The economic Damage from the Spring Flood in the Republic of Sakha (Yakutia)

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Abstract. The Republic of Sakha (Yakutia) having a vast territory located in various climatic zones and a developed network of water bodies exposed to a wide range of natural emergency. The spring-summer floods are the most characteristic. They cause extensive flooding of territories, facilities and infrastructure. This article draws attention to one of the main problems of the natural emergency in the Republic of Sakha (Yakutia). At ice drift on some parts of the river ice gorge is formed and causes flooding of nearby settlements and this brings huge social and material damages to the population and economy of the Republic. The use of satellite information and GIS in emergency situations (ES) allows to perform cartographic modeling of dangerous situation conditions. Cartographic modeling is necessary as a tool to visualize the situation and to simulate its changes. Using satellite images of Landsat 8, the zones of a settlement flooding are revealed and according to them the map of zones of the district subject to spring flood is created in the ArcGis program. Damage calculation is performed with the use of the "Guideline on the assessment of damage caused by large-scale flooding in the regions of the Far Eastern Federal district", approved by the Ministry of emergency situations in Russia. The decree of the Russian Federation Government on prevention and liquidation of emergency situations and consequences of natural disasters is used to compensate the damage caused to the victims of floods.

1. Introduction

Spring floods are the most large-scale area of seasonal hydrological phenomena in Russia. No country in the world is subjected to such a regular inrush of floods simultaneously on vast territories in different regions of the country that does not allow concentrating the necessary forces and means in one place. The Republic of Sakha (Yakutia) is one of the largest territories in the Russian Federation (RF) [1]. The hydrographic network of the Republic is several large rivers in the permafrost zone. The total length of all is 2 million km. A large number of settlements are located on the river valleys. Every year at ice drift of rivers the ice gorges are formed in areas where different kinds of run-of-river obstacles (sharp turns, narrowing, islands, talus fan, and the changes of slopes from a greater to a lesser water surface) affect the ability of the river ice pass. As a result of the formation of ice gorges the water level of rivers can dramatically increase which leads to flooding of nearby settlements. Large floods cause great material damage to the population and strike the economy of the Republic of Sakha (Yakutia) [2]. In this regard, it is necessary to monitor the flood and mapping of flood zones in the GIS space-based technologies to better assess the damage and determine the actual damage of amount used for relief measures.
2. Materials and methods

At present there is no single approved methodology for calculating flood damage. The peculiarities of damage calculation can be direct or indirect.

**Direct damage:**
- damage and destruction of residential industrial buildings, railways, roads, power and communication lines, irrigation and drainage systems;
- loss of livestock and crops;
- destruction and damage of raw materials, fuel, food, feed, fertilizers;
- costs of temporary evacuation of the population and transportation of material values to non-flooded places;
- washing away of the fertile soil layer and entering the soil with sand, clay or stones.

**Indirect damage:**
- costs of purchase and delivery of food, clothing, medicines, building materials and machinery, animal feed to flood-affected areas;
- reduction of industrial and agricultural production and slowdown of national economy development;
- worsening of living conditions of the local population;
- impossibility of rational use of the territory subject to flooding;
- increase in depreciation costs for the maintenance of buildings and production facilities spaces;
- increased wear of capital buildings and structures that periodically fall into the flood zone [3,4].

To calculate the damage, we used the "Methodological recommendation on the assessment of damage caused by large-scale flooding in the regions of the Far Eastern Federal district" (approved by the Ministry of Emergence Situations of Russia).

To calculate the damage to property and housing of the population of flood zones, the following relations are used:

\[ Y_s = B_i \times P \]  
\[ Y_h = N \times (0.9 \times D_p + 0.1 \times D_c) \]  

Where \( Y_s \) and \( Y_h \), respectively, damage to property and housing affected;
\( P \) – number of residents affected by floods;
\( N \) – number of affected houses;
\( B_i \) – average value of property per victim;
\( D_p \) – the cost of partial loss of a house (housing) meaning the need to perform capital repair;
\( D_c \) – the cost of total loss of a house (housing) meaning the need to build a new house [5,6].

Compensation for damage caused by flooding is paid from the Federal and regional budget. The amount of compensation payments has been calculated by the resolution of 2014 "On the order of carve-out of budget allocations from the reserve fund of the Russian Federation Government for prevention and liquidation of emergency situations and consequences of natural disasters" [7].

Budget allocations from the reserve fund are allocated to Federal executive bodies’ authorities and executive authorities of the member states of the Russian Federation for partial coverage of financial support for the following activities related to the liquidation of emergency situations and consequences of natural disasters in the amount of:
- in connection with partial loss of property the financial assistance to citizens in the amount of 50 thousand rubles or the total loss of property in the amount of 100 thousand rubles per person;
• financial assistance to corporate bodies (for partially lost property – up to 200 thousand rubles per one legal body, for completely lost property – up to 400 thousand rubles for one legal body);
• one-time financial assistance in the amount of 10 thousand rubles per person with no limit on number of family members, but not more than 50 thousand rubles.;
• one-time financial assistance;
• other payments provided by normative legal acts[8,9].
From the republican budget for 2018 the one-time financial assistance in the amount of 5 thousand rubles and financial assistance for the loss of property: partial – 10 thousand rubles, total loss – 20 thousand rubles [10,11].
Financial assistance to legal bodies will be approximately 600 thousand rubles according to the RF Government decree from February 15, 2014, No.110 "On the procedure of budget allocations from the reserve fund of the Russian Federation Government for prevention and liquidation of emergency situations and consequences of natural disasters" [7].
For damage assessment of earth roads GOST Р50597-93, by the Decision of GosStandart of the Russian Federation from the 11th October 1993 No. 221, "Highways and streets. Requirements for operational status permissible under conditions of road safety": not applicable.
"The standard extends:
• until 01.01.95 for the operated federal roads, trunk roads and streets of cities and other settlements;
• since 01.01.95 all operated public roadways with cement-concrete coating and any coating of bitumen mineral mixtures and for all roads and streets of cities and other settlement" [12-16].
As an example, the calculations of flood damage during the ice drift of rivers by means of space image of Landsat 8: settlements of Amga and Tabaga. The value of property is calculated according to the cadastral value of housing [17,18].

3. Results and discussion
According to the satellite image of Landsat 8 on May 7, 2018. in the settlement of Amga: 4 residence buildings, 6 yard areas and 10 people including 3 children, road of 228.53 m long, the yard of the hospital were in the area of flooding (Figure 1). According to the methodology the general damage for individuals from the federal budget is 1682376,241 rubles, the republican one is 1471376,241 rubles.

![Figure 1](image1.jpg)

Figure 1. The flooding zone on the satellite image of Landsat 8 in the settlement of Amga (2018) [18,20].

On the site of Tabaga-Yakutsk a gorge of fine ice was formed, which affected the rise of the level of water in Khangalassky district and the settlement of Tabaga. In Tabaga water level reached a peak at 1124 cm at the critical level of 970 cm [19]. According to the satellite image of Landsat 8 on May 21, 2018 six yard territories, three houses, one arch garage and a sawmill were flooded (Figure 2).

![Figure 2](image2.jpg)
Damage for individuals from the federal budget is 734419 rubles, republican is 542419 rubles.

**Figure 2.** The flooding zone on the satellite image of Landsat 8 in the settlement of Tabaga (2018) [18, 20, 21].

The cost of damage caused by flooding according to the satellite images of Landsat 8 from the republican and federal budget for the above mentioned settlements is given in table 1.

**Table 1.** Calculation of damages from the natural disaster in the Republic of Sakha (Yakutia) during the spring flood (2018).

| Settlement | Damages by the methodology | Republican budget | Federal budget |
|------------|----------------------------|-------------------|---------------|
| Amga       |                            | 1471376.241       | 1682376.241   |
| Tabaga     |                            | 542419            | 734419        |

4. Conclusion

It should be noted that the proposed calculation of damage in the future will help to calculate more accurately the amount of damage caused by flooding in settlements. Actual costs are determined by the application of the victims and the size of the allocated funding from the republican budgetary funds. Data space image clearly shows the flooded objects and the calculation of damages takes into account all victims of a natural emergency (ES).

As well as the table 1 shows the ratio of the amount of damage in the Republic of Sakha (Yakutia) and the Russian Federation.

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