Integrating Activities for Advanced Communities

D4.2 - Report on monitoring by Indigenous and local residents of extreme weather events and other unpredictable environmental challenges and their consequences

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the Consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

Table of Contents

Publishable Executive Summary

Deliverable D4.2 is within the Task led by Partner 10, TSU, which aims to "Report on monitoring by Indigenous and local residents of extreme weather events and other unpredictable environmental challenges and their consequences". Considerable engagement with Indigenous and local people has been achieved involving thousands of individuals in Western Siberia and significant "added value" has been provided by TSU and co-workers. Three main types of study have been developed.

Firstly, a citizen science program has been developed with 500 respondents in the Yamal-Nenets Autonomous Okrug. The respondents include people from many sectors of society including Indigenous People Nenets and Zyryane reindeer herders and fishermen, local residents in settlements, administrative staff in settlements, professionals including the emergency services' personnel *(fire services etc.),* medical doctors and educators, and College students. A web site ((https://siberiaweather.ftf.tsu.ru/) has been established to record local observations. Although it is too early to analyse the results, several extreme events have been registered by residents and media items have also been collated. They include devastating impacts of warm winter conditions on reindeer herders, storms that damaged infrastructure, rapid thermokarst that destroyed infrastructure and changed the landscape and the sudden arrival of southern species into the North. Relevant information has been passed on to INTERACT WP4 members who are collating information on the impacts of extreme weather events on biodiversity (Task 4.1) and also seeking to improve forecasts of extreme weather events (Task 4.3). A paper has been published on the methodology.

The second activity reported in D4.2 involved a survey of about 1,000 Indigenous People from the Nadym area by the Task Leader and medical researchers to investigate changing traditional diets and the implications of these changes for health and reproductive success. Changes in the fish catch calendar and reindeer slaughter calendar are leading to an increase in the duration of periods when local products are completely absent in the diet of the Nenets and the consumption of imported canned food and local, processed canned food is increasing as are cases of hypertension and reductions in fecundity. Three papers have been published.

The third activity reported in D4.2 involved a survey of 680 local people along a latitudinal transect of 1,500 km from the Arctic settlements of northern Yamal to the city of Tomsk in the south. This sociological study explored the perceptions of local people on climate change and then compared these conceptions with meteorological observations from met stations along the transect. The dependence of the perceptions depended on age, gender, education level, type of settlement the respondents lived in, and type of livelihood, i.e. how close to nature the people lived. The understanding of how local people perceive climate change depending on various cues and backgrounds is important if adaptation and mitigation measures advised by authorities are to be successfully implemented.

All of the studies have followed appropriate ethical guidelines. In particular, the studies are gender neutral, ethnicity inclusive, the respondents to questionnaires and interviews remain anonymous, and sources of environmental change information are credited appropriately.

1. Introduction

Global awareness of climate change was raised by the Intergovernmental Panel on Climate Change more than 30 years ago (Houghton et al., 1990). Although the predictions of global warming and their impacts were relatively accurate, and, in fact, conservative, they underestimated changes in frequency and magnitude of extreme weather events and their societal impacts. Later, the World's first regional assessment of climate change – the Arctic Climate Impact Assessment of 2005 – recognized the future impacts of events such as forest fires, disease etc. (Callaghan et al. 2005) and reports of impacts on Arctic ecosystems of rain-on-snow events (Aanes et al. 2000), mid-winter thaws (Robinson et al., 1998) and storms (Klein 1968) became available. Such events have profound impacts on local communities but awareness of such impacts has focussed on regions outside the Arctic such as Californian and Australian forest fires, US mid-west tornados and storms in the Philippines. Although climate models predict increases in extreme weather events, these tend to be represented by increased variability in climate while regional weather forecasting fails to give sufficient resolution of time and space for local residents to prepare for damaging events.

A hazardous (extreme) natural phenomenon (event) is defined by Russian State meteorological service ROSHYDROMET as a hydrometeorological or heliogeophysical phenomenon, which in terms of the intensity of development, duration or moment of occurrence can pose a threat to the life and health of citizens, and can also cause significant material damage (tangible damage). Four classes are defined according to the degree of danger (listed according to the decreasing negative effect): I - natural disaster; II - a catastrophic event; III - a dangerous event; IV - adverse event.

The objective of INTERACT Work Package 4 is to document and improve awareness of the many consequences of extreme weather events in the Arctic that are of importance to ecosystem services, local people, and global communities, so that appropriate timely responses can be made.

The specific aims are to:

- Document the effects of extreme weather events on rapid changes in biodiversity (Task 4.1).
- Identify the societal impacts of extreme weather on local communities through community engagement (Task 4.2).
- Evaluate the ability of current state-of-the-art weather predictions to forecast such events (Task 4.3).

The WP will also provide guidance on how the INTERACT network can be used to improve weather forecasts and the way they are used in the Arctic and beyond.

Specifically, Task 4.2 led by INTERACT Partner 10 TSU aims to *"Identify societal impacts of extreme weather and other events and explore ways in which local communities can contribute to identify these events and their impacts.* The protocols for observations of extreme weather events and rapid biodiversity changes

developed in Tasks 4.1 and 4.3 were to be implemented in the design of the citizen science programme in Task 4.2.

Deliverable D4.2 is "Report on monitoring by Indigenous and local residents of extreme weather events and other unpredictable environmental challenges and their consequences". We report on both extreme weather events and "other unpredictable environmental challenges" such as changes in biodiversity and landscapes. We also present wider aspects and include awareness of INTERACT Station Managers and their local communities by interfacing with WP2 and linking to a citizen science program in Alaska (LEO www.leonetwork.org).

2. Establishing Collaboration with Local Communities

INTERACT Partner 10, TSU, operates a megatransect of research stations in Western Siberia from the Yamal-Nenets Autonomous Okrug in the North to the Altai Mountains in the South (Kirpotin et al., 2018). One research station belongs to a Nenets reindeer herder. TSU also operates a network of Russian and international institutions as well as local and indigenous communities to study environmental change in Siberia, the largest land mass in the Arctic (Callaghan et al, 2020; Callaghan, Shaduyko and Kirpotin (ed.), 2021). For the INTERACT Task 4.2, we focussed on settlements in the Yamal-Nenets Autonomous Okrug but we also included settlements further south when relevant. Tomsk State University, in cooperation with YaNAO Scientific Research Center of the Arctic and a health organization in the Nadym area of the Yamal-Nenets Autonomous District created a local monitoring system for recording dangerous and extreme weather activity based on the participation of residents of the YaNAO (Figure 1).

Figure 1. Main approximate areas of study in the Yamal-Nenets Autonomous Okrug.

Groups of local residents have been identified to maximize the range of experience and observational capacity in the region (Figure 2). The groups include:

- **Group I.** Indigenous People (Nenets and Zyryane) – reindeer herders, fishermen
- **Group II.** Local residents in settlements
- **Group III.** Administrative staff in settlements
- **Group IV.** Professionals including the emergency services' personnel *(fire services etc.),* medical doctors and educators
- **Group V.** College students

Figure 2. Examples of some of the citizen science members. Top left, teachers; top right, reindeer herders in tundra near Tambej, bottom, school students from Tazovsky. Photo credits: S.Ignatov, M.Okotetto, O. Semenova.

So far, 500 respondents have been contacted in the Yamal-Nenets Autonomous Okrug including residents of 10 settlements of the YaNAO and workers' settlements of the JSC "Gazprom Transgas Yugorsk" in the Nadym District. In addition, almost 2,000 Indigenous People and local residents have been interviewed on location. We also collated scientific observations including meta-data, contemporary records, and information about current weather conditions and natural phenomena, collected and received online by weather stations of the Yamalo-Nenets Service for Hydrometeorology and Environmental Monitoring.

3. Operating the Citizen Science Programme

The citizen science programme has been designed and implemented with the help of a team of experts including Medics working with Indigenous Peoples, even in remote field camps. Visits by TSU staff to settlements and field camps have been made (Figure 3).

- Khanymej settlement in 2020
- Tazovskiy region, summer 2021
- Fishing settlement near Nori, September 2021
- Reindeer herding camp near Nori, September 2021
- Schools in Tazovskiy settlement, December 2021

Figure 3. Visit to remote field camps near Nori, September 2021. Left, river fishing camp, right, reindeer herder's camp. Photo credits: T.V. Callaghan

A common data collection protocol has been developed for many groups of respondents, and the observations are tailored to different living conditions (Figure 4). The basic questions/requests are:

- Take a picture of a weather event or its consequences.
- Specify the coordinates or location of your photographs.
- Describe how the weather (extreme) event affects you. How does the weather event affect your health? How does the weather event affect your mood? Score from 0 to 5 where 0 is no effect and 5 is the maximum effect.
- Describe how the weather event affects economic activities (reindeer herding, fishing, transport). Score from 0 to 5 where 0 is no effect and 5 is the maximum effect.

The resulting information is submitted continually to TSU for inclusion on a Citizen Science web site.

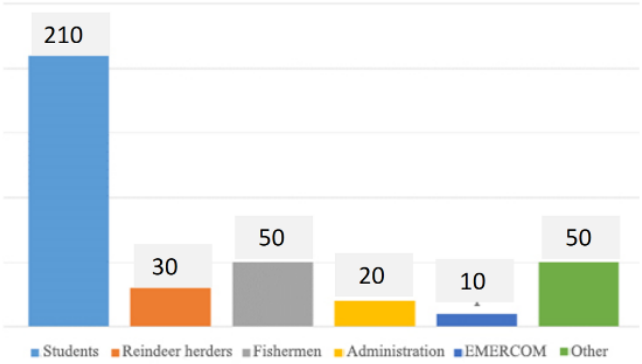

Fig. 4a. Number of respondents

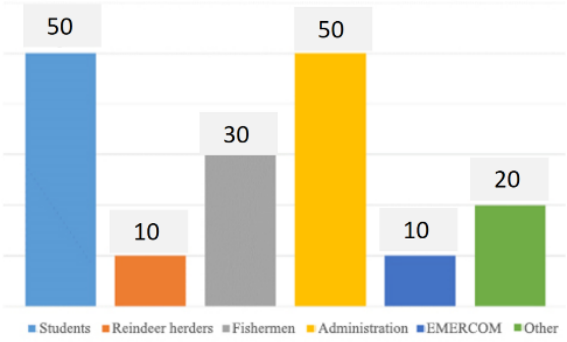

Fig. 4b. Average number of messages per respondent per month

Figure 4. Numbers of respondents excluding those interviewed by experts. Note: scales are different on each figure.

A web site has been developed to receive this citizen science information (https://siberiaweather.ftf.tsu.ru/) (Figure 5). Already, an extreme event and its consequences have been recorded (the Yamal Peninsula Extreme Event, winter 2020-2021) by TSU which gathered information from local people in Yamal and from meteorological data. Information was also collected on the later societal impacts of this event (January 2021). This information was passed onto Task 4.1 at WP4 meeting (February 2021) and also at a meeting between WP4 and WP2 (May 2021). Already, initial results from the web site have been presented at high-level meetings.

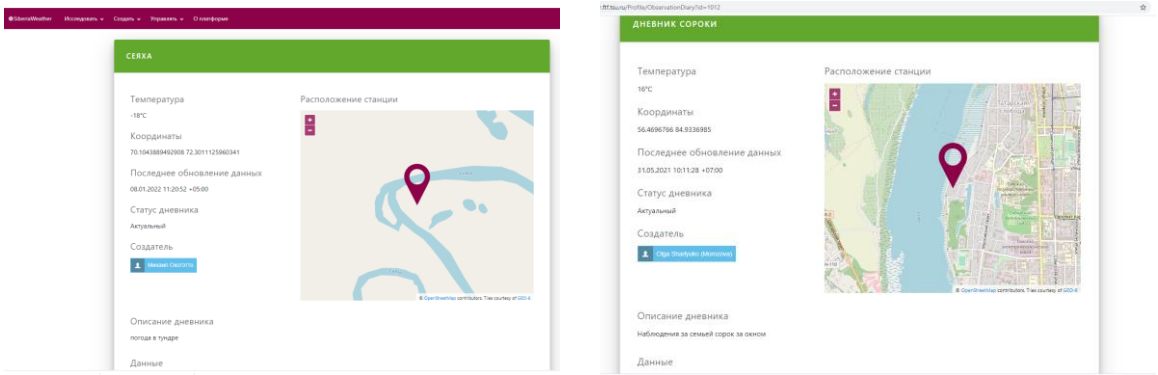

Figure 5. Screen shots from the web site that has been developed to receive citizen science information.

In addition to the continuous process of Citizen Science recordings, a questionnaire was distributed during visits to settlements in 2020 and 2021 when interviews were also carried out. The questions were:

1. Changes in air temperature

1.1 Annual mean temperature increased

1.2 Temperature increased in winter

1.3 Temperature increased in summer

1.4 Number of hot days increased

1.5 Number of cold days increased

1.6 The degree of hotness of hot seasons increased

1.7 The degree of coldness of cold seasons increased

2. Rainfall in Summer Seasons

2.1 Rainfall amount increased

2.2 The onset of rainfall became more unpredictable

2.3 The cessation of rainfall became more unpredictable

2.4 Number of rainy days increased

2.5 The intensity of rainfall increased

2.6 The occurrence of untimely rainfall increased

2.7 Drought occurrence frequency increased

3. Snowfall in Winter Seasons

3.1 Snowfall amount increased

3.2 The onset of snowfall became more unpredictable

3.3 The cessation of snowfall became more unpredictable

3.4 Number of snow days increased

3.5 The intensity of snowfall increased

3.6 The occurrence of untimely snowfall increased

4. Dangerous meteorological phenomena

4.1 The frequency of strong winds increased

4.2 The frequency of strong glaze ice increased

4.3 The frequency of frosts increased

The basic question is “What kinds of climate changes have you seen in your village over the past 10 years? Please evaluate them on a 5-point scale (totally disagree, disagree, neutral, agree, or totally agree) and put a tick in the desired row of the table.”

Already, results from the interviews have been analysed and published while several presentations at high-level meetings have been given.

4. Initial Results

4.1 Analysis of Concept and Methodology

A paper “Involving the local communities to the scientific research» has been published in a Russian journal by the Task Leader and medical colleagues. This paper describes the experience of the project in Gydan tundra (Yamal Peninsula)” (Shaduyko et al., 2020) and analyses the motivations of the various classes of respondents.

The main motivation of the Indigenous People (reindeer herders and fishermen designated as Group I) was the desire to share their daily problems and observations. At the same time, residents of the workers' settlements (Group II) were mainly motivated to share unusual observations (the so-called "selfie effect"). The central problem of the respondents of Group I is that most of the time they are out of cell phone range; they do not work well with the Internet and gadgets, and rarely use social networks. Factors, such as irregular observations, insufficient experience, and not always quality comments are the major problems for the respondents of Group II. The respondents of Group III, including the administrative staff (usually, this category consists of local executive authorities) and the representatives of the EMERCOM, were motivated to participate in this project by factors, such as the desire (and need) to analyze and predict situations. The motivation for Group IV, consisting of professionals in the educational field (school teachers, and staff teaching at specialized secondary schools) and medical staff, was an additional opportunity for professional development and scientific activity. A major challenge for the respondents of Groups III and IV was factors, such as lack of time to describe observations, external and internal censorship of comments and information placement. Group V, students of secondary and vocational schools (colleges), who were the largest group of respondents, were motivated primarily by the need to perform school and non-school tasks. There was a very interesting fact that the possibility of thematic communication in social groups and the increase of

personal rating in web communities constituted the second most important motivation factor for these respondents. We have identified that Group V has the same problem as for Group II: irregular observations, insufficient experience, and not always quality comments.

4.2 Initial Citizen Science Observations

Significant steps have been made to start a vital process but it is too early to present research results which will become available later. However, we can already present some important examples of various observations including examples from the media. Among the important factors that determine the conditions and level of life safety in the region are: spring floods, heavy rains and snowfalls, natural fires, strong winds, extreme air temperatures, and natural/new diseases (Figure 6).

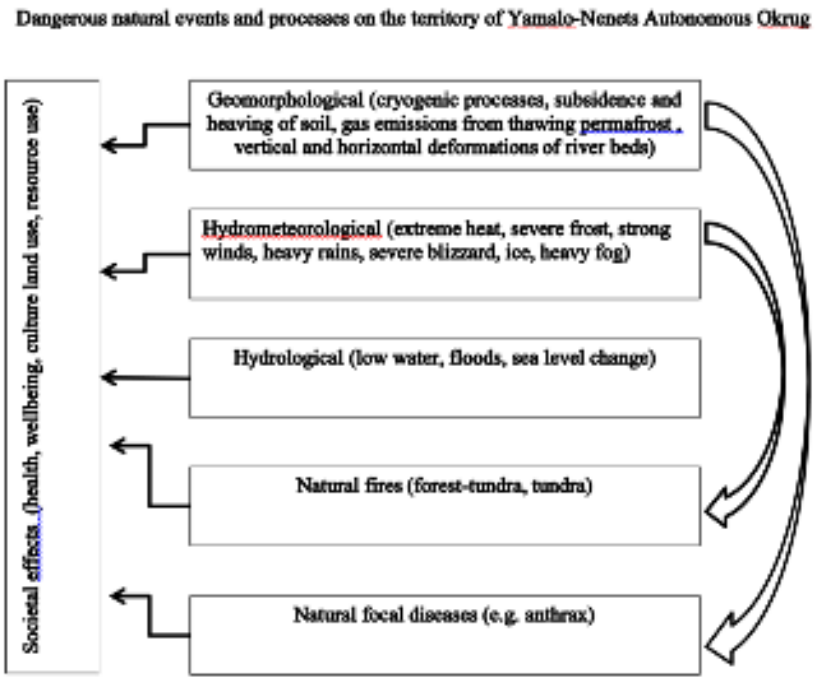

Figure 6. Dangerous natural events and processes in the Yamal-Nenets Autonomous Okrug.

New information on observed extreme events includes (Figure 7):

- An understanding that official figures of reindeer deaths from an extreme event in winter 2020-2021and compensation are underestimates because weakened reindeer die later in spring and

summer and subsequent birth rates were zero or very low. (Details from various sources including meteorological stations (http://omsk-meteo.ru/index.php/ru/), local people (M.Okotetto, V.Okotetto, A.Vengo, V.Vengo, K.Salinder, R. Laptander, social network "vkontakte-seyakha") and the media (vesti-yamal.ru/, yamal-media.ru/, https://www.mk-yamal.ru/)

- Main road between Salekhard and Nadym closed in spring 2021, partly because of permafrost thaw and anomaly warm spring provoked a lot of ground water. (Observations by F. Nasyrova and S. Kozlov in April 2021, vesti-yamal.ru/, local residents)
- River levels were so low in the Nadym River in September 2021that boats had to be pushed by people wading. (Observation by T.V. Callaghan, September, 2021.)
- Thermokarst processes have created a new lake near Tazovskiy in one year. (Observations by Maria Semenova (school student) and S.A. Kunin, and O.A. Semenova (school teachers), September, 2021)
- Sharp change from very hot weather to cold accompanied by storm winds with thunderstorm and hail that caused breakage of electrical wires (Tazovskiy) and damage to antenna-posts (Gas-Sale) (Observed by V.Chizhik, August 26-30th 2021). Also, a building was destroyed (Yar-Sale). (Observed by N.Khudi, August 04, 2020.)
- Smog from forest fires in Yakutia reached the Yamal in August 2021. Due to the deterioration of visibility, the operation of the ferry between Salekhard and Labytnangi was suspended. (Observation by M. Akhmetov.)
- The storm wind of September 17-21, 2021, with gusts up to 27 m/s, closed the ferry crossings Salekhard-Labytnangi , Salekhard-Yar-Sale, Muzhi-Salekhard-Berezovo, and Ratravorzh-Salekhard. Also, local and interregional flights were delayed. (Observation by local people E.Romanova, M.Lozhachev, D.Urzhinskiy, and others.)

Low water levels, Nadym River. Photo: D. Gureev, September 2021

Storm damage, Yar-Sale. Photo: N. Khudi, August 2020

Traffic queues at Salekhard waiting for ferry to re-start. Photo: I. Makarova, Sept 2021

Reindeer killed by rain on snow extreme event and strong cold in winter 2020-2021. Photo: M. Okotetto

Main road between Salekhard and Nadym, partly damaged by permafrost thaw. Photo: S.Kozlov,April 2021

Telecommunications antenna damaged by storm winds in Salekhard. Photo: V.Margeev, February, 2021

Figure 7. Example extreme weather events.

In addition to extreme weather events, biodiversity is changing quickly. It can be argued that some biodiversity changes are events as they are caused by stochastic processes such as births, deaths, immigration and emigration. Initial examples are: a) the first sand martin (*Riparia riparia*) birds were seen in 2015 in Tazovskiy and b) the first squirrels were seen in 2020, also in Tazovskiy. (Observations by S. Kunin, O.Semenova, D.Dusharina, L.Lurmina).

Figure 8. Recently arrived species in Tazovskiy. Left: sand martins (Riparia riparia) on eroded river bank. Right: squirrels. Photo credits: S.Kunin, O.Semenova

4.3 Related, added value results from co-production of data

As added value and background to the study, the Task Leader and medical colleagues have published three papers on impacts of environmental change on diets and health of people in the Yamal-Nenets Autonomous Okrug as well as a major study on perceptions of climate change held by various members of society along a north-south 1,500 km transect in Western Siberia.

1. Changing diets and traditional lifestyle of Siberian Arctic Indigenous Peoples and effects on health and well-being

Andronov *et al.* (2020a) showed considerable reductions in meat and fish consumption in the diets of Indigenous People interviewed in various settlements of the Yamal Peninsula and reported how this was associated with impacts on their health evidenced by increases in hypertension. 985 Indigenous People were interviewed by medics. Furthermore, the change in diet can be related to studies by Partner 10 TSU on biodiversity changes in Siberia showing reduced catches of native fish species and reductions in wild reindeer populations (Kirpotin *et al.* 2021) (Figure 9) as well as our own observation on extreme weather events and herded reindeer mortality (as described above). The Kirpotin *et al.* (2021) biodiversity paper is also added value to INTERACT.

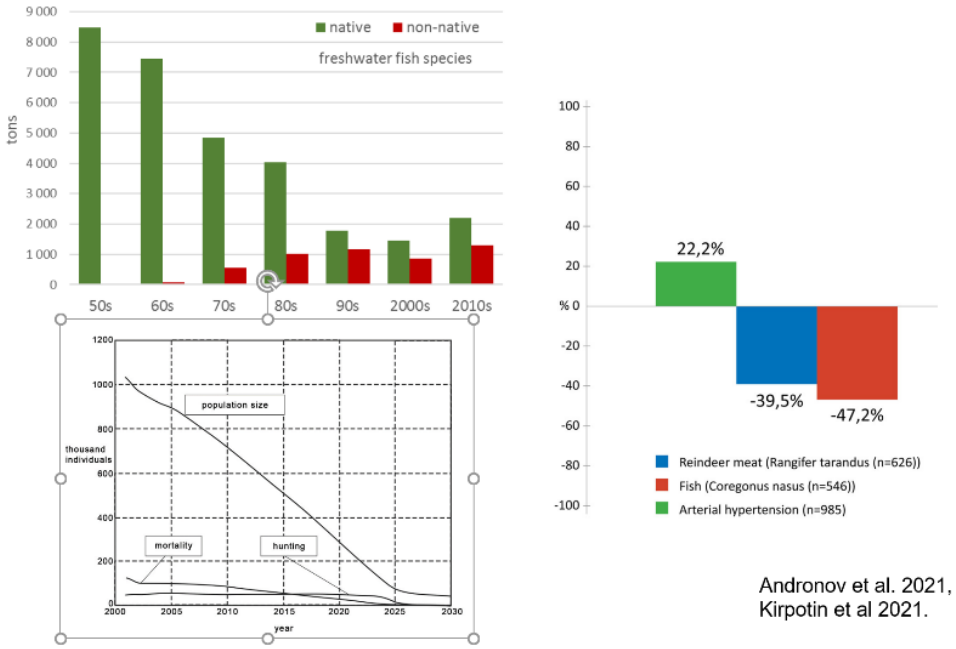

Figure 9. Changes in fish biodiversity (top left), reindeer populations (bottom left), diet (left blue and red bars) and hypertension (left green bar). From Andronov et al. 2021 and Kirpotin et al. 2021.

2. Traditional nutrition and demography in the Arctic zone of Western Siberia.

Andronov *et al.* (2020b) showed that the high requirements for macro- and micronutrients of pregnant women living in the Far North are associated with the extreme factors of high latitudes, and the needs of the mother and the growing fetus. The unique food culture of the Arctic people – e.g. the Nenets, makes it possible to meet these emerging needs. The aim of the work was to study the impact of traditional nutrition on the reproductive health of Nenets women living in the Arctic zone of Western Siberia. Records of 619 indigenous inhabitants of the Yamal, Nadym and Taz districts of the Yamal-Nenets Autonomous Okrug at the age of 18–65 years were examined. We found that the number of children born increased with the consumption of reindeer and river-fish products (1 – 3 times a week or more compared with 0 – less often than 3 times a week) as they provided sufficient intake of macro- and micronutrients. This makes it possible for the women to gestate and give birth to a healthier generation of the Nenets society.

3. Seasonality of consumption of traditional products of reindeer husbandry and river fishing by indigenous people of the Arctic zone of Western Siberia in the context of climate change.

Andronov et al. (2020c) showed that the diet of the Nenets in the Arctic zone of Western Siberia is characterized by a significant proportion of traditional products (raw, thermally unprocessed local fish and reindeer meat), which is the most important factor for survival in the Arctic. Preservation of food for

a long period is not typical for the Nenets. Climate change and industrial development of the Arctic primarily affect the seasonality of consumption. Changes in the fish catch calendar and reindeer slaughter calendar lead to an increase in the duration of periods when local products are completely absent in the diet of the Nenets and the consumption of imported canned food and local, processed canned food is increasing.

4. Perspectives of climate change

Rakhmanova *et al.* (2021) interviewed various members (680 people) of society in different types of settlements along a 1,500 km transect of Western Siberia that included settlements in the Yamal-Nenets Autonomous Okrug. The results reveal different attitudes of local residents to climate change that vary according to age, profession, education, and gender. Perceptions were also compared with meteorological observations to look for consistency and deviations so that causes and implications of perceptions could be determined. The study addressed the need to reconcile observed climate changes with perceived changes to enable decision-makers to engage more constructively with the local population to develop and implement adaptation (Figure 10).

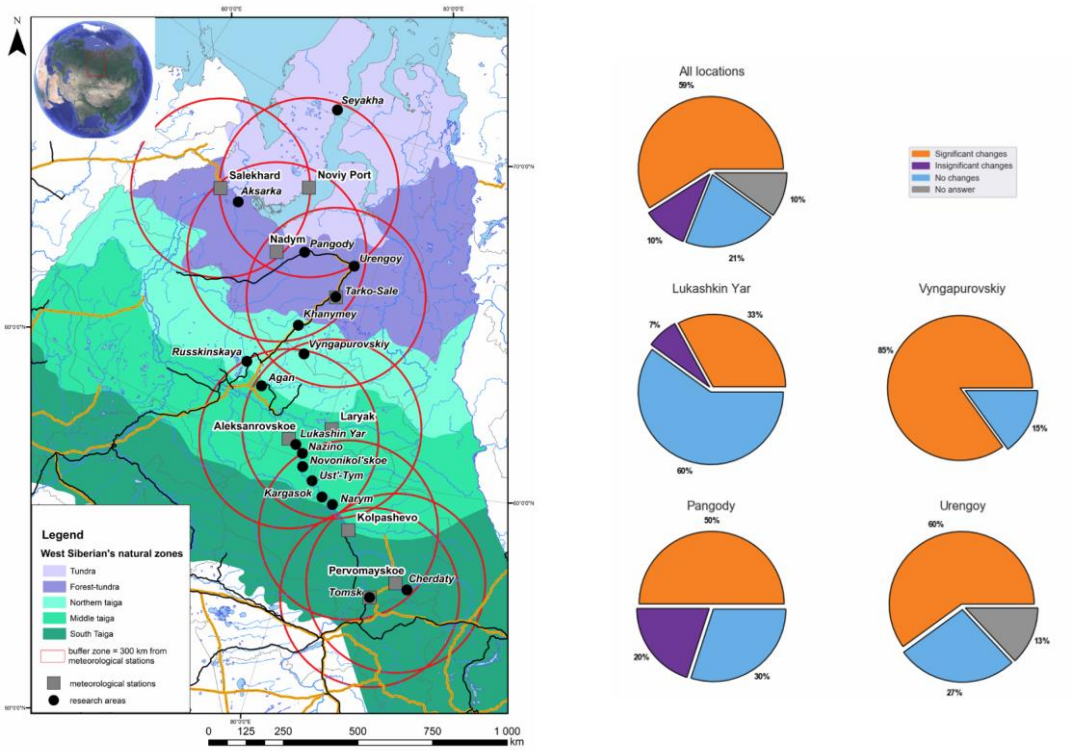

Figure 10. Left: settlements included in the study by Rakhmanova et al. 2021 (red circles represent areas covered by meteorological station data). Right: examples of varying perceptions on the change in frequency and intensity of extreme weather events. Reprinted from Ambio.

5. Contributions to integration within WP 4, and INTERACT

1. Integration meetings and general support of INTERACT objectives

    - The 4.2 Task Leader has joined 3 integration meetings (February, 25, 2021, March 24, 2021, May 10, 2021) with the WP4 leader and other task leaders in this WP and has passed on information gained so far as detailed above. This information also included data for the CBMP/CAFF task 4.1.
    - The 4.2 Task Leader has also joined integration meetings between WPs 2 and 4 as detailed above. (April 15, 2021)
    - As added value, the 4.2 Task Leader has met with the Leader of WP9 to contribute to the INTERACT stations specific tourism guidelines (AECO).
    - Also as added value, the 4.2 Task Leader contributed to the production of guidelines for researchers visiting and working in the Russian Arctic – "Arctic Permits System" (WP2 report)
    - Pictures and videos from remote settlements and landscapes are being used in the INTERACTive e-book (WP2) and will be used in the BBC films (WP7).

2. Presentations

    - The Task leader has contributed to many presentations and several high level presentations led by the INTERACT Founder and Science Coordinator. Examples include presentations on a) Citizen Science, b) Education c) Environmental Change in Siberia d) Opportunities for Networking and Collaboration in Siberia e) Researcher Mobility and f) Science Diplomacy. These presenttaions were given at meetings organised by the Science and Innovation Network of the British Embassy in Moscow, the British Council, the German Consulate in Novosibirsk, The Czech Embassy. Some of the meetings were attended by Ambassadors and Government Ministers from several nations and Governors of Russian Arctic Regions.

6. Wider issues

Exploring other citizen science networks

At the outset of the Task, we explored how other citizen science networks operated. In particular, we explored the operation of a citizen science program in Alaska (LEO www.leonetwork.org) and northern Norway (https://ww.miljolare.no/en/aktiviteter/pnc/?nmlpreflang=en). In addition, a Citizen Science programme in the Evenki District operated by A. Lavrillier and S. Gabychev was invited to join SecNet and contributed to the INTERACT Stories of Arctic Science book (Lavrillier and Gabychev 2020) as well as the Ambio Special Issue on Siberian Environmental Change (Lavrillier and Gabychev 2021 in Callaghan et al. 2021).

Implementing Science Diplomacy

As added value to the project, the 4.2 Task Leader has attended and contributed to several high level meetings and has facilitated INTERACT's involvement in these activities thereby increasing its visibility. Meetings were attended by e.g. Chairman of the Arctic Council, Russian Government Ministers, UN and other Ambassadors, and Governors of Russia's northern regions. The task leader and INTERACT Founder and Science Coordinator have worked closely with the Science and Innovtion Network of the British Embassy in Moscow.

7. Ways forward

Task 4.2 is an integral part of INTERACT. It interfaces local people with research stations, with the Joint Research Activity reviewing the impacts of extreme events on biodiversity in the Arctic (Task 4.1) and with the Joint Research Activity seeking to improve forecasting of extreme weather events so that people can be better forewarned of impending harm. In addition to integration within INTERACT, TSU has reached out to thousands of Indigenous and local people by interfacing with medics and sociologists. Such contacts need to be maintained and strengthened. Also, further developments of science and outreach are required (Figure 11; 12). In particular:

- The experiences of extreme events by Indigenous and local people need to be collated continually with appropriate acknowledgement and feedback.
- Indigenous and local people need to be better forewarned of impending potentially harmful events through better weather forecasting in the short term and predictive environmental manipulation experiments in the longer term.
- Outreach on climate change and its impacts needs to be strengthened and targeted to correct imprecise perceptions by Indigenous and local people so that necessary adaptation and mitigation measure can be more easily accepted and implemented.

Figure 11. The road between Noyabrsk and Muravlenko with the first snow, 18/09/2021 Yamal. This snow fall was not in-line with meteorological forecasts and exemplifies the need for better local weather forecasting. (Anton, vk.com/nojabrsk)

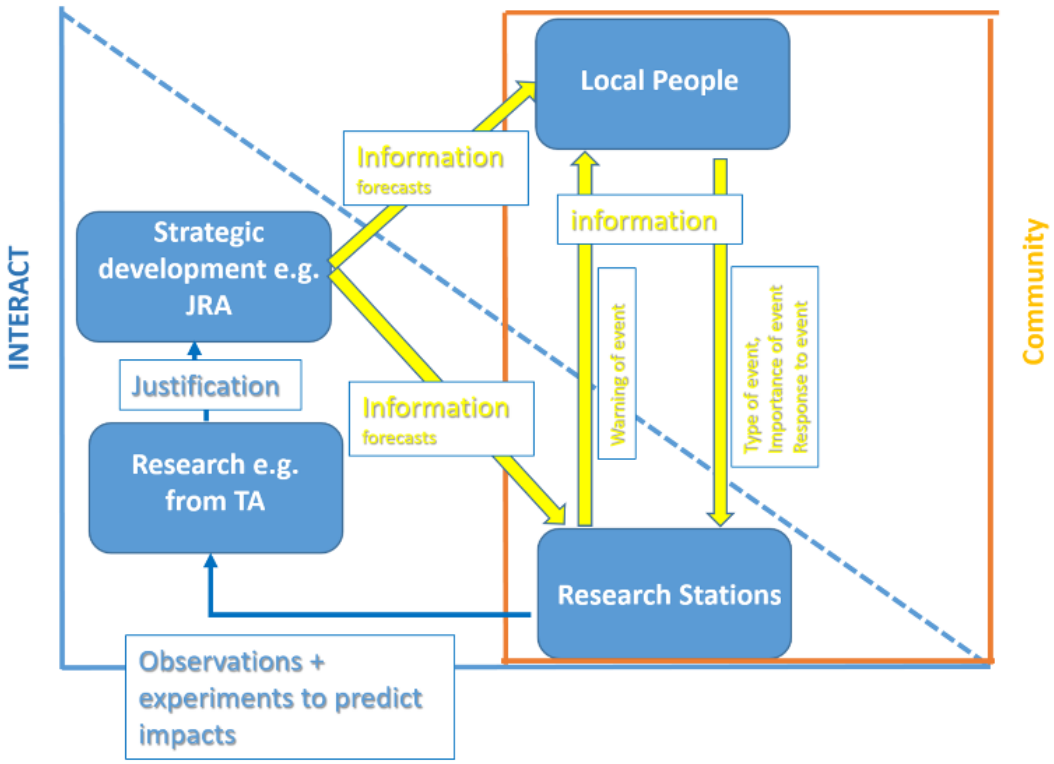

Figure 12. Scheme of integration of extreme event tasks and actors within INTERACT as well as needs for future interactions.

8. Overall summary conclusions

- Thousands of people have been contacted and have either been interviewed or have agreed to submit observations to the TSU web site on Citizen Science (https://siberiaweather.ftf.tsu.ru/).
- It is too early to analyse and present the findings of citizen science but important information already exists.
- Data from interviews with Indigenous People and other Arctic residents have been published in 4 scientific papers.
- Further work is needed to reconcile the mismatch between a) perceptions of change and meteorological observations and b) the ability of local people to respond to imminent extreme events and forecasts of these events.

9. Ethics

All of the studies have followed appropriate ethical guidelines. In particular, the studies are gender neutral, ethnicity inclusive, the respondents to questionnaires and interviews remain anonymous, and sources of environmental change information are credited. One ethical aspect that is difficult to overcome is the challenge of interviewing people who have lost everything due to an extreme event. However, we have used great sensitivity and explained that our work is intended to prevent or lessen such devastating impacts of extreme events in the future.

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