CLUSTER: VULNERABLE POPULATIONS IN THE ARCTIC

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Climate change and water security with a focus on the Arctic

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Water is of fundamental importance for human life; access to water of good quality is of vital concern for mankind. Currently however, the situation is under severe pressure due to several stressors that have a clear impact on access to water. In the Arctic, climate change is having an impact on water availability by melting glaciers, decreasing seasonal rates of precipitation, increasing evapotranspiration, and drying lakes and rivers existing in permafrost grounds. Water quality is also being impacted as manmade pollutants stored in the environment are released, lowland areas are flooded with salty ocean water during storms, turbidity from permafrost-driven thaw and erosion is increased, and the growth or emergence of natural pollutants are increased. By 2030 it is estimated that the world will need to produce 50% more food and energy which means a continuous increase in demand for water. Decisionmakers will have to very clearly include life quality aspects of future generations in the work as impact of ongoing changes will be noticeable, in many cases, in the future. This article will focus on effects of climate-change on water security with an Arctic perspective giving some examples from different countries how arising problems are being addressed.

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Water security may be defined as 'sustainable access, on a watershed basis, to adequate quantities of water of acceptable quality, to ensure human and ecosystem health' (1).

Water is of fundamental importance for human life; access to water of good quality is of vital concern for mankind. Currently however, the situation is under severe pressure due to several stressors that have a clear impact on access to water. These stressors include a continuous increase in the world population, an increase of urbanisation, consequences of agricultural changes when the demands for dietary changes occur during development, increasing pollution of water resources and the overuse of groundwater and various impacts of climate change (2, 3). In the Arctic, climate change is having an impact on water availability by melting glaciers, decreasing seasonal rates of precipitation, increasing evapotranspiration and drying lakes and rivers existing in permafrost grounds. Water quality is also being impacted as manmade pollutants stored in the environment are released, lowland areas are flooded with salty ocean water during storms, turbidity from permafrost-driven thaw and erosion is increased and the growth or emergence of natural pollutants is increased.

Global aspects on water security

The global population growth is estimated to increase from 6.8 million today to 8 billion by 2025, which will put pressure on water demand from many perspectives as water is used in the production of both food and energy (4). More people demand more food and also, with a shift in diet to more so-called westernised food, there will be an increased pressure for water; agriculture accounts for 70% of all water use today (5).

By 2030, it is estimated that the world will need to produce 50% more food and energy that means a continuous increase in demand for water. The pollution of the seas is an established fact, and ocean transport of contaminants is growing as a health concern for populations in the area (6–8).

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impact of ongoing changes will be noticeable, in many cases, in the future.

Recently, an estimation of an increase of 30% of fresh water is needed to mitigate the causes of and adapting to climate change (5).

Thus, according to these estimations, the demand for water will without doubt be increased in the near future.

This article will focus on effects of climate change on water security with an Arctic perspective, giving some examples from different countries how arising problems are being addressed.

Water stress and water footprint

Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use.

In 2010, a report from the World Bank found that the effects of water shortages are felt strongly by 700 million people in 43 countries (9). Another report from 2010 states that 80% of the world's population is exposed to high levels of threat to water security (3). The stress is not limited to the human sphere as a majority of the flora is also threatened; a majority of biodiversity dependent on river discharge is at risk for extinction as well as flora and fauna are dependent upon Arctic lakes (3).

The impact on human health is thus complex with many parts of nature being affected and interacting in an interwoven biological/physiological communication.

It is a scenario that causes anxiety and worries. Although the situation is a cause for considerable concern, technologies and expertise are being developed that can help address these problems. But to implement effective adaptation measures, it is important to raise awareness among decision makers as well as the general public as changes in water consumption at an individual level will be crucial to tackling water scarcity. It is a challenge of pedagogical nature to show the need for individual actions and for personalised willingness to take on responsibility for mitigating changes of climate.

Water has traditionally been regarded as a free resource, but this can be changed. The term water footprint is a measure how much water has been used during the production process of any goods or food. Recognition of the water footprint in all aspects of society is needed to change public awareness about water value, and ultimately water consumption behaviour.

Climate change in the Arctic

Air temperature has increased in the Arctic, warming 0.6°C since the early 20th century, with seasonal as well as geographical variations.

Precipitation is a parameter that is difficult to measure in the Arctic and complex to predict. Arctic climate impact assessment (ACIA) suggests that a 1% increase in precipitation per decade has occurred over the last century (2). Seasonal distribution of precipitation is important to consider as winter precipitation has increased since the 1970s and because Arctic winter precipitation is projected to increase with continuing climate change. Despite increased annual precipitation, a net summer drying effect is occurring due to decreased seasonal precipitation, increased temperatures, thawing permafrost and increased evapotranspiration.

There has also been an increase in wind since the 1960s and in cyclone activity.

Ecosystem change is occurring due to a longer growing season–this is favourable for northward expansion of agriculture and in natural plant and animal distribution. Shrubs are expanding into the tundra and the Arctic tree line is moving north. This will cause an increased loss of water due to evapotranspiration contributing to drier summer conditions in the future.

Climate change effects on water security in the Arctic

Degradation of the permafrost can result in drainage of ponds. In Siberia and Alaska, lakes in permafrost regions have undergone rapid change, some increasing in size and number, whereas others have decreased and in some instances disappeared. Siberian rivers have, as rivers in Alaska, increased in winter discharge, even in non-dammed tributaries. Vast territories of the tundra in the Russian Arctic may be replaced by taiga. Forecasts say that the total area of permafrost may shrink by 10–12% in 20–25 years with permafrost borders moving 150–200 km northeast in Russia (10).

In the Arctic, permafrost extends to up to 500 m below the ground surface, and it is generally just the top metre that thaws in the summer (8). Lakes, rivers and wetlands on the arctic landscape are normally not connected with groundwater in the same way they are in temperate regions. So, when the surface is frozen in the winter, only lakes deeper than 2 m and rivers with significant flow retain liquid water. Surface water is often abundant in summer, when it serves as a breeding ground for fish, birds and mammals. In winter, many mammals and birds are forced to migrate out of the Arctic.

Many humans in the Arctic rely on surface water for community use, so when conditions change and access to water is diminished, the prerequisites for human survival are affected. Only 40% of Yakutia's population is supplied with running water from centralised sources and 140 operational water pipes fail to meet sanitary standards (10). The population in the Arctic part of Russia is also estimated to increase as huge investments in infrastructure and regional planning will occur during the next coming decades.

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A study from Alaska shows that when access to water is limited, it causes consequences for the health care. Studies have shown a 2–4 times higher hospitalisation rates among children <3 years of age for pneumonia, influenza and childhood respiratory syncytial virus infections and higher rates of skin infections in persons of all ages in villages where the majority of homes had lower water availability because of no in-house piped water source, compared to homes that had higher water availability because of in-home piped water service (11). In Alaska, climate change is resulting in damage and disruption of community water infrastructure in many Arctic communities (12). Reduced availability to safe water results, according to the study performed in Alaska, in increased rates of hospitalisation for respiratory and skin infections. This could increase the use of antibiotics, and an overuse of antibiotics might result in an increase in resistant bacteria. Studies are in progress to investigate the situation.

Today in parts of northern Russia as well as other areas of the Arctic, surface water meets domestic needs as drinking, cooking and cleaning as well as subsistence and industrial demands. Indigenous communities depend on sea ice and waterways for transportation across landscape and access to traditional country foods. The industries also use large quantities of surface water during winter to build ice roads and maintain infrastructure. For all of these reasons, it is critical to understand the impacts of climate change on water security in the Arctic with its specific demands.

Arctic warming means thawing of permafrost that is impacting both the community source water (groundwater, rivers and lakes) and water infrastructure, the piped water and water storage and purification systems often build on permafrost. Hence, disturbances of infrastructures as housing, railroads, roads are already occurring. Floods have affected Yakutia more than other regions in Russia. In 2001, a flooding occurred in the city of Lensk. A spring flood made the water level rise by 2.0–2.5 m resulting in city infrastructure being destroyed and a 30-fold increase of hepatitis A. The total damages amounted to over 7 billion roubles (10).

The so-called geocryological hazard index used to assess the risk of damage to structures built on permafrost is especially high in Chukotka, on the coast of the Kara Sea, in Novaya Zemlya and the north of the European part of Russia. Permafrost degradation along the coast of the Kara Sea may lead to intensified coastal erosion that moves the coastline back by 2–4 m per year posing considerable risks for coastal population centres in Yamal and Taymyr.

Even in areas where there is good infrastructure, unexpected problems arise. During 2010 and 2011, outbreaks of *Cryptosporidium parvum* infections occurred in two municipalities in northern Sweden causing disease in thousands of individuals and disrupting everyday life as water had to be boiled before being used. In Östersund, the first municipality struck, $>12{,}000$ persons got sick with gastrointestinal symptoms, 61 were hospitalised. More than 50,000 persons were affected by the advice from the authorities that all water used for drinking or cooking should be boiled. This regulation lasted 84 days.

The second outbreak affected the population in Skellefteå, in northern Västerbotten where $>6{,}000$ got sick. The water used for drinking had been boiled since the middle of April and the final cleaning of the water occurred in September 2011. The advice about boiling caused a rapid response; 2 days after this statement to the public, the number of new persons with symptoms declined.

One cause that is under investigation is that the intake of surface water for drinking water is close to the sewage outlet and as more precipitation has occurred during the last decades, a connection is established. As in other parts of the Arctic, the infrastructure of yesterday, supposed to last until tomorrow, is not sufficient for the situation of today.

Surveillance

Improved surveillance systems are needed for community source water, including waterborne and water-washed diseases to detect impacts of climate change in the Arctic, and international networks need to be further developed. Microbial surveillance of drinking water including water sources for indigenous peoples in the Arctic should be prioritised. Climate change health assessment methods have been developed in Alaska (13).

In Greenland, water quality is secured by legislation, day-to-day running of the water supply and supervision of the water resource. The Government is implementing the EU Drinking Water Directive that also is an EU demand, if Greenland wants to continue to export foodstuffs to EU (14). The directive demands water quality information from public utilities at a level not used in Greenland before. So, there is a need for information material, both in the form of data sheets with analysis results and as explanations and descriptions of the analysis results. A portal, owned by Greenland Resources, is the authorities' medium for information to the public. Besides, there is a general request for a gathering and structuring of all the knowledge that is accumulated in the last 5 years about water quality, water resources, water handling and authority matters including legislation and the last 20 years' water chemical analysis results.

Policymaking

The impact of policy in one nation can have impact on the water security of other nations. There is a need for governance at all scales–global, regional, national, local as well as the catchment level and a need for linkages between these scales.

The Arctic Council has, through the Sustainable Development Working Group, established the Arctic Human Health Expert Group (AHHEG). This group of experts have the task to develop working plans for improvement of health for the people living in the Arctic.

Agreements for water allocation and sharing across borders may be stated in international treaties. Water security is important for national security as demonstrated by the international conflicts around access to water occurring in East Africa.

What is required to meet the increased demand is the implementation of effective governance, financing and regulation to allow technical solutions to be effective for global water security.

Thus, today it is of uttermost importance to raise awareness of key issues and potential responses and have a broader public debate on sustainable resource use and management.

Existing values, cultural norms and organisational structures that empower the individual determine patterns of individual behaviour and organisational response–to influence this is a great pedagogic challenge, but the success of implementation from governments and public authorities relies on the response from the individual.

Maintaining and ensuring the security of water and ability to supply demands from the water resources available are essential to humankind everywhere now and in the future and are equally important for vulnerable populations in the North.

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