

# Permafrost degradation and devastating floods of the 20th – 21st centuries for the Livelihoods of Yakut Arctic villages

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**Abstract.** The article uses the example of the Argakhtakh village of the Srednekolymsky ulus of the Republic of Sakha (Yakutia) located in the middle course of the Alazeya river basin to analyse the consequences of floods during the period of a relatively stable state of the environment and in recent decades, characterized by its imbalance due to global climate transformation, based on analysis of archival data, published literature and own field materials. Due to this, the causes, history and consequences of h floods of 1977-1978 were examined. It is shown that it caused significant damage to agriculture, specifically to the fodder supply of bovine cattle and horses. At the same time the materials found confirm that the territory of the village itself was not significantly affected. A different situation occurred during the floods of 1997, 2007-2008 and 2017-2018. In the first case, not only the farmlands were flooded, but the new streambed of the Alazeya River appeared next to Argakhtakh and the local farm zoo was deprived of its stable land connection to the village. The flood rises of the 21st century, apart from disastrous consequences for cattle ranges and meadows, caused damage to the housing stock of Argakhtakh, household outbuildings and infrastructure objects. all this led to a radical reduction in the scale of involvement of the local population in traditional sectors of economic activity (cattle and horse breeding), the elimination of fur farming, the degradation of transport accessibility of the village and the costs of the population to restore the economy.

## 1 Introduction

Water is life. During the whole history of human evolution, the presence of a river or other large water reservoir has been the most important condition for life. The largest subject of the Russian Federation, which is the Republic of Sakha (Yakutia), has about 800 thousand lakes and about half a million large and small rivers, the total length of which is over one-and-a-half million kilometers. In Yakutia, rivers are not only benefactors, but actually transport carcasses, connecting everyone living along them. If during the hot summer month, ships, boats and other floating crafts can move along the rivers, then the long winter turns streambeds into winter motor roads allowing not only passenger, but also cargo transportation. The republic has entire districts that can only be reached by automobile transport by winter roads. Currently winter roads take more than 60% of the total length of roads in Yakutia, and about 80% of all cargo is transported on them. At the same time, of course, rivers are a source of not only additional opportunities, but significant risks which are associated primarily with destructive floods.

More and more often, one of the causes of such floods is the degradation of permafrost, within the zone

of continuous spreading of which almost the whole territory of Yakutia is located, [1]. It is here that the frozen earth reaches its maximum capacity exceeding 1.3 km. At the same time, 31% of the total area of the region is covered by the wet permafrost rock massif, which is the most vulnerable to the consequences of global climate changes of the last decades, which clearly confirms the fact that permafrost, i.e., permanent freezing of the land, unfortunately, is not at all permanent [2].

About 15 years ago the problem with rising water levels of one of the northern rivers of Yakutia, which is the Alazeya River, and flooding of settlements located on its banks (Andryushkino, Argakhtakh and Svatay) became so serious that in 2007-2008 a scientific group was created at first and then an expedition was organized in order to discover the reasons of these flood events according to special decrees of the Government of the Republic of Sakha (Yakutia). According to the results of these studies of 2018, the members of these examinations published a monograph in which they noted that the genesis of floods is based on the degradation of permanently frozen ground, which led to the growth of amount of supra permafrost groundwater due to an increase of the depth of seasonal melting and

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degradation of a wet array of permafrost rock mass. The work also dealt with a range of consequences of ‘big water’ on the ecosystem of the Alazea River basin. However, the social consequences were not considered [3].

In general, the risk of devastating floods in the Arctic is now not prevalent in the scientific discourse aimed at analyzing natural disasters in this region. Floods are approximately on a par with coastal flooding, erosion and oil spills [4, 5]. In addition, authors who study the impact of climate change on northern communities pay some attention to the risk of flooding in the Arctic [6, 7, 8]. The case of Yakutia is represented mainly by studies of the consequences of floods for local communities in Central and Southern Yakutia [9, 10, 11].

The consequences of the floods of 1997 and 2007-2008 for livelihoods were briefly mentioned in a chapter on the migration of Yakutian population published in «Global Warming and the Human Natural Dimension in Northern Eurasia [12]. The possibilities of calculating the economic damage caused by floods on the Alazea River were analysed by O. Parfenova and D. Nogovitsyn in their article [13].

At the same time, the literature existing to date does not answer a range of important questions. Firstly, it is unclear if such floods have occurred earlier and to what consequences they led. Were there any differences from today’s floods? Secondly, the certain impact of the recent floods on the Alazea River on the life support system formed here over decades has not been studied. In this article, the author will try to fill the existing historiographic gap. Its purpose is to analyze the history of the floods that took place during the 20th-21st centuries in the Alazea River basin and their influence on the life support system through the example of the village of Argakhtakh, as well as to identify the differences between the consequences of floods during the period of active climatic transformations and the time when perpetually frozen ground was, as it is believed relatively stable.

## 2 Materials and Methods

This study is based primarily on the results of field studies conducted in Srednekolymy sky ulus in March-April 2021. In the course of these studies, 39 respondents were interviewed, the consequences of flooding (affected residential and household buildings) were recorded and one-time observations of the permafrost temperature regime in mine workings 9 meters deep (2 boreholes) were conducted. Important materials were obtained while getting acquainted with the permanent exposition of the museum of Argakhtakh village and studying materials of the Municipal Archive of the municipal district “Srednekolymy sky ulus”. This work was financially supported by the Russian Science Foundation, project number 19-78-10088. Interpretation of the obtained data, inclusion of accumulated materials in the modern concepts of analysis of destructive floods in the Republic of Sakha (Yakutia) and their impact on the existing life

support systems of the local population was carried out with the financial support of FORMAS (project DNR: 2019-02332), RFBR (project No 20-55-71005) and JST (Grant No. JPMJBF2003) through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic, HYPE-ERAS project.

## 3 Results and Discussions

### 3.1 History of the village of Argakhtakh and the Floods on the Alazea River

The village of Argakhtakh is located in the middle reaches of the Alazea River and is administratively classified as a part of the Alazea nasleg of Srednekolymy sky ulus of the Republic of Sakha (Yakutia) (See Fig. 1). According to some sources, the village was founded in 1946 [14]; according to others, it was founded two years earlier, as part of the Soviet policy of settlement formation (concentration of scattered clans, many of whom led nomadic lifestyle, in the established settlements) conducted in northern Yakutia from the 1930s through the 1950s [15]. The central base of the Alazeysky state farm (sovkhos) was located in Argakhtakh. The base of the state farm activity included meat-and-milk cattle breeding, meat horse herd farming, fur farming (silver fox breeding), fishing and fur trade. The population of Argakhtakh is decreasing. According to the 2002 census of Russia, the population of the village was 581 people, while in 2021 it is 469 persons. The vast majority of the population of Argakhtakh is traditionally Yakuts.



**Fig. 1.** Argakhtakh village, Srednekolymytsky ulus of the Republic of Sakha (Yakutia).

As follows from the materials found in the administration of the Alazea nasleg and the archive of the Srednekolymytsky district, as well as from a survey of the local population, from the 1950s through the 1980s, Argakhtakh suffered from floods 4 times: in 1958, 1968-1969, 1977-1978 and 1985. In 1969 and 1978, the water

level reached 807 cm and in 1985 it reached 766 cm. [Archive of the administration of the Alazea nasleg].

At the same time, unlike the fast-passing underfloods lasting for a few days that are characteristic of most rivers in Yakutia, the Alazea River is characterized by a long rise in water level, counted in months due to a number of features. This explains that floods in Argakhtakh may last for two consecutive summer seasons in those cases when ice formation took place when the water levels were critically high. This explains that floods in the Argakhtaya can last for two consecutive summer seasons in those cases when ice formation occurred at critically high water levels.

In particular, this happened in 1977-1978, when one of the well-documented floods on the Alazea River occurred. These documents remained after the work of the district commission on the determination of the damage from this natural disaster. They show that the flood was caused by continuous heavy rainfall from July 20 to September 15, 1977. As a result, the precipitation norms were exceeded almost 3 times. According to the data from the Andryushkino gauging station, ice formation took place on October 08, 1977, when the water level was 878 cm, while the average value of this indicator at the moment was 696 cm. Moreover, by October 30, the water level reached 905 cm. As it was mentioned during the work of the commission, something similar was observed only once, in the autumn of 1968, when ice formation started at a water level of 892 cm. However, that year, on the contrary, it decreased by the end of October.

As a result, by the winter of 1977-1978, 150 tons of stored haystacks, 300 tons of silage and 104 tons of mowing were found in the water at the Alazea department of Alazeysky state farm. During the summer of 1977, the Alazeysky state farm fulfilled less than 70% of the hay harvesting plan. The situation was aggravated by intensive snowfall, which started on September 14, 1977, and further increase of air temperature accompanied by new rains, which then were replaced by frosts. As a result, an ice crust formed on the winter pastures cattle and animals could not reach the grass. Such situation, when cattle ranges were flooded and then frozen, was noted for the first time in the history of observations on the Alazea River (which, however, was not that long at that time). Besides, due to water flooding of the areas, the depth of seasonal melting of perpetually frozen ground increased, which contributed to the formation of swamps at the hayfields.

The situation continued to develop negatively in the spring and summer of 1978, when melt waters began to flow into the Alazea River as well. By the end of June, around 80% of all hayfields and cattle ranges of the Alazea department of Alazeysky state farm were flooded. As a result, the state farm lost 156 heads of bovine cattle and 186 horses in 5 months of 1978 alone. Therefore, the main consequence of the floods of 1977-1978 for the life-support system of the village of Argakhtakh was the damage caused to traditional economic activity. Besides, the documents mention that the take-off grounds were affected by the underfloods. Argakhtakh is not included in the list of named affected

settlements, but the large number of helicopter flights to transport workers conducted at the expense of the Alazeysky state farm in 1977-1978, suggests that the situation contributed to the deterioration of the transport accessibility of the village. It should also be noted that among the types of damage caused by the 'big water' to the state farm listed in the documents not a single mention of any construction within the territory of the central estate were damaged was found. Besides, the cattle numbers exceeded the 1976 data in 1979 (548 and 569 correspondingly) [Municipal Archive of Srednekolymytsky ulus municipal district].

### 3.2. Floods of the end of the 20th century and the first decades of the 21st century

The 1990s and early 2000s in the history of Yakutia were marked by a number of devastating floods. The most famous example is the spring flood on the Lena River, which is the largest in the region. In 1992, due to the superposition of two waves of flood (due to a rapid increase of air temperature, the snow in the river heads melted earlier than normal and the main ice motion was followed by the so-called black water), for instance, in Olekminsk, where the critical water level is 930 cm, it reached the indicator of 1,109 cm. In 1998, as a result of the spring flood on the Lena River, 172 settlements were affected, 160 bridges, 133 dams and 760 km of roads were destroyed. 97 thousand residents were in the flooded area, and 15 people died. Another natural disaster happened in the spring of the following year. However, the most infamous event is the 2001 flood, when the water level at the source of the Lena River exceeded the critical mark by 6.5 meters and almost washed away the city of Lensk [9].

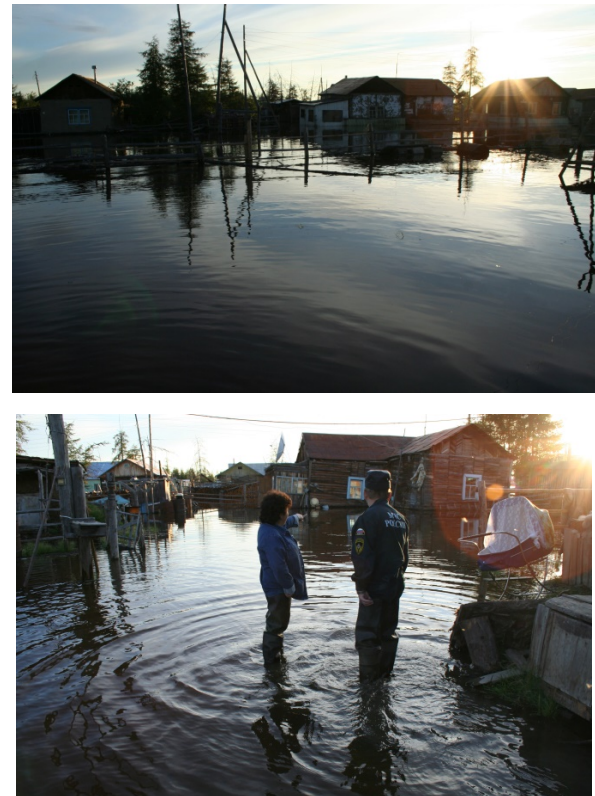
Alazea was no exception. In 1991, the water level here reached 767 cm. In 1997, it exceeded the critical (for Argakhtakh) mark of 782 cm and reached 834 cm. Three years later, these numbers were 835 cm; in 2002 it was 802 cm; in 2003 – 762 cm; in 2007-2008 – 771 cm, and in 2011 – 737 cm. The most disastrous were the floods of 2007 and 2017-2018. In the first case, the water level reached 869 cm, and in the second – 897 cm. No wonder that the floods of those years, as well as the flood of 1997, are most vivid in the memory of the local population [Archive of the administration of the Alazea nasleg].

In 1997, the elements flooded the agricultural lands in the same way they had two decades earlier. The high water level lasted from July to September. In the following years, no fodder grasses grew on these lands, because everything was covered with sludge. As a result, all the lands in the vicinity of the village were cycled out. The requirement to use distant lands with the active use of transport naturally led to an increase in the economic load on economic subjects. It should be noted that if during the 1977-1978 flood the administration of Alazeysky state farm had enough resources to practically continuously use helicopters to transport brigades and required cargoes, then after the collapse of socialist economy even the extensive use of ground freight

transport became difficult due to the high cost of fuel in the Arctic districts of Yakutia.

Probably the main reason why the 1997 flood was well-remembered by the local population was that the Alazea River changed its streambed next Argakhtakh, washed away the road and blocked the farm zoo from the rest of the village. Our respondents associate the change of in the nature of the following devastating floods with the fact that the Alazea River has become closer to the residential buildings as a result of previous cataclysms.

For instance, the flood of 2007-2008 not only flooded the agricultural lands, but also directly affected Argakhtakh, where the elements affected 29 households, and residents travelled along the village streets by boat. Ten years later, the flood affected 85% of agricultural lands and 50% of the stored-up hay. 22 residential houses were under water [12] (See Fig. 2). [12] (see Fig. 2).



**Fig. 2.** Argakhtakh village, flood of 2007 (photo from the funds of the Argakhtakh museum)

As the study has shown, natural disasters had the most negative consequences for the life support system of the Argakhtakh residents. First of all, enormous damage was caused to animal breeding: the lack of fodder led to the forced butchering of animals or further abandonment of its maintenance due to significant expenses and labour costs. Particularly, if in 2015 the population of Argakhtakh kept 139 heads of cattle, in 2019 – 87. The number of horses during the same period decreased from 477 heads to 325. Of course, this trend was influenced not only by the 'big water', but also by the general social and economic situation, as well as the aforementioned high cost of animal keeping.

However, the fact that the most significant changes in livestock numbers took place in 2017 indicates that floods made the main contribution. Besides, between 2015 and 2019, another branch of traditional economic activity, which is fur farming, went down from 45 heads to nought [Archive of the administration of the Alazey nasleg]. In this case, according to local residents, the situation was influenced not only by general trends in the development of agriculture in Yakutia and the lack of demand for the products during the post-Soviet period, but also by the consequences of the 1997 flood, which made it much more difficult to reach the farm zoo (See Fig. 3).



**Fig. 3.** Abandoned farm zoo in Argakhtakh village, March 2021 (Author's photo)

The increased transport isolation of Argakhtakh was also an important consequence of the 2017 flood (See Fig. 4). traditionally, the village had a stable land connection with the administrative centre of the ulus, which is Srednekolymsk, only by winter road the "Arktika" (See Fig. 5). In summer, there were flights to Argakhtakh. In 2017, the take-off site was flooded and so damaged that an expensive helicopter communication became the only option. Helicopters fly to the village twice a month [Author's field materials, March 2021].



**Fig. 4.** Argakhtakh village, flood of 2017 (photo from the funds of the Argakhtakh museum)

"Big water" also led to the limited use of ice boxes – "glaciers", which are special constructions buried in the frozen ground, which provide for storing frozen products all year round (See Fig. 5, Fig. 6) [author's field materials, March 2021]. This option is an important component of the traditional farming of the rural population of the Arctic districts of Yakutia [16]. However, in Argakhtakh, as a result, many ice boxes were flooded and abandoned. Besides, the widespread distribution of freezer chests and ground thawing affect the reduction of their used [17, 18]. According to the data we obtained during the research at the end of March 2021, the temperature of the grounds in Argakhtakh at a depth of 3 m was only  $-2.65^{\circ}\text{C}$  [ Author's field materials, March 2021].



**Fig. 5.** Winter road “Arktika”, March 2021 (photo of the author)



**Fig. 6.** One of the surviving ice boxes in Argakhtakh, March 2021 (photo of the author)

The floods seriously impacted the housing stock of Argakhtakh, as well as the well-being of local population; some residents had to build new homes to replace those that had been damaged by the disaster. In particular, one of the retirement-age families we interviewed had to abandon the house they had lived in for four decades and build a new.

Traditional collectivism and mutual assistance, characteristic of the rural residents of Yakutia, especially in its Arctic part, are an important adaptation mechanism that makes it possible to neutralize at least partially, the resulting costs. Because of this, residents of flood-stricken territories could wait for months for the end of the natural disaster in the houses of their relatives and households located in the higher part of the village.

#### 4 Conclusions

Therefore, the above data confirm that Argakhtakh has been prone to flooding since the first decades of its existence. At the same time, if from the 1960s through the 1980s the main strike was mainly on agricultural land, and agriculture recovered fairly quickly on the basis of available resources, then at the turn of the 21st century floods began to occur more frequently and, most

importantly, on a larger scale. At the same time, agriculture no longer had the same stability as before. As a result, the combination of new social and economic conditions and powerful floods led to a radical sequestration of traditional sectors of economic activity, which the Yakut population had been involved in for ages (animal and horse breeding), as well as to the actual liquidation of the fur trade, successfully practiced during the Soviet period. The main difference between the floods of recent years, which occurred during the time of forced degradation of the permafrost, and the floods that had taken place earlier, is their disastrous conditions directly for the village of Argakhtakh, its residential and household buildings, as well as infrastructure facilities.

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