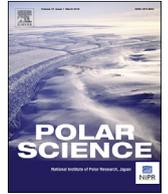


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Limits of pastoral adaptation to permafrost regions caused by climate change among the Sakha people in the middle basin of Lena River

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ABSTRACT

This article focuses on the pastoral practices of the Sakha people in eastern Siberia to explore the impact of climate change on human livelihood in permafrost regions. Sakha use grassland resources in river terraces and the alaa thermokarst landscape for cattle-horse husbandry. Although they practice a different form of subsistence than other indigenous arctic peoples, such as hunter – gatherers or reindeer herders, the adaptation of Sakha has been relatively resilient in the past 600–800 years. Recent climate change, however, could change this situation. According to hydrologists, increased precipitation is now observed in eastern Siberia, which has resulted in the increase of permafrost thawing, causing forests to die. Moreover, local meteorologists report an increase of flooding in local rivers. How do these changes affect the local pastoral adaptation? While describing recent uses of grassland resource by local people, and their perception of climate change through anthropological field research, I investigated the subtle characteristics of human–environment interactions in pastoral adaptation, in order to identify the limits of adaptation in the face of climate change.

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1. Introduction

The purpose of this paper is to explore the impact of climate change on human livelihood in the permafrost region. Arctic anthropologists heretofore have used their accumulated knowledge in discussing culture and climate change by focusing on indigenous peoples as the main stakeholder, and indeed, rights-holders, of arctic societies and on the socio-cultural settings of these peoples. Their primary interests have been the sea-mammal hunters and their social conditions related to the decrease of sea ice (e.g., [Krupnik and Jolly, 2002](#); [Laidler and Ikummaq, 2008](#); [Wenzel, 2009](#)) and reindeer herders and their social conditions related to the change of the tundra environment (e.g., [Forbes et al., 2010](#); [Forbes and Stammer, 2009](#); [Nakada, 2015](#); [Stammer-Gossmann, 2010](#)). The condition of sea-ice has been a notable focus of Arctic climate observers, both natural scientists and policy makers. While research trends have reflected anthropological knowledge and theories regarding arctic adaptation of marine hunters and reindeer herders in tundra, taiga and (sea) coastal ecologies ([Krupnik, 1993](#)), cultural adaptations to the permafrost ecology has not been the mainstream of arctic anthropological research: indeed such

research has only appeared quite recently ([Crate and Fedorov, 2013](#)). Permafrost and climate change is rather mostly examined in terms of the oil and gas development due to the thaw affecting the pipelines and other infrastructure (e.g., [Zum Brunnen, 2009](#)).

For the natural sciences, permafrost is a paleothermometer that can be used to identify fluctuations of air temperature in order to estimate the extent of climate change. Geographically permafrost contributes to the formation of unique topography and flora, because it contains water.¹ This is critical to the cultural issue, since water is a key substance in interactions of humans with the environment. What is the relationship between human cultures and societies and permafrost?

The word permafrost might symbolize cold and barren landscapes, with negative connotation to human existence. However, anthropologically, permafrost contributes to cultural diversity and expands human adaptability. One Eurasian arctic people, the Sakha, historically developed a unique cultural adaptation of cattle-horse production in the permafrost region of eastern Siberia. The pastoralist Sakha originally migrated from Baikal region with a subsistence culture similar to that of Mongolian and Central Asian

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¹ See the website of International Permafrost Association. <http://ipa.arcticportal.org/resources/what-is-permafrost> (2015/10/15).

nomads. There another indigenous adaptation, that hunting–fishing and reindeer herding, predominated. The exceptional character of traditional subsistence provides the unique ethnic identity of the people and the source of historical development of the political economy. Today Sakha are geographically distributed across most parts of eastern Siberia. They number 470,000, which is 10–15 times larger than other indigenous² peoples of Siberia. Their ethnic autonomy within the political system of the Russian Federation is guaranteed at least nominally through the Sakha Republic (Yakutia). As I will explain, the background to their success lies their specific adaptation to the hydrological effects of permafrost. The permafrost contributes to constitution of the local culture and identity (Crate, 2006; Takakura, 2015). Climate change is now challenging this historical development. Through the process of describing this change, I also discuss the possibilities and vulnerabilities of cultures that have developed in permafrost regions.

First, I briefly introduce the natural history of the local environment and culture, and describe the recent effect of climate change in this region, which is causing an increase of precipitation. Then, I explore the human–environmental interactions from the perspective of local knowledge, in order to identify the limits of pastoral adaptation by the local population.

2. Permafrost and pastoral culture: *alaas* and Lena River terraces

The region on which this paper focuses is in the middle basin of Lena River, a sub–arctic region covered by taiga. Globally, the boreal forest ecology covers regions of the same latitude. However, the precipitation of this region is very low compared to that of western Siberia and the American sub–arctic. To take an example, in Yakutsk, the capital city of the Sakha Republic (Yakutia), the precipitation is 236.9 mm per year, which is nearly identical to that of Ulaanbaatar, and typical of the dry–steppe biome. Generally, the formation of forest requires precipitation of more than 300 mm per year, rates experienced in western Siberia and Northern America. Theoretically, given the low precipitation rate, the middle basin of Lena River should be covered by grassland. Why does the boreal forest grow under such conditions? The key is that permafrost stores water, which makes it possible for a forest to grown on the land (Fukuda, 1996, 1999; Sakai and Saito, 1974).

Permafrost enables the growth not only of forest, but also of grasslands around lakes known as *alaas*, in thermokarst depressions.³ The countless patchy grasslands with lakes and flood plains in the forest are a special feature of the middle basin of the Lena River in central Yakutia (Saito, 1985; Jordan and Jordan–Bychkov, 2001). *Alaas* are the product of long–term climate change, the origin of which could go back to early Holocene. The larch and the pine tree, the key trees of these ecosystems, has been dominant since the late glacial period. The *alaas* formation process was triggered by global climate amelioration after the late glacial period. Conditions of high humidity combined with poor drainage facilitated the development of the bodies of water that cause thermokarst subsidence (Katamura et al., 2006, 2009; Nelson et al., 2002; Sakai and Kinoshita, 1974).

The forests, grasslands, lakes and rivers form the cultural landscape of Sakha people. In particular, the grasslands are critical for

the formation of horse–cattle pastoralism. Two types of grasslands are recognized in Central Sakha society. One is the *alaas* grassland. Such grasslands are found in seven to eight terrace elevations varying from 10 to 30 m in height and ranging from 30 to 40 km in surface width (Saito, 1985:71). Another type of grassland is formed on the extensive riverbank terraces of the Lena River. *Alaas* are also found on riverbanks in relatively higher–moist elevations in the east (right) side of Lena River, which expands into the inner forest areas. However, there are few *alaas* on the drier, lower elevation riverbank on the west (left) side of the Lena (Saito, 1985:73).

The local people perceive the *alaas* and terraced riverbanks as different cultural landscapes. The terraced grassland is associated with the ethnic origin of Sakha people. The legendary hero–founder of the people, Ellei, migrated from the south and started his livelihood in the river terrace grassland called Tyimaada. The type of grassland provides the local people with their identity: people today refer to being of terrace origin (*khocho oggoto*) or *alaas* origin (*alaas oggoto*). *Oggo (to)* means child in the Sakha language, and therefore *khocho oggoto* literally means “child of the terrace”.

The forest and grassland sustained by permafrost are key elements in the evolution of Sakha cattle–horse pastoralism in this region. Historical sources suggest that before moving northward their pastoral ways were the ways of inner Asian nomads, with five species of livestock — sheep, goat, cattle, horse and camel (Tokarev and Gurvich, 1964). After migrating, due to the harsh climate only horses and cattle could be sustained. Hunting in forests and fishing in rivers and lakes are also important sources of subsidiary food procurement for the Sakha people. It is noteworthy that a vast volume of hay made from grass is used as fodder for livestock during winter (Takakura, 2015). Sakha people have developed a semi–sedentary form of pastoralism as their traditional way of life, living in fixed wooden houses at summer and winter pastures and moving between the two sites.

It is hypothesized that the northern migration of the Sakha people occurred either in the 10th–13th centuries (Okladnikov, 1970), or in 13th–15th centuries along the Lena River (Pakendorf et al., 2006). They must have first used the grassland in river terraces and then moved to the *alaas* region. Since then, during the past 600–800 years, the Sakha people have been relatively resilient in their adaptations to changes in the middle basin of Lena River. It is certain that colonization by imperial Russia had increased the pressure for fur–bearer hunting in the forests. The economic significance of livestock changed from horses to cattle, and agriculture was introduced into the region during 18th–19th centuries. The socialist modernization in the 20th century stopped the semi–nomadic ways of life through forced sedentarization. Nevertheless, horse and cattle breeding, which is sustained by the local environmental conditions, has always occupied most Sakha people as their main subsistence activity. The recent climate change could change this situation.

3. Recent floods in the Sakha Republic (Yakutia)

What impact has climate change had on the middle basin of Lena River? The Lena River's middle basin lies within the Sakha Republic (Yakutia) of the Russian Federation. Recently damage due to flooding has increased in the republic. If catastrophic flood events have occurred seven times during 1900–1997 serious floods, which brought about the economic loss of more than 1% of republican expenditures, occurred four times since 1998 (Filippova, 2010; Takakura, 2015b). Several anthropologists have reported an increase of flood related disasters on the Tatta Viliui and Anabar Rivers (Stammler–Gossmann, 2012; Fujiwara, 2013) and on the *alaas* lands in Viliui region (Crate, 2012). Causes for flooding appear to be either due to the earlier thawing of ice and snow in the spring,

² The Sakha are not considered an indigenous people in the Russian legal conceptualization. The term implies rather “aboriginal,” or “local,” in a historical sense in this paper. By using the term “indigenous,” I highlight traditional features of adaptation by Sakha, comparable to those of other indigenous peoples.

³ The term “*alas*” is often used in most scientific literature, but here I adopt the term “*alaas*” designating thermokarst depression with cultural implication which is originated from a local word of Sakha language.

related to climate change, both in the river and alaa lands (Sukhoborov, 2006) or due to anthropogenic activities such as lack of river-dredging (Kusatov et al., 2012), which was practiced in the socialist era.

Here I have examined the issue of culture and permafrost in a period of climate change by focusing on the river terrace grasslands (as opposed to the alaa). My findings draw on anthropological fieldwork in Sakha villages situated mainly on the west bank of Lena River and specifically in communities on river terraces.

There are countless rivers and streams, both in the Arctic and subarctic regions. Everywhere, it can be observed that the water freezes in the autumn and then thaws in the spring. Climate change affects this process, because air temperature is one of the main factors controlling both periods of freezing and the thickness of the ice (Prowse, 2007). Ice jam flooding can be observed in early spring in a wide ranging area from the Arctic to certain middle latitude regions, such as Hokkaido in Japan (Yoshikawa et al., 2012). These floods happen because of the gradual and uneven process of thawing of river ice, and because the ice gets jammed at some point of the river. Ice-jam floods contribute to the revitalization of the water environment and the regional flora and fauna (Beltaos, 1995). A case study of the Peace Athabasca delta in Canada reported that recent warming has decreased regional ice-jam floods, which has resulted in the decrease of biodiversity of the region (Beltaos et al., 2006), while having a positive impact on the societal infrastructure (Prowse and Beltaos, 2002).

Ice jam floods are a complex phenomenon, and climate change does not impact different water systems equally. Concerning the traditional subsistence of Sakha people, snow and ice also play an important role in its renewal. In particular, the ice-related spring flooding of the Lena River system has been a blessing for subsistence activities in the region of river terrace grasslands. The flooding contributes to the revitalization of the ecosystem and grass resources, which is the basis of the development of Sakha cattle-horse breeding. As previously noted, an increase of floods has been observed in Lena River system, including by satellite (Sakai et al., 2011). Moreover, hydrologists have reported an increase of precipitation in the form of snow and rain, which has resulted in an inflow of water into the rivers. The increase of precipitation has also affected the deepening of permafrost thaw, causing the death of inland forests (Iijima et al., 2014). In addition, the growth of lakes in thermokarst depressions has triggered changes in the environment of ice-rich permafrost terrain (Fedorov et al., 2014).

4. Concepts and methods

Heretofore, I have described human-nature relations in permafrost by discussing the case of Sakha people in Eastern Siberia, and noted recent events in the local permafrost region related to climate change. Scientists have certainly observed changes such as an increase of water in the local environment resulting from precipitation; however, the cause and effect relationship still remains unclear.

As a social scientist, my position (rather than to explore causal relationships) is to inquire if the impact of recent changes in climate events could be identified in local pastoral adaptation. How does the increase of water affect long-term interactions between permafrost and humans as a form of cattle-horse breeding through grassland resource subsistence? How do the remarkable climatic events change individual behaviors and society of local pastoralism? I have attempted to explore these questions by using local knowledge accumulated through my anthropological fieldwork.

Anthropologists conventionally regard a given subsistence culture as being the result of selection in an environment through historical processes and insist that it is cultural adaptation (Smit

and Wandel, 2006: 283). This concept is heuristic with an inclusive and a long-term perspective; therefore, it does not rely on assumptions regarding the failure of cultural adaptation. The failure or breakoff could certainly happen under special circumstances, such as disasters or colonialism. However, such events are regarded as exceptional events in understanding subsistence cultures, whereas the natural environment has been regarded as stable and resilient. Anthropologists rather focus on changes in socio-cultural process. On the other hand, the anthropologists in climate change studies have begun to consider the limit of cultural adaptation under the current conditions of climate change (Adger et al., 2007). This is partially because of the declaration by the Intergovernmental Panel on Climate Change, an interdisciplinary climate science organization, which states that the natural environment is very likely changing, triggered by anthropogenic warming of the climate system (IPCC, 2013). The natural environment is no longer stable, a fact anthropologists have recognized. Understanding the limits of adaptation entails detailing the mechanisms of the process of failure in a once manageable subsistence culture, by taking into consideration the changing effects of nature. This would lead to a deeper comprehension of the delicate balance in human-environment interactions. The goal of this paper is thus to identify limits of adaptation in the context of climate change in a river-terrace grasslands environment, by focusing on local knowledge and corresponding behaviors.

The ethnographical material presented here was collected between 2010 and 2012, over the course of a total of six weeks. The material was gathered by using the methodologies of participatory observation and unstructured interviews, which were conducted in both Russian and Sakha languages. In order to investigate the relations of human culture and climate change, I selected three villages, all of which are located near the west (left) coast of Lena River (Fig. 1): Khamagatta village (Namskii district), Tulagino village (Yakutsk city), Nemiug village (Khangalaskii district). I first compared two villages: Khamagatta, a community that did not suffer floods very often, and Tulagino, a community that had suffered frequently.

During my field trip in May 2010, there was a disastrous spring water flooding of the Lena River. According to the local newspaper, 2000 houses were damaged and the flooding affected 6000 people. Economic loss was reported as reaching 1.2 billion rubles⁴ and included the loss of more than 2300 head of livestock. While both villages experienced damages to houses, Tulagino experienced no loss of livestock, because of preparations made by the local administration. Khamagatta reported the loss of 30 head of livestock, a relatively small loss. The local TV broadcasted about the more serious situation farther to the south. It was reported that the floods had heavily damaged this village where 209 houses among a total of 700 had been flooded, and 230 cattle and horses had been killed.⁵ (Figs. 2 and 3).

I started my field interviews in 2010 with people I had known through my previous research on local knowledge related to ice-jam floods and pastoral activities. I conducted my interviews by talking to people who I encountered walking in the village. In 2012, I revisited some of the people who I had interviewed in 2010, and also interviewed other people. I also visited the local administrative offices and asked about the damage caused by the 2010 flooding, and about policies and countermeasures taken by the

⁴ Novosti NEWSru.com. 23 May 2010 (<http://www.newsru.com/russia/23may2010/yakut.html>) [2015.2.1] and Russiiskaia gazeta, 3 VI, 2010 (<http://www.rg.ru/printable/2010/06/03/pavok.html>) [2013/9/17].

⁵ Russiiskaia gazeta, 3 VI, 2010 (<http://www.rg.ru/printable/2010/06/03/pavok.html>) [2013/9/17].

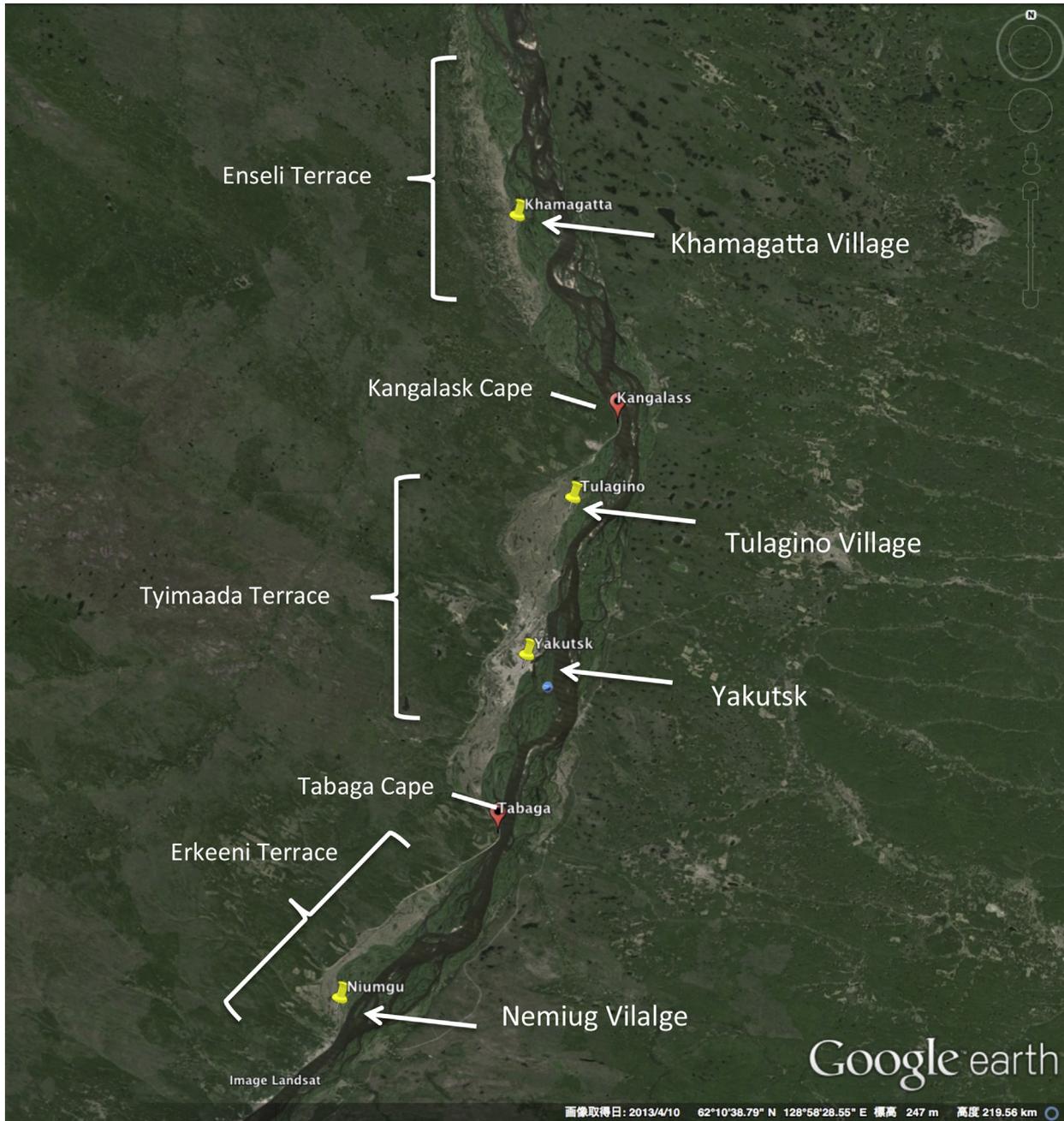


Fig. 1. Lena River and village map.

administration. I interviewed 29 individuals in 2010 and 28 in 2012. The ethnographic documentations of this field research and the preliminary analysis have been reported in previous papers published in Japanese (Takakura, 2013, 2015b). Here, I wish to highlight the limits of adaptation to climate change by using an interdisciplinary approach that draws on both anthropology and hydrology.

5. Local knowledge of floods and the adaptation

5.1. The perception of local farmers

First, allow me to describe local knowledge related to floods. The local people in all three villages recognize three types of floods: ice-related floods, known as spring water floods (*saasky uu*), snow-

thaw -related floods, known as black water floods (*khara uu*), and rain-related floods, known as summer water floods (*saiun uu*). The first type of flooding to occur in the spring is usually ice-jam floods, and the second type of flood usually occurs ten days after the first and consists of black water, so-named because it carries soil.

Here is a narrative of a farmer regarding flooding, which is typical of the descriptions given by the people in the three villages.

Kharyy (ice-jam) is necessary for the river flood plain, and it gives a supply of water so that grass can grow. But the black water (second flooding) is not welcome, because it brings a lot of soil to the ground. But, if it were to stay for only a short period, there would be no problem (Source 1, Khamagatta village, 17 May 2010).

It is remarkable that the local people rather welcome ice-related floods, because it is a blessing for the hay stocks used for animal



Fig. 2. Giant ice after the ice-jam flood, May 2010, provided by Khangalaskii District administration of Sakha Republic.



Fig. 3. The loss of livestock caused by ice-jam flood, May 2010, provided by provided by Khangalaskii District administration of Sakha Republic.

husbandry. The local population has developed a unique geographical knowledge of the region, as can be seen in Fig. 4, illustrating the sandbank of the river, and geographical names of places near the Khamagatta village. Although this village has not

often suffered disastrous floods, the people do recognize the possibilities for such related to the local topography and can identify hot spots for ice-jam floods. It is noteworthy that the environment of the floods has been assimilated into the complex of local culture

and livelihood.

As noted above, the tendency for floods is increasing, which is disastrous for the local society. According to local administrative officers, damage caused by the catastrophic ice-jam flood of May 2010 to Tulagino included 24.5% of houses flooded, with no loss of livestock. The damage to Khamagatta included flooding of 50% of houses (but not so seriously) with a small loss of livestock. And the damage to Nemiug included flooding of 29.5% of houses with a loss of 230 heads of livestock.

The damage from floods depends on the location of a house within the village. Therefore, if local people were to receive a flood warning, they could prepare for the flood by taking countermeasures, such as moving furniture and electrical equipment to higher places, or by preparing to evacuate. The biggest concern of the local people was for the safety of their livestock. At night the cattle are kept in cowsheds, but during the day they are pastured in the open grassland, either in alaa or in river terraces. Guiding the livestock to safer places is a key measure against flood damage taken by the local people (Takakura, 2015b).

Does local knowledge of Lena River floods contribute to disaster risk reduction? In the strict sense, the answer to this question is negative, because the timing of flood events cannot be predicted. Disaster risk reduction would be possible if appropriate measures were undertaken by the local administration, rather than depending on local knowledge. As I have discussed in a previous paper, the vocabulary and expressions in the Sakha language related to river ice and floods are extremely well developed (Takakura, 2013). The local knowledge that is elaborated by this lexicon provides a conceptual framework for understanding the series of events related to the thawing of river ice in spring, but it is not decisive to decisions needed for the implementation of behaviours for disaster risk. This leads to the question as to whether the recent increase of floods related to climate change has exceeded the limits of local knowledge. Is the utility of local knowledge as a long-term interface between the environment and culture being threatened by climate change? During my field research in 2012, I heard an interesting narrative on this matter, which can further our understanding of local knowledge.

Spring water flooding is caused by ice jams. This is good water and it is even necessary. In June, black water floods come to us. This year, this second flooding has continued longer than usual, and the water stayed with us for two to three weeks. In addition, the summer water floods started around 13–15 July, which is the time for beginning haymaking, and it also continued for two weeks. It was all very bad. Nothing like this year's floods happened in the past. I remember that there was a disastrous flood in May 2010, but it did not stay long, so it had no impact on the haymaking, and rather, we had a good harvest (Source 2, 17 September 2012, Nemiug village).

The reader might remember that Nemiug faced a disaster in the 2010 flood. Certainly it resulted in serious damage, because livestock was lost, but it did not affect the growth of the grass resource. On the contrary, the 2012 floods were not large scale, but it stayed longer, which had a more serious impact on local pastoralism.

Here is a similar narrative by a local farmer from the different village.

In this year, the spring water flooding happened around 20–30 of May. Its scale was small, but the black water floods were bigger. Plus, during the summer, the water stayed in the grassland until the middle of August and it affected the growth of grass. Therefore, there were almost no haystacks in communities on the left flood plain of Lena River (Source 3, 8 September 2012, Khamagatta village).

The local farmers recognize that the disastrous impact of flooding is not caused by the ice-jam floods, but rather by the

length of time that the snow-thaw floods and summer-rain floods remain on the ground. The reader might recall the account of hydrologists regarding the increasing trend of precipitation and humidity in this region. These trends seem to affect river condition and seem to deteriorate the grass resources, which are related to the human livelihood.

According to an interview conducted with the vice chairman of the Nemiug village administration (18 September 2012), there would not be enough hay for village livestock that year, because of the prolonged flood. As a result, 30% of the cattle would have to be slaughtered, which is 25% more than the usual slaughter. However, even this increased rate of slaughter would not be adequate to compensate for the paucity of hay, and additional hay would have to be bought from other regions.

This is an important statement, because it clearly suggests the limits of local pastoralism. The Sakha's cattle-horse breeding has been sustainable in self-sufficient local communities, supported by the drier climate in the region, and by water supplied from the active layer of permafrost. Even if the scale of ice-jam floods were to increase, if the water were to continue to recede soon, such an increase would not result in a disaster. The local knowledge on river flooding is a reflection of long-term interaction of Sakha society and river environments. The culture has developed to accommodate the disturbance caused by natural ice-jam flooding, which are seemingly disastrous. However, the prolonged flood of snow-thawed waters and summer water floods, which are a completely new phenomena, might have a decisive effect on the resilience of the local pastoral sustainability. These anthropological findings are also supported by the expertise of hydrologists (Iijima et al., 2014; Hiyama, 2015).

5.2. The disasters in the local context

We were able to confirm that there were two types of disastrous effects that corresponded with different types of flooding of Lena River: the damage to houses and livestock caused by ice-jam floods, and the damage to hayfields caused by snow-thawed floods and summer water floods.

As indicated, according to the local knowledge regarding the flooding of Lena River, ice-jam floods are considered a blessing for the prosperity of the grass resources. However, the recent increase in both the frequency and scale of ice-jam floods have caused damage to local private property, such as houses and livestock, but has had no effect on the condition of pasture. Given the traditional livelihood condition of Sakha people involving transhumance between summer and winter settlements both of relatively small size (Tokarev and Gurvich, 1964), the recently observed damage to houses and livestock can only occur in the current, fully sedentarized setting. The implementation of policy measures can somehow reduce these risks even in this “new” rural community. In conventional anthropological terms, local knowledge of Lena River floods related to pastoral resource management informs cultural adaptive measures.

The important finding here is that floods resulting from snow thawing, and summer water floods caused by rain do serious damage to the pasture on river terraces, but no harm to human dwellings or to livestock. The increased precipitation harms the cycle of pasture growth, which might be detrimental to long-term interactions between the local environment of the permafrost and the pastoral adaptation of the Sakha. The climate change affects all the elements of the environment, but hazards are different for various aspects of human livelihood. The increase of earlier spring water leads the local risk of movable property, but the policies to safeguard property against floods could be implemented through scientific and technological measures such as precautionary

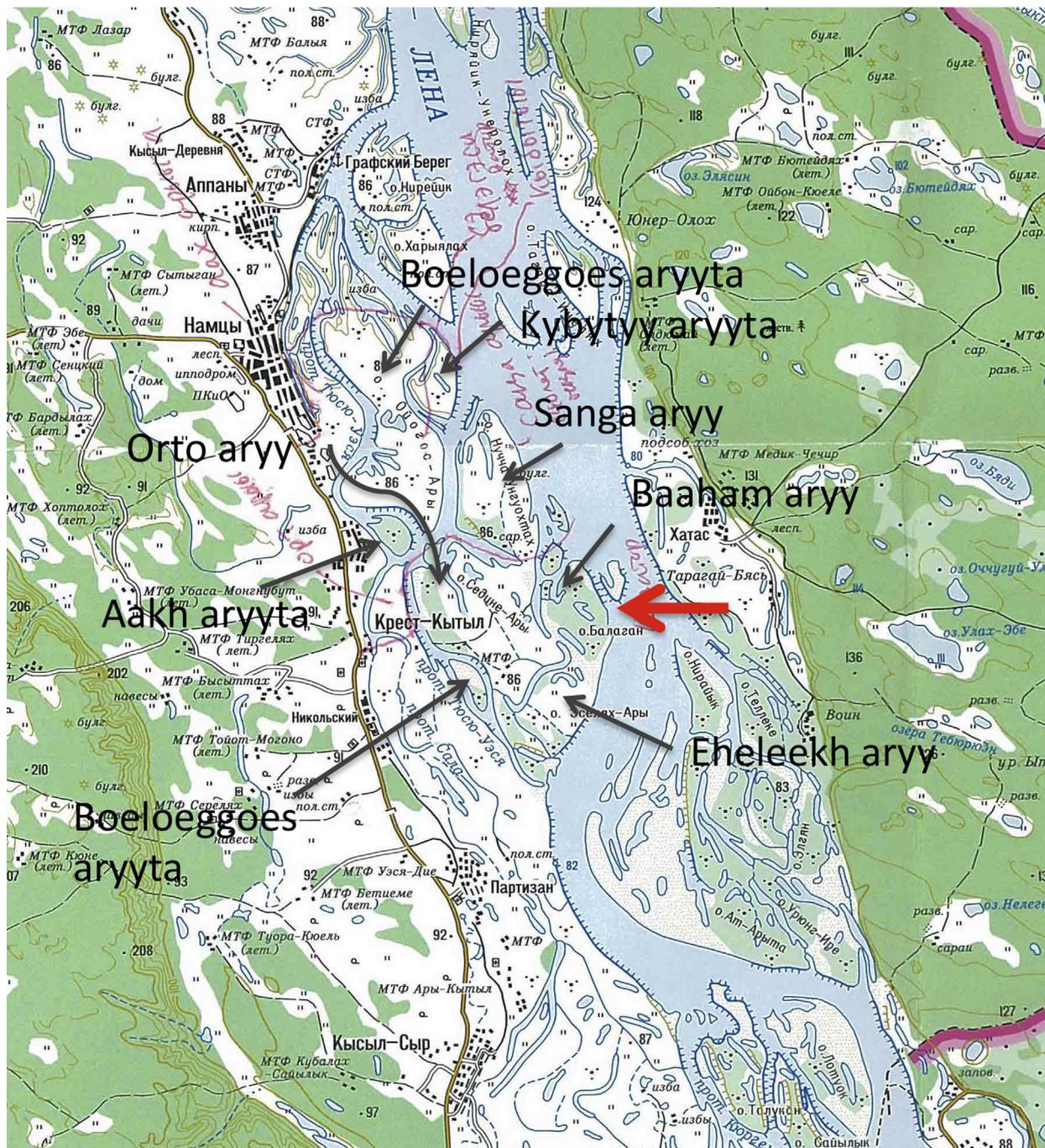


Fig. 4. The local geography of the sandbanks of Lena River. The red arrow signifies the frequent spot of occurrence of ice jam. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

warning. On the other hand, the increase of water from late spring to summer merely increases the vulnerability of cultural legacy or local pastoralism.

The key to long-term cattle-horse pastoral adaptation is in the local availability of grass resource in a dry condition. The current climate change with the increase of precipitation is highlighting to Sakha people the inability of local ways to address the changing conditions, ways that previously worked well in the local environmental setting. If the hay can be transported from other regions by truck, pastoralism might somehow be manageable, but the quality of pastoralism would be completely changed.

6. Conclusions

The relationship among permafrost, river and human culture faced with climate change that is described in this paper can be illustrated using a chart highlighting the interactions between the different elements that are involved (Fig. 5). An interdisciplinary approach that draws on both anthropology and the expertise of hydrology can better lead to an understanding of the limits of adaptation that is resulting from the progress of climate change.

What I observed is that the permafrost region could sustain the sub-arctic forest in eastern Siberia. Among indigenous peoples, only the Sakha, who originated from inner Asia, recognized the

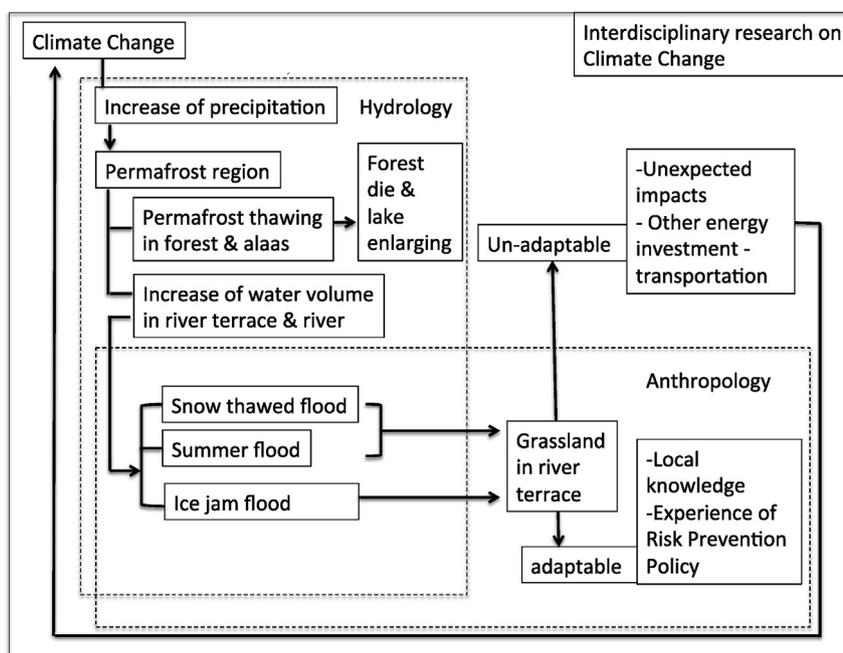


Fig. 5. The charts of interaction of local environment and culture in climate change.

grass as a resource for adaptation. The sustainability of the Sakha grass ecosystem (river terrace and alaaas) depends on permafrost. On the river terraces, the focus of this paper, ice-related floods in particular are a disturbance that expands the possibilities of human culture in this environment. This ecological interaction between human society and river terrace environments has continued for the past 600–800 years. The environment in this way, has contributed to the development of culture. It could be considered a unique example of environmental possibilism in permafrost.

However, the recent climate change definitely enhances the vulnerability of local pastoralism, because the increase of precipitation and humidity would ruin the grassland and decisively confront the resilience of pasture management. Local pastoralism can be sustained with under 200–300 mm of precipitation (a dry climate) and disturbances caused by ice-related flooding. The low precipitation in the permafrost region along with the annual disturbance caused by ice-jam flooding are the keys to maintaining local resilience.

The cultural adaptation based on the local knowledge related to these conditions has evolved through a certain range of weather, ecology, and disturbance like flood. It is adaptive and resilient for this human population to view the seemingly disastrous flood is an expected events and even anticipated by the people as a blessing of nature. The human-nature interaction has crystalized the body of local knowledge on river flooding. However, it does not lighten the burden on the people having to make adjustments to the prolongation of spring floodwater and summer rainy floods. The climate change in progress may change the long-term human-nature interaction.⁶

Other related forms of adaption could be effective with investments in other activities, such as the transportation of hay or the provision of feed, which might help sustain local pastoralism.

However, this kind of adaptation would mean that the local sustainability would be lost, because it truncates the long-term interaction between the permafrost environment and local culture. The local pastoralism would risk be subsumed into the outer world, connected to larger markets and their fluctuations. The pastoral production sustained by local energy flow is being challenged and changed in the face of climate change, and this is revealing the limit of pastoralism practiced today in the middle basin of Lena River.

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⁶ The author could not examine the issue of alaaas type grassland, however, the increase of precipitation and the related death of the forest, as well as the enlargement of lakes in the alaaas landscape might similarly preclude the possibility of local grass resource.

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