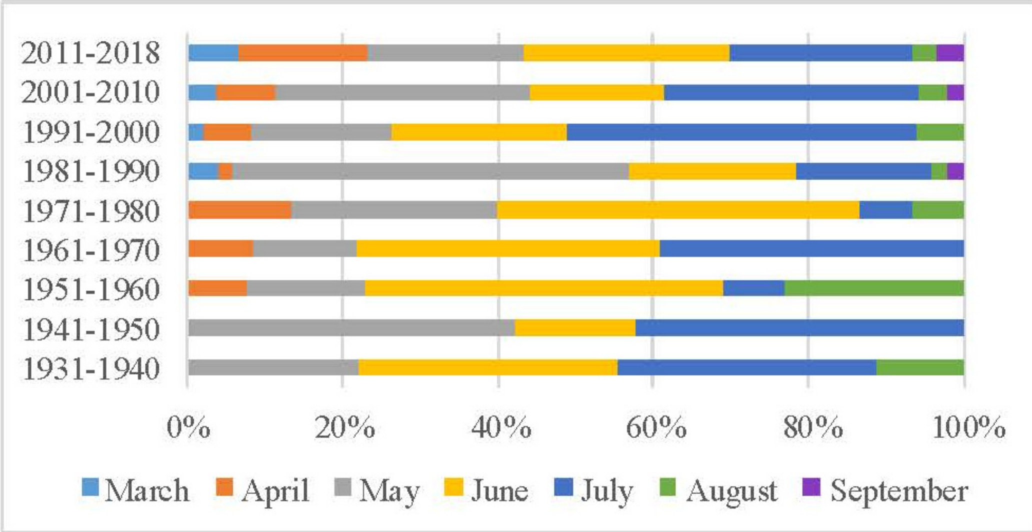


Figure 3 – Monthly mudflow frequencies (bars) in the Almaty river basins (1931-2018)

Sections of mountain river basins, where conditions for mudflow formation occur, are called mudflow centres. The mudflow centre serves as a place of accumulation of clastic sedimentary rocks that is able to concentrate runoff and has a sufficient bias for the development of shear or transport-shear mudflow processes and thereby for the formation of a mud(debris)flow of high density [15].

This study used a digital elevation model (DEM) to calculate catchment properties. The elevation data were obtained for 1970 and 2018 years.

The results of research and monitoring allow us to conclude on the nature of mudflows of the basin; about mudflow centres and a possible mechanism for the mudflows initiation; about the genesis and type of mudflow, the volume of removal and the frequency of mudflow.

Due to a lack of DEM data, the terrain information was obtained in this study by digitizing the 1/5,000 scale contours on the aerial and ground survey photos. With the aerophotogrammetry and on-site measurements of the terrain during the period 1970-2018, the terrain information at an accuracy 1/1,000 was obtained by the KMP services (Fig. 4).

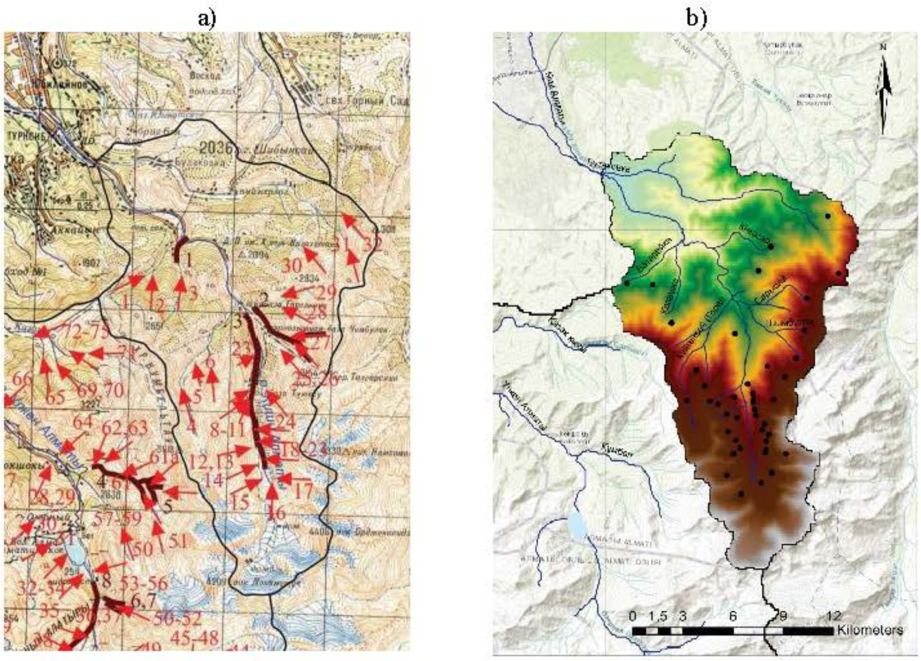


Figure 4 – Location of mudflow centres in the Kishi Almaty river basin:
a) Map of mudflow centres in 1970s;
b) Updated location map of mudflow centres based on satellites and field studies (2018)

Changes in the number of mudflow centres that occurred as a result of climate change in various parts of mudflow catchments from the glacial circus to the mudflow fan zone were consistently evaluated and new centres were identified based on satellite imagery and field research.

Identification of new mudflow centres based on satellite imagery and field research. According to the data of the State Agency “KazMudflowProtection”, on the territory of Kazakhstan, mudflow centres are confined to the areas of the most active mud manifestations, covering mainly the mountainous regions of the south and southeast of the republic. According to landscape features, mudflow centres can conditionally be divided into two groups: potential and active, on which periodic or recent emergence of mudflows left an undeniable imprint. Yesterday's potential mudflow centre can become active today.

The mudflow centres of Ile Alatau are distributed as follows: of the total number of mudflow centres, 19% are in the midlands, 9% are in the lowlands, 34 and 38% are steep-slope highlands and rocky-glacial highlands, respectively (Fig. 5).

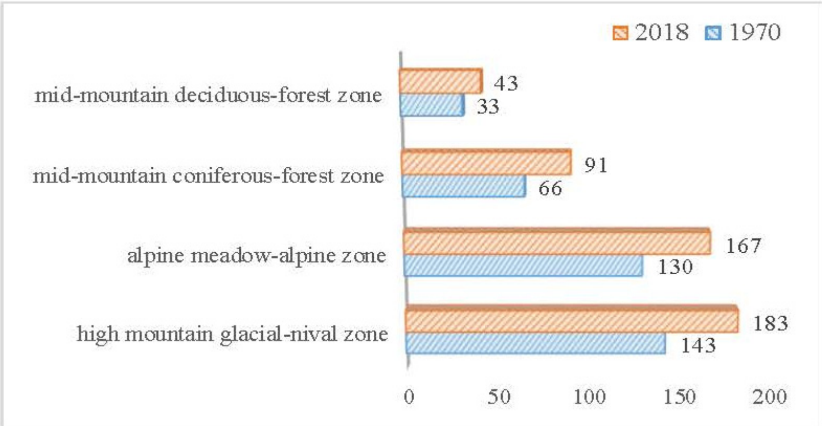


Figure 5 – Distribution of mudflow centres in the central part of Ile Alatau among high-altitude zones

Based on the analysis of the patterns of the temporal distribution of the recovered and recorded mudflow data, it was revealed that until the 50s of the last century only 10% of their total number was observed. And the remaining 90% falls on the period 1951-2018. This is due to a general increase in mudflow activity against the backdrop of climatic changes, the development of mountain and foothill areas, as well as the development of an observation system. The analysis results indicate that the river basins in the central part of the Ile are sufficiently mudflow hazardous.

During the analysis of the results of these works, a regularity of the distribution of mudflow types in various mountain belts was revealed. So, mudflows occurring in the highlands are most powerful and catastrophic. High-density mudflows forming in the midlands are usually smaller, which is associated with a decrease in the stock of friable material, sometimes with a decrease in slopes and better afforestation and sodding of the slopes. Mudflows with low density are most often distributed in the lowlands, and also partially within the middle mountains.

The impact of climate change is reflected in the intra-annual distribution of mudflows. Rainfall genesis mudflows occurred on May-August earlier and in recent decades this period has been increasing from March to September.

References.

1. GF Wieczorek, T Glade, Climatic factors influencing occurrence of debris flows. In: Debris-flow Hazards and Related Phenomena, ed. M Jakob, O Hungr (Chichester: Springer, 2005), pp. 325–362.

2. R Worni, C Huggel, M Stoffel, Glacier lakes in the Indian Himalayas: glacier lake inventory, on-site assessment and modelling of critical glacier lakes. Science of the Total Environment, 468–469 (2013), S71–S84.

3. M Stoffel, M Bollschweiler, M Beniston, Rainfall characteristics for periglacial debris flows in the Swiss Alps: past incidences – potential future evolutions. Climatic Change, 105 (2011), 263–280.

4. M Schneuwly-Bollschweiler, M Stoffel, Hydrometeorological triggers of periglacial debris flows in the Zermatt Valley (Switzerland) since 1864. Journal of Geophysical Research, 117 (2012), F02033

5. PAGES 2k Consortium, Continental-scale temperature variability during the past two millennia. Nature Geoscience, 6 (2013), 339–346

6. N Salzmann, J Noetzli, C Hauck, et al., RCM-based ground surface temperature scenarios in high-mountain topography and their uncertainty ranges. Journal of Geophysical Research, 112 (2007), F02S12.

7. C Harris, LU Arenson, HH Christiansen, et al., Permafrost and climate in Europe: monitoring and modelling thermal, geomorphological and geotechnical responses. Earth-Science Reviews, 92 (2009), 117–171.

8. M Stoffel, C Huggel, Effects of climate change on mass movements in mountain environments. Progress in Physical Geography, 36 (2012), 421–439.

9. S Gruber, W Haeberli, Permafrost in steep bedrock slopes and its temperature-related destabilization following climate change. Journal of Geophysical Research, 112 (2007), F02S18.

10. C Baroni, S Armiraglio, R Gentili, A Carton, Landform–vegetation units for investigating the dynamics and geomorphologic evolution of alpine composite debris cones (Valle dell'Avio, Adamello Group, Italy). Geomorphology, 84 (2007), 59–79.

11. M Stoffel, C Graf, Debris flow activity from high-elevation, periglacial environments. In: The High-Mountain Cryosphere, ed. Christian Huggel, Mark Carey, John J. Clague and Andreas Kääb (Cambridge University Press, 2015), pp. 295-314

12. Stefano Luigi Gariano, Fausto Guzzetti, Landslides in a changing climate. Earth-Science Reviews, 162 (2016) 227–252

13. DJ Parker. Floods. Tangler and Francis, National Academy Press, Asian Disaster Preparedness Centre, Thailand. (2000) 431 pages.

14. AR Medeu, VP Blagoveshenskiy, TA Baymoldayev, TL Kirenskaya, BS Stepanov. Mudflows of South-East Kazakhstan / The basics of monitoring in Ile Alatau, Almaty (2018), 288 (*in russian*)

15. TA Baimoldayev, MK Kassenov, AK Mussina, ZhT Raimbekova. Spatial-temporal analysis of the mudflow phenomena distribution and ways of preventing and reducing their destructive effects in mountainous and foothill areas of Kazakhstan //Debris Flows: Disasters, Risk, Forecast, Protection. Proceedings of the 5th International Conference. Tbilisi, Georgia (2018) pp. 262-270 (*in russian*)