A comparative analysis of disaster mitigation, response, and recovery practices in the northern US and Russian cities

Tuyara Gavrilyeva[1] and Yekaterina Kontar[2]

1. North-Eastern Federal University (NEFU), Yakutsk, Russia; 2. The Fletcher School of Law and Diplomacy, Tufts University, Boston, USA

1. Introduction

Traditional settlements are rather resilient to disruptions, including natural hazards and wars. In their research on strategic bombing of Japan during World War II and its impacts on the distribution of population and infrastructure, Davis and Weinstein (2001) noted that the country's population, infrastructure, and industries were rapidly restored to their pre-war locations. Similar conclusions were reached by the researches investigating bombing of German and Vietnamese cities (e.g., Brakman et al., 2004; Miguel and Roland, 2011; Redding et al., 2011; Kolomak, 2014), which highlighted that no long-term impacts on the spatial distribution of economic activity in these regions has not been revealed. This trend is apparent in countries and regions with high population density.

The trend, however, reverses in the regions with low population density, especially in the Circumpolar North. Historical analysis has revealed numerous episodes of settlement extinctions due to epidemic, as well as depletion of natural and economic resources. Moreover, most northern settlements have undergone a significant transformation at the beginning of the 21 c. In Russia, for example, most northern settlements were formed through forced collectivization and industrialization, while in the US - through the initial militarization and later deactivation of military bases (Kontar et al., 2015; Gavrilyeva et al., 2017). Most northern cities are relatively new settlements rarely older than 90 years. Since their formation and development did not follow gradual paths, northern cities lack resilience to disruptions. Therefore, disaster risk in northern settlements is significantly higher than in older cities that gradually developed over centuries.

2. A comparative case study: causes and impacts of ice-jam floods in Alaska and Yakutia in May 2013

River ice thawing and breakup is an annual springtime phenomenon in the North. Depending on regional weather patterns and river morphology, breakups can result in floods (Beltaos & Prowse, 2001). Breakup floods often cause catastrophic ice and water damage to exposed and vulnerable riverine communities, and lead to socioeconomic and ecological crisis (e.g., Beltaos, 1983; Gerard & Davar, 1995; Buzin, 2004; Kontar et al., 2015). Frequently resulting in severe damage to homes and infrastructure, destruction of livelihoods and services, ecological degradation, and negative health effects, breakup floods often lead to socioeconomic and ecological crisis in impacted communities.

Breakup floods are complex natural and social phenomena. Their scale, frequency, and impact can be effectively addressed only through holistic policy solutions, which are based on coherent science-based assessments (Boaz and Hayden, 2002; Cutter et al., 2015).

2.1 Methodology

To analyze causes and impacts of breakup floods we conducted a comparative analysis between two flood-prone communities, Galena in Alaska, USA and Edeytsy in Sakha Republic (Yakutia), Russia. Within a week of each other in May 2013, Galena and Edeytsy sustained major ice jam floods. In both communities, floodwaters and ice floes destroyed or severely damaged nearly all homes and key infrastructure and displaced hundreds of people. The 2013 floods caused multi-million dollar damages in both communities, impelling local administrations to call for state and federal disaster response and recovery funds. As a result, an array of stakeholders from governmental, non-governmental, public and private sectors were engaged in flood relief and recovery in both regions. For that reason, Galena and Edeytsy provided a great opportunity to compare and contrast collaboration and communication between the diverse stakeholders involved in DRR in both regions.

Galena is a remote community of 467 people, located in traditional Koyukon Athabascan Indian territory in central Alaska (U.S. Census Bureau, 2015). It is situated on the northern bank of the Yukon River, over 430 kilometers away from the nearest urban center in Fairbanks, and 1600 km from the State's capital, Juno. As pointed out by Sprott (2000), Galena exhibits both unique features and similarities to other rural Alaskan communities. The distinction is obvious in its population's size and proportion. Galena's population of over 450 people is larger than most villages, while the proportion of aboriginal population (about half) to non-aboriginal is lower than in most villages.

The community can be reliably accessed year round only via aircraft, snowmachines in the winter, and barges in the summer (Taylor et al., 2016). Despite the absence of road access, Galena contains infrastructure unmatched for a rural Alaskan community. In 1993, a U.S. Air Force (USAF) base was deactivated in Galena, and its entire infrastructure (except for the state owned airfield) was transferred to the village. The former airport base is the only part of Galena that is protected from breakup floods by a dike, which was constructed in 1945 (Taylor et al., 2016). In 1997, USAF buildings were turned into classrooms and dormitories of the Galena Interior Learning Academy (GILA); the boarding school offers vocational training along with a standard academic curriculum to over 100 students from rural Alaska each year (GILA, n.d.). GILA also provides additional employment opportunities for Galena residents.

Due to its strategic geographic location and unmatched for a rural Alaskan community infrastructure, Galena is a regional transportation, economic, cultural, and educational hub for many rural communities in central Alaska (Sprott, 2000). Galena's inability to recover after the next spring flood would lead to the demise of a network of communities in Interior Alaska (Kontar et al., 2017, *in press*). The airfield and former airbase infrastructure are crucial during flood relief and recovery operations. During the 2013 flood, Galena residents took shelter in GILA's dorms, while emergency managers set up their camps on the only dry land behind the dike (Pelkola and Korta, 2015). The water-free airfield facilitated evacuations and transportation of emergency personnel and supplies to the impacted community. According to Korta (2017), the dike came very close to breeching during the flood in May 2013, and still needs to be repaired to sustain future floods. The village does not have enough funds to take up a million-dollar project, while the USAF no longer sees it as their responsibility (Korta, 2017).

The flood in May 2013 destroyed or severely damaged over 90 percent of the homes in New Town; most residents were caught off guard and unprepared for evacuation and further consequences. After the 2013 flood, as part of enhanced FRR (flood risk reduction), most houses in Galena were rebuilt on steel pilings (Denver, 2017; Korta, 2017). Old Town, the original Native settlement, is situated between the dike and the river, and thus remains exposed to floods.

The 2013 breakup floods caused over 70 million USD of damage in rural Alaska, thus impelling local administrations to call for state and federal disaster response and recovery funds. As a result, an array of stakeholders from governmental, non-governmental and private sectors were engaged in flood relief and recovery. Insufficient interagency communication and collaboration led to significant delays in Galena's recovery (Gavrilyeva et al., 2017, *in press*; Kontar et al., 2017, *in press*).

Edeytsy is a rural community of 1,261 people, located in central Sakha Republic in Northeast Siberia (Yadreev, 2017). As in most rural Sakha communities, Edeytsy's population is over 90 percent aboriginal. Sakha language and customs are well preserved and practiced daily Lindenau, 1983). Cattle-ranching is the traditional mean of livelihood in Sakha Republic, and it is still largely practiced in rural communities (Lindenau, 1983). As within most of rural Sakha, Edeytsy is a predominantly agricultural and cattle-ranching community. Similarly to Galena, Edeytsy has supplementary livelihood opportunities, including employment at the local school, kindergarten, clinic, fire department, and post office (Yadreev, 2017).

Edeytsy is situated on the eastern bank of the Lena River, only 35 kilometers from the regional center Namtsy, and 60 kilometers away from the Republic's capital of Yakutsk. Unlike Galena, Edeytsy can be reliably accessed year-round via freeway, thus facilitating flood relief and reconstruction efforts. Thereby, Edeytsy's key infrastructure was rebuilt in only six months after the flood in May 2013 (Yadreev, 2017).

Despite the quick response and relief efforts, the 2013 flood caused socio-economic crisis in Edeytsy. In two weeks, floodwaters inundated nearly all farms, shrinking arable land to 70 percent of pre-flood, and decreasing the growing season by one month. Consequently, the autumn harvest was low, and most residents incurred financial losses (Yadreev, 2017; Gavrilyeva et al., 2017, *in press*; Kontar et al., 2017, *in press*).

Floodwater and ice debris also destroyed or severely damaged most of Edeytsy's homes and key infrastructure. The overall flood damages in Edeytsy reached over 10 million USD, and prompted the local administration to call for federal and republic flood relief and recovery funds. The rapid six-month recovery in Edeytsy was facilitated through ongoing interagency communication and collaboration (Yadreev, 2017; Gavrilyeva et al., 2017, *in press*; Kontar et al., 2017, *in press*). I compare flood risk and crisis management frameworks in Alaska and Sakha Republic in Chapter Five.

Greater losses in Edeytsy were avoided due to the timely relocation of cattle to higher ground. In the last six years, flood preparedness and early warning have significantly improved in Edeytsy. The precursor was the second largest breakup flood to date in May 2010, which killed cattle, and thus left the residents without their primary means of livelihood (Yadreev, 2017). Reports indicate no loss of cattle in the 2013 flood.

Similarly to Galena, flood risk was not factored into the investment decisions during the initial settlement of Edeytsy in their current floodplain location. Prior to the late 1920s, Sakha people were nomadic and lived in groups that rarely exceeded 30 people. According to the 1926 census, there were over 11 thousand rural settlements in Sakha with a mean population of 23.3 (Argunov, 1985 as cited in Gavrilyeva et al., 2017, *in press*). Similarly to Koyukon Athabascans, Native Sakha followed the seasons by migrating between their winter and summer camps (Lindenau, 1983; Vakhtin, 1992).

Edeytsy, as a municipality, was formed in 1930 by the Soviet government. Establishment of the Soviet regime and collectivization[1] throughout the Sakha lands co-occurred with forced settlements of populations into permanent locations (Argunov, 1985 as cited in Gavrilyeva et al., 2017, *in press*). Several Native groups were integrated into Edeytsy to advance local kolkhozy[2]. Edeytsy was settled on the river to facilitate irrigation and water supplies for large cattle herds. The initial flood risk has amplified over decades due to the river channel migration and population increase (Gavrilyeva et al., 2017, *in press*). In surveys, Edeytsy residents noted the following flood years: 1968, 1978, 1997, 2007, 2009, 2010, 2011, and 2013.

To minimize FR, a range of FRR measures have been implemented in Edeytsy with varying degree of success. A combination of structural and nonstructural mitigation efforts were implemented prior to and after the flood in May 2013. With financial support from the State (Republic) government, the construction of a dike was initiated after the breakup flood in May 2010 (the second largest flood on record). Due to incremental funding, construction of the dike was not completed prior to the flood in May 2013; construction is still ongoing (Yadreev, 2017). After the 2013 flood, a few residences and key public buildings (e.g., school, kindergarten, clinic, and office of the local administration) were elevated. Houses elevated on wood pilings have proven to be unreliable at withstanding ice damage.

Via two case studies, we assessed underlying causes of flood risk, and analyzed existing practices in mitigation, response, and recovery in the United States and Russia (Table 1). We collected information via a series of focus group discussions with representatives from federal and state agencies responsible for flood management, interviews with the population who suffered the consequences of the 2013 floods, and historical analysis of flood management evolution in both regions over the last century.

2.2 Key findings

To conduct the necessary data collection on site, a bilateral and interdisciplinary team was established as part of the US Department of State U.S.-Russia Peer-to-Peer Dialogue Initiative. The team consisted of US and Russian geoscientists, social scientists, students, emergency managers, and civil and tribal community leaders. Each of the team participants represented a key stakeholder group that takes part in flood management in both countries, and shared his/her expertise with the relevant counterparts.

The historical analysis revealed that the vulnerability of northern rural communities to spring floods traces back to the original settlements of Native Alaskans and Sakha into their

[1] *Collectivization* was a policy of forced consolidation of individual peasant households into collective farms called "kolkhozes" as carried out by the Soviet government in the late 1920's - early 1930's (Osofsky, 1974).

[2] *Kolkhoz* (pl. kolkhozy) is a collective farm in the former Soviet Union. It was operated on state-owned land by peasants from a number of households who were paid as salaried employees on the basis of quality and quantity of labor contributed (Osofsky, 1974).

permanent locations. Traditionally, Native communities in Alaska and the Sakha Republic avoided spring floods by not establishing permanent settlements in floodplains. Seasonally nomadic, Native Alaskans migrated between their fishing and hunting camps (Arundale, 1985; Sprott, 2000). Native Sakha originally settled around lakes located on higher ground (Lindenau 1983; Vakhtin, 1992). Compelled by government programs to settle on floodplains in more permanent structures and communities in the first half of the twentieth century, Native Alaskans and Sakha began to face flood risk (Kontar et al., 2016). Flood risk was not factored into investment decisions during the initial settlement decisions (Kontar et al., in press). Communities were settled on the shores of the Lena and Yukon Rivers with no structural or nonstructural protection against spring flooding.

The economic and political incentives (e.g. establishment and maintenance of a US Air Force base in Galena and kolkhoz in Edeytsy) for the communities' expansion further outweighed considerations for flooding. Although pursuing different underlying goals, state governments in Alaska and the Sakha Republic similarly focused on rapid community settlement and expansion. The growing concentration of people, infrastructure, livelihoods, and services close to the riverbanks has been driving flood exposure in Galena and Edeytsy for the last eight decades. The original absence of flood risk governance resulted in a lack of building codes, and flood prevention, mitigation, and preparedness measures. For decades, flood-ravaged houses in Galena and Edeytsy were rebuilt on the same places with no intent to reduce populations' exposure and vulnerability to spring floods (Morgan, L., 1972; Lindenau, 1983).

2.3. Spring Flood Prevention and Mitigation

Through the analysis of focus group discussions with US and Russian representatives from the agencies responsible for FRM, we revealed two key categories of ice jam flood prevention and mitigation strategies in Alaska and Sakha (Table 1):

1. *Ice jam prevention*: preventive measures to eliminate or lessen the likelihood of a damaging ice jam event from occurring.
2. *Reduction of ice jam flood impact*: preventative measures undertaken to reduce the potential damages from floodwater and ice debris. These measures are further divided into structural and nonstructural.

Despite flood mitigation in Galena and Edeytsy, both communities sustained severe adverse impacts during the breakup in May 2013. After the floods, new structural measures were initiated in both communities. I analyzed and compared old and new mitigation measures in Galena and Edeytsy for their effectiveness and applicability across borders.

As mentioned above, flood risk was not factored into the investment decisions during the initial settlement of Galena and Edeytsy in their current floodplain locations. The initial lack of enforcement of the building regulations in Galena and Edeytsy led to the construction of key infrastructure and many homes in flood-prone locations. Until 1972, the airport was the only part of Galena that was protected from ice jam floods. According to the Alaskan Air Command report (Mongin, 1972, as cited in Kontar et al., 2015), a dike was built around Galena Airport in

1944. The original native settlement Old Town, however, is located between the dike and the river, and thus remained exposed to floods.

Due to their flood-prone location, Old Town residents do not qualify for reconstruction reimbursement. The majority of the Old Town residents are elder Native Galena residents, who settled there in the mid-twentieth century, or inherited property from their elders. Even after the devastating impacts of the 2013 flood, most Old Town residents rebuilt their homes in the old place at their own expense.

After the 1971 flood (the largest ice jam flood to date), an area called New Town was constructed several miles upriver with the goal to relocate Galena residents on higher ground, further from the flood plain. According to Pelkola and Korta (2017), over four decades without floods led New Town residents to develop a false sense of security. The flood in May 2013 destroyed or severely damaged over 90 percent of the homes in New Town; most residents were caught off guard and unprepared for evacuation and further consequences. After the 2013 flood, as part of enhanced flood mitigation, most houses in Galena were rebuilt on steel pilings (Denver, 2017; Korta, 2017).

The flood recovery was also an opportunity for sustainable development in Galena. The Cold Climate Housing Research Center (CCHRC) collaborated with the Federal Emergency Management Agency (FEMA) and the Alaska Department of Homeland Security and Emergency Management (ADHSEM) to develop six energy-efficient and affordable replacement housing units for Galena residents (Hébert, 2017). The houses were developed specifically for Galena. The construction materials are easy to transport and assemble. The floor, walls, and roof are combined into single pre-built trusses that can be easily tipped up (Hébert, 2017). Easy and rapid assembly is an important factor, because a large portion of reconstruction in rural Alaska has to be completed in a short period of time with help from volunteers, who might not have the necessary labor skills. The houses contain 10 inches of polyurethane spray foam insulation, which is airtight and moisture resistant, and thus critical for maintaining dry and mold-free walls. The foam is also an economical option for Galena and other remote Alaskan villages because of its low shipping costs and high R-value (Hébert, 2017).

Although only six houses in Galena were reconstructed according to the resilient design described above, it was a step towards the sustainable development of rural Alaska. Sustainable and resilient development is an integral part of DRR (UNISDR, 2016). As Hébert (2017) noted, Galena is part of a larger project with the state to create a matrix of approaches that can be used for emergency replacement housing.

In Edeytsy, a combination of structural and nonstructural mitigation efforts were implemented prior to and after the flood in May 2013. With financial support from the State (Republic) government, the construction of a dike was initiated after the breakup flood in May 2010 (the second largest flood on record). Due to incremental funding, construction of the dike was not completed prior to the flood in May 2013; construction is still ongoing (Yadreev, 2017). After the 2013 flood, a few residences and key public buildings (e.g., school, kindergarten, clinic, and office of the local administration) were elevated. Houses elevated on wood pilings have proven to be unreliable at withstanding ice damage.

2.4. Spring Flood Preparedness

Due to a partial community relocation and a 40-year break between the latest major floods, a large segment of Galena's population had not experienced severe flooding in their lifetime. As a result, most residents and local administration were caught off guard and unprepared (Korta, 2017). Pelkola and Korta (2015) pointed out that the former city manager of Galena had been recently appointed to his administrative position, and was not prepared to lead the community during the crisis. The floodwater and ice floes inundated the entire community within a few hours, leaving little to no time to assist the population at risk in evacuation efforts.

Experienced with more frequent severe flooding, Edeytsy residents were more proactive in relocating their cattle, farm equipment, and personal vehicles to higher ground. According to the survey results, over 90 percent of Edeytsy respondents avoided losses beyond their houses and outbuildings, while over half of Galena's respondents reported additional losses of vehicles and machinery. The Edeytsy administration begins flood preparations a week prior to potential flooding, thus assuring that at risk groups (e.g., elderly, children, and disabled) received the necessary assistance, and livestock had been relocated to higher ground. A predominantly cattle-raising society, Edeytsy residents suffered severe economic impacts when they lost their livestock during the last major flood in May 2010.

Edeytsy, as most rural riverine Sakha communities, relies predominantly on mechanical ice jam prevention and removal measures. When dangerous ice jams form, a series of ice dusting, cutting, and blasting operations take place (Figure 6). Although ice jam prevention and removal measures are regularly implemented, there is no statistical evidence of their effectiveness. Although the Russian ice jam mitigation efforts are proactive, they are not necessarily effective. According to Androsov et al. (2015), over $52,000 were invested in ice cutting and dusting measures along the Lena River in Spring 2013. Yet, the breakup resulted in significant flooding. Nevertheless, survey results reveal a significantly higher satisfaction rating with the mitigation and prevention measures among Edeytsy residents.

Ice jam mitigation efforts, such as ice cutting weakening, and demolishing are designed according to hydrological models developed by academic and Roshydromet scientists. However, no criteria for the effectiveness of these models has yet been established. Therefore, there is no published evidence of these methods' effectiveness. More comparative analysis is needed to determine the costs, benefits, and effectiveness of the mitigation efforts. Further in-depth comparative analysis is needed to determine the costs and benefits of breakup flood mitigation and prevention measures. Advances in ice jam and flood risk mitigation would improve the overall FRR in both regions.

Administration in both communities received timely warnings prior to the 2013 floods. As a rule, flood-prone communities in Sakha Republic receive regular breakup and flood forecasts and flood warnings from Roshydromet (Androsov et al., 2015). In rural Alaska, communities receive flood forecasts and warnings from the NWS hydrologists and ADHSEM emergency managers that are part of the Alaska River Watch program.

Table 1. Existing ice jam flood mitigation and prevention techniques in Alaska and Sakha Republic.

Ice Jam Prevention			
Technique	**Description & Function**	**Region**	**Drawbacks**
Ice dusting/sanding	Spreading a thin layer of a dark solid substance (e.g., coal) to promote the deterioration of an ice cover by decreasing the albedo of the ice, and thus increasing its melting rate.	Sakha	• Often ineffective due to fresh snow covering dusted areas, or new periods of freezing. • Not effective in persistently cloudy regions. • Possible water and soil contamination. • No statistical evidence of effectiveness.
Blasting (pre-breakup)	Fracturing ice cover to promote early release of small ice floes prior to high spring flow.	Sakha	• Expensive. • Dangerous for practitioners. • Negative environmental impacts. • No statistical evidence of effectiveness.
Ice cutting (saws)	Creating lines of weakness to promote deterioration of ice cover and release of stationary ice prior to high spring flow. Decreasing size of ice floes to promote release and flow of ice.	Sakha	• No statistical evidence of effectiveness.
Flood Impact Reduction			
Technique	**Description & Function**	**Region**	**Drawbacks**
Floodplain MGMT	Prevention/discouragements of	Alaska	Can lead to interagency and intergovernmental

	communities in flood-prone areas.	Sakha	conflicts.
Flood-proofing • Dikes • Elevation of structures	Construction of dikes to confine streamflow to the river channel, thus to protect infrastructure and homes from inundation and ice debris damage. Corrective elevation of existing structures or preventative elevation of new structures to a height above the largest flood to date.	Alaska Sakha	These structural measures require large initial investments and, in some cases, continuous future investments for after-flood repairs and maintenance.
Relocation	Partial or full relocation of the at-risk communities away from the floodplain.	Alaska Sakha	• If relocation is imposed on communities, it is often unsuccessful because residents tend to return to their original settlements. • Disaster assistance funds often exclude money for preventive measures.
Flood forecasting and EWS	Predicting timing, duration, and magnitude of water level rise.	Alaska Sakha	Inaccurate forecasts could lead to unnecessary evacuations, and hence discourage further future evacuation.
Blasting (ice jam removal)	Release already formed ice jams by fracturing ice cover.	Sakha	• Expensive. • Dangerous for the practitioners. • Negative environmental impacts. • No statistical evidence of effectiveness.

Although the River Watch team provided Galena with the timely flood warning, the community was not ready to withstand the flood (Pelkola and Korta, 2017). The local administration requested outside assistance. Immediate assistance was provided by the Tanana Chiefs Conference, and later by the ADHSEM and FEMA. In Edeytsy, flood assistance was provided immediately due to well established interagency communication and collaboration.

In Edeytsy and other rural Sakha communities, annual flood preparedness measures begin with the evacuation of special risk groups approximately two-three days prior to the potential flood. In the Sakha Republic, the overall coordination of breakup flood mitigation, preparedness, response, and recovery efforts are organized and initiated at the federal level. This unified and centralized system encourages an ongoing year-round interagency communication throughout the flood cycle (Figure 8). It also facilitates the availability of the necessary financial and human resources to execute flood prevention and relief efforts in a timely and effective manner.

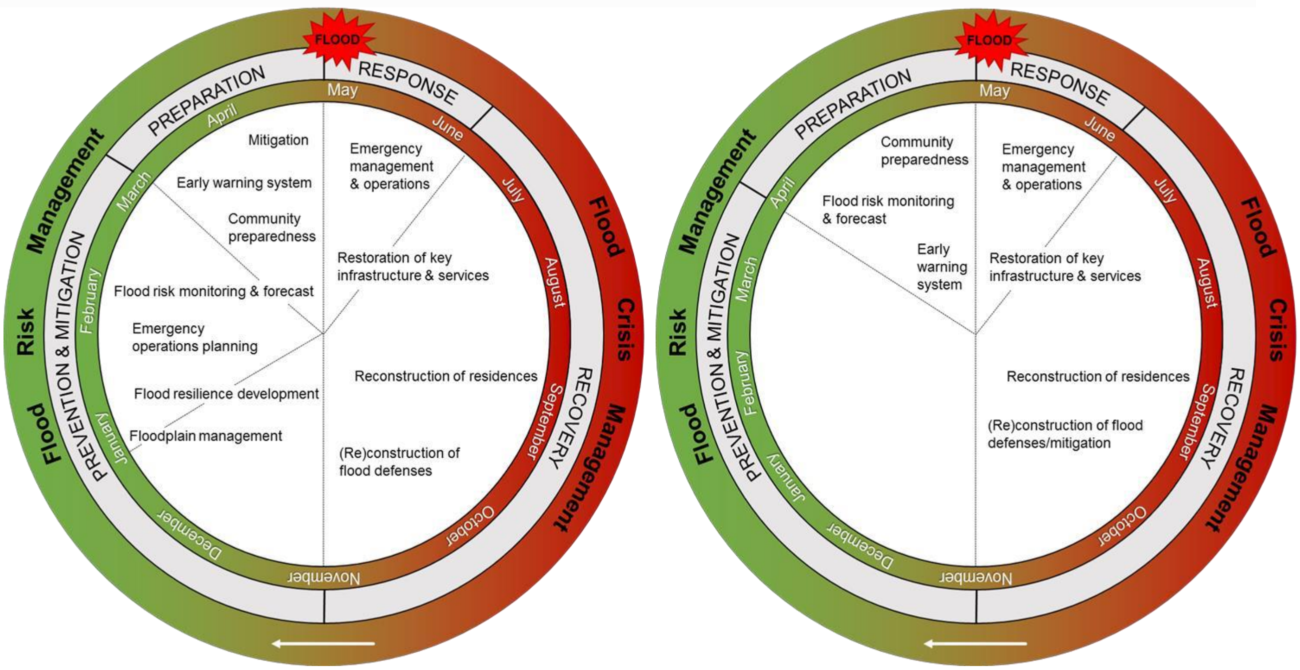

Figure 8. Spring Flood Management Cycle Models. **(left)** Examples of interagency activities during key flood risk and crisis management phases in the Sakha Republic; **(right)** Examples of activities during key flood risk and crisis management phases in Alaska.

Disaster preparedness is an integral component of DRR. It encompasses activities which increase a population's ability to predict, prepare for, as well as respond to and recover from disasters (Hansford, 2011; IPCC, 2012). Preparedness, similarly to mitigation, is a pre-disaster measure, which is aimed at protecting a population before a disaster strikes. During the 2013 floods, preparedness measures in Galena and Edeytsy included early warning, evacuation of at-risk population and livestock to higher ground, and facilitation of rapid response (Kontar et al., 2017, *in press*).

Due to a partial community relocation and a 40-year break between the latest major floods, a large segment of Galena's population had not experienced severe flooding in their lifetime. As a result, most residents and local administration were caught off guard and unprepared (Korta, 2017). Pelkola and Korta (2017) pointed out that the former city manager of Galena had been recently appointed to his administrative position, and was not prepared to lead the community during the crisis. The floodwater and ice floes inundated the entire community within a few hours, leaving little to no time to assist the population at risk in evacuation efforts.

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In Alaska and Sakha Republic, multiple stakeholders from federal, state, and local governmental agencies, as well as NGOs and the private sector engage in spring flood risk reduction (Table 2). In Sakha Republic, coordination of breakup flood prevention, preparedness, response, and recovery efforts are organized at the federal level. This unified and centralized system encourages an ongoing year-round communication between the stakeholders throughout the flood cycle (Androsov et al., 2015).

Approximately four months prior to the breakup onset, an interagency working group forms to allocate the necessary resources for flood prevention, mitigation, preparedness, and potential relief and recovery efforts, and to assign tasks and responsibilities among stakeholders involved in flood risk and crisis management. The group consists of representatives from federal, regional, and local governments and emergency preparedness and relief agencies. The group's decisions are based on the breakup and flood predictions from the Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet) of the Sakha Republic.

Table 2. Key stakeholders involved in FRM in Sakha Republic and Alaska.

Sakha Republic, Russia	
Stakeholder	**Role in FRM**
Lena River Basin Water Management (LBWM)	A federal agency responsible for organization and coordination of breakup flood mitigation (e.g., ice cutting, dusting, and blasting) and relief efforts relative to federally owned infrastructure.
Roshydromet - Russian Federal Service for Hydrometeorology and Environmental Monitoring	A federal agency responsible for flood hazard assessment, breakup and flood monitoring, flood forecasting and warning.
Ministry for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (MchS)	A state agency responsible for organization and coordination of preventative flood measures, response and recovery efforts, and damage assessment.
Spring Flood Relief, Recovery, and Restoration Agency (FRRRA)	A state agency responsible for damage assessment, appointment for construction contracts, and compensation allocations.
Local government	Various local agencies cooperate during floods with the goal to facilitate evacuations and allocation of compensations for damaged private property.
Alaska, United States	
Stakeholder	**Role in FRM**
Federal Emergency Management Agency (FEMA)	A federal agency responsible for coordinating the response to a disaster that overwhelms local and state resources, and providing the necessary financial and technical assistance to impacted areas. FEMA provides financial means to impacted individuals and families through the allocation of individual assistance grants, and local and regional administration through the allocation of the public assistance grants.
National Weather Service (NWS) Fairbanks Forecast Office and River Forecast Center	Under the National Oceanic and Atmospheric Administration (NOAA), NWS is responsible for monitoring river ice conditions, providing flood forecasts, and warning at-risk communities and emergency managers.

Alaska Division of Homeland Security and Emergency Management (AKDHSEM)	A state agency responsible for coordinating response and providing a rapid recovery to Alaskan communities during disasters that overwhelm local resources.
The Tanana Chiefs Conference (TCC)	A non-profit tribal consortium promoting health and wellbeing for Native communities and addressing the needs of the tribes during disasters. Although not a response agency, TCC coordinates with private, state, and federal agencies to provide the impacted populations with needed resources, e.g., housing and food, during and after the flood.
American Red Cross of Alaska	A non-profit agency that collaborates with the State of Alaska, TCC, and local administration and provides relief to disaster victims and assist communities in emergency prevention, preparedness and response.
Local and tribal governments	Various local and tribal agencies cooperate before, during and after the flood to assist residents with evacuations and property relocations, and coordinate with the state, federal, and non-profit agencies to facilitate disaster preparedness and relief.

Two months prior to the breakup onset, the working group begins to collaborate on a detailed flood prevention and response plan. The plan highlights communities at risk and locations for ice jam mitigation efforts (e.g. ice cutting and blasting). Based on the up-to-date forecasts from the Roshydromet, the state government issues advisories about potential floods and collaborates with local administration on potential flood relief and recovery efforts.

Approximately four-to-two weeks prior to the flood onset (based on the regional hydrological and weather conditions), federal and state emergency specialists conduct ice jam and flood mitigation efforts, including ice weakening, removal, and detonation techniques. Meanwhile, local administration establishes emergency response posts, prepares for and informs the population at risk about potential evacuation. Evacuation of elders, children and disabled residents, as well as relocation of cattle, cars, and farm equipment, begin two to three days prior to the flood.

After the floodwaters recede, an interagency commission evaluates the damages and determines individual (family) and public compensation (Gavrilyeva et al., 2017, *in press*). As soon as the damage assessments are completed (usually by early July), the rebuilding of houses as well as critical infrastructure and services begins.

In Alaska, breakup flood disaster cycle begins with the flood response efforts (Figure 8). No centralized ice jam mitigation efforts (e.g., ice cutting and removal) are conducted prior to the breakup onset. Once a flood overwhelms a community's capacity, local administration requests the state's support. If the flood exceeds the state's resources, the governor requests a federal disaster declaration and support. This succession significantly delayed relief and recovery efforts in Alaska in 2013. From May 17 through June 11, 2013, a series of breakup floods ravaged Galena and four other communities in Interior Alaska. Governor Parnell requested a major disaster declaration on June 14. On June 25, President Obama declared disaster in Alaska and approved federal assistance (FEMA, 2016). Reconstruction of infrastructure and homes did not begin until August, and was completed three years later.

The delays were caused by Galena's remoteness, Alaska's limited infrastructure, short rebuilding season, and interagency miscommunication. The lack of the standardized spring flood risk and crisis management resulted in additional damage assessments and approvals, and adjustments of paperwork and regulations.

As pointed out by Kontar et al. (2015), the River Watch is the most prominent example of effective interagency communication and collaboration in Alaska. For over 50 years, River Watch has been conducting assessment of ice conditions throughout Alaska with the goal to provide accurate assessments of flood threats and navigational hazards (NWS, 2015). To conduct these assessments, the River Watch engages (on a volunteer basis) private and commercial pilots as well as village residents to provide their observations on the ice conditions, and thus supplement reports acquired from ground observations, aerial reconnaissance, and remote sensing.

The River Watch is managed by the National Weather Service (NWS) and supported by the State of Alaska Division of Homeland Security and Emergency Management (DHS & EM). During the River Watch, NWS hydrologists are tasked to conduct flyovers with the DHS & EM personnel. Scientific experts determine whether ice and river conditions are likely to cause ice jams and flooding by identifying potential locations of ice jams, flood threat, and magnitude of flooding. They also monitor water conditions if flooding is occurring, and forecast when floodwaters will recede. This information is crucial for the DHS & EM in determining best approaches in assisting endangered communities with emergency preparedness, evacuation, and/or response.

The River Watch team also works closely with local emergency management, the community, and tribal officials by providing regular briefings on the current river, ice, or flooding conditions. They often take community leaders on flyovers to get a local perspective and knowledge of the situation. For example, during the flood in Galena in May 2013, a DHS & EM official was on the ground assisting the community while a NWS hydrologist continued to make frequent flights over the ice jam and flooded area to determine if conditions would improve or get worse. A NWS hydrologist would also conduct regular briefings to the emergency officials and community leaders on the ground.

In rural Alaska, the Alaska River Watch program has been fostering a long-term dialogue with the local emergency management, tribal officials, and residents of rural Alaska communities. As a result, they were able to establish and maintain a sense of partnership as well as trustful and reliable communication patterns between multiple disaster actors.

Due to their efforts in developing long-lasting, open, and reciprocal communication with the community, the River Watch program is able to provide information and guidance to local officials and residents so they can take prompt actions. In addition to establishing and fostering effective communication with emergency state agents and affected communities, the Alaska

River Watch program provides flood forecasting and warnings as necessary precautionary measures.

The overall satisfaction levels of flood response and recovery efforts were significantly higher among Edeytsy than Galena residents. Edeytsy residents were generally satisfied with the assistance they received from all stakeholders. Except for the assistance they received from their neighbors and relatives, Galena residents were generally disappointed with the flood response and recovery efforts.

Based on the higher reported satisfaction ratings in Edeytsy, the Russian flood risk and crisis management system appears to be more effective. Its effectiveness largely depends upon an extensive system of social controls, effective interagency communication and collaboration, and more frequent disastrous springtime flooding. Adapting an interactive flood risk and crisis management model in Alaska would allow memories of the previous flood disasters to be kept alive and improve upon the existing system, thus reducing community's vulnerability and facilitating timely and effective disaster response and recovery.

However, in this scenario the Russian and Sakha state governments administrate flood management programs via top-down regulations at the detriment of local actions (Gaillard & Mercer, 2012). Local governments do not take part in flood management planning, but are merely tasked to relay actions from the top down. Opinions and knowledge of the population at risk have not been encouraged or incorporated in the decision-making regarding spring flood management.

In the Sakha Republic, flood management is executed predominantly by federal agents, which rely on military chain of commands and top-down regulations. Since the underlying political, economic, social, and cultural causes of spring floods are not regarded as civil-defense matters, they remain largely ignored (Gaillard & Mercer, 2012). After flood recovery is completed, the community's vulnerability still remains. Continuing not to include local stakeholders into the decision-making process would further propagate the implementation of flood management strategies that do not help to reduce the communities' vulnerability and risk drivers.

In Alaska, the breakup flood cycle begins with flood response efforts (Figure 8). No centralized flood risk reduction efforts are conducted prior to the breakup onset. Once a flood overwhelms a community's capacity, local administration requests the state's support (Denver, 2016). If the flood exceeds the state's resources, the governor requests a federal disaster declaration and support (McEntire, 2007; Denver, 2016). As pointed out by Kontar et al. (2015) and Taylor et al. (2016), this succession significantly delayed relief and recovery efforts in Alaska in 2013. The lack of interagency communication resulted in additional damage assessments and approvals, and adjustments of paperwork and regulations (Kontar et al., 2015).

3. Discussion

To facilitate the integration of local stakeholders and knowledge in flood risk reduction, disaster scholars call for decentralization (Gaillard & Mercer, 2012; Sendai Framework, 2015). Decentralization could strengthen capacities of local administration in rural Sakha to mitigate, prepare, respond to, and recover from spring floods. On the other hand, local rural governments, such as in Edeytsy would lack financial means and skills to undertake substantial flood risk management efforts, such as building dikes or relocating at-risk population, independently from the central Russian government. In this scenario, decentralization would undermine flood risk reduction.

To facilitate timely and effective flood response in rural Alaskan communities such as Galena, federal and state agencies could adapt their policies and strategies to the unique needs of impacted populations who have limited cash resources and who reside in remote and inaccessible locations. These strategies need to be in place before a disaster strikes. To have a clear understanding of the communities at risk, local stakeholders as well as their knowledge, opinions, and concerns should be integrated into decision-making (Gaillard & Mercer, 2012).

To advance the overall flood risk reduction in Alaska, all stakeholders should join the dialogue, and thus facilitate cooperation and mutual learning. The dialogue approach to flood risk communication is challenging as it involves coordination and 'cross-cultural' communication between outside actors (disaster managers) and inside actors (community members) (Gaillard & Mercer, 2012).

4. Conclusion

Disaster risk is especially high in rural and remote communities, where flood relief and recovery are complicated by the region's unique geographical and climatological features, limited physical and communication infrastructure, and insufficient disaster mitigation and preparedness measures (Kravitz & Gastaldo, 2013; IRDR, 2014). To reduce disaster risk, one needs to, foremost, accurately identify and assess it (Cutter et al., 2015; Sendai Framework, 2015).

Disaster has resulted from complex interactions between a series of natural processes and human actions that generated conditions of hazard (i.e., spring floods), exposure, and vulnerability (GFDRR, 2014; Kontar et al., in press). Therefore, disaster risk in can be reduced by managing conditions of hazard, and decreasing exposure and vulnerability of the at-risk populations (GFDRR, 2014; UNISDR, 2016; Kontar et al., in press). To facilitate integrated disaster reduction in the North, it is crucial to provide a space for a dialogue among key stakeholders, including communities facing disaster risk.

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