**Extracts from IPCC AR5 with respect indigenous populations**

**Dr Peter Carter Jan 2016**

**Conclusion:**

This evidence from the IPCC shows that the greatest ever crime / human rights injustice is being perpetrated against the huge numbers of most climate change vulnerable populations, which includes indigenous peoples worldwide.

The most documented population in this regard is the Northern Arctic indigenous people.

**IPCC AR5 WG2 (impacts)**

**Indigenous Peoples**

**Note.** Most of this AR5 science comes from the long ‘technical’ reports of the three Working Groups. These are condensed and negotiated with IPCC Panel government bureaucrats (called IPCC Policy Makers) to produce the final short IPCC Summaries for Policy Makers (SPMs). Only these SPMs are recognized by governments for policy and international negotiations.

A more complete coverage of impacts and risks to indigenous peoples would include the AR5 WG2 documentation on ecosystems and species.

**WG2 Summary for Policy Makers**

**Table SPM.A1 | Observed impacts** attributed to climate change reported in the scientific literature since the AR4

**Food Production & Livelihoods**

• Impacts on livelihoods of indigenous groups in Arctic Russia, beyond economic and sociopolitical changes (major contribution from climate change

Impacts on livelihoods of indigenous groups in the Canadian Arctic, beyond effects of economic and sociopolitical changes (major contribution from climate change)

More vulnerable livelihood trajectories for indigenous Aymara farmers in Bolivia due to water shortage, beyond effects of increasing social and economic stress (major contribution from climate change)

Impact on livelihoods of Arctic indigenous peoples, beyond effects of economic and sociopolitical changes

**Polar Regions**

Risks for freshwater and terrestrial ecosystems (high confidence) and marine ecosystems due to changes in ice,

snow cover, permafrost, and freshwater/ocean conditions, affecting species´ habitat quality, ranges, phenology, and productivity, as well as dependent economies

Risks for the health and well-being of Arctic residents, resulting from injuries and illness from the changing physical environment, food insecurity, lack of reliable and safe drinking water, and damage to infrastructure, including infrastructure in permafrost regions (high confidence).

Unprecedented challenges for northern communities due to complex inter-linkages between climate-related hazards and societal factors, particularly if rate of change is faster than social systems can adapt (high confidence)

**Technical Summary**

Table KR 1

**Sea level rise**

Risk of severe harm and loss of livelihoods. Potential loss of common-pool resources; of sense of place, belonging, and identity, especially among indigenous populations

**North America**

**Wildfires and drought conditions**

Indigenous groups, low-income residents in peri-urban areas, and forest systems.

Risk of loss of ecosystem integrity, property loss, human morbidity, and mortality due to wildfires

**Polar Regions**

Indigenous communities that depend on sea ice for traditional livelihoods are vulnerable to this hazard, particularly due to loss of breeding and foraging platforms for marine mammals. Ecosystems are vulnerable owing to the shifts

in the distribution and timing of ice algal and ocean phytoplankton blooms.

**Risk of loss of traditional livelihoods and food sources.**

Risk of disruption of synchronized timing of zooplankton ontogeny and availability of prey.

Increased variability in secondary production while zooplankton adapt to shifts in timing.

Risks also to local marine food webs.

To many traditional subsistence food sources— especially for indigenous peoples—such as Arctic marine and land mammals, fish, and waterfowl. Various traditional livelihoods are susceptible to these hazards.

Rural and remote communities as well as urban communities in low-lying Arctic areas are exposed. Susceptibility and limited coping capacity of community water supplies due to potential damages to infrastructure

Community and public health infrastructure damaged resulting in disease from contamination and sea water intrusion.

People living from subsistence travel and hunting, herding, and fishing, for example indigenous peoples in remote and isolated communities, are particularly susceptible.

Livelihoods of many indigenous peoples (e.g., Inuit and Saami) depend upon subsistence hunting and access to and favorable conditions for animals. These livelihoods are susceptible. Also marine ecosystems are ----susceptible (e.g., marine mammals).

Livelihoods and lifestyles of indigenous peoples, pastoralists, and fisherfolk, often dependent on natural resources, are highly sensitive to climate change and climate change policies, especially those that marginalize their knowledge, values, and activities.

Indigenous peoples in both Australia and New Zealand have higher than average exposure to climate change due to a heavy reliance on climate-sensitive primary industries and strong social connections to the natural environment, and face additional constraints to adaptation

Already, accelerated rates of change in permafrost thaw, loss of coastal sea ice, sea level rise, and increased intensity of weather extremes are forcing relocation of some indigenous communities in Alaska (high confidence)

Mitigation efforts focused on land acquisition for biofuel production show preliminary negative impacts for the

poor in many developing countries, and particularly for indigenous people and (women) smallholders

Regional inequity is also of concern (Green and Smith, 2002),particularly indigenous or marginalized populations exposed to current climate extremes, who may become more vulnerable under a changing climate

**Chapters in Working Group II (WGII) in the 2007 Fourth Assessment Report (AR4) identified the risk climate change poses to livelihoods, cultures, and indigenous peoples globally.**

**12.3.2. Indigenous Peoples**

There are around 400 million indigenous people worldwide (see Glossary for an inclusive definition), living under a wide range of social, economic, and political conditions and locations (Nakashima et al., 2012). Indigenous peoples represent the world’s largest reserve of cultural diversity and the majority of languages (Sutherland, 2003).

Climate change poses challenges for many indigenous peoples, including challenges to post-colonial power relations, cultural practices, their knowledge systems, and adaptive strategies. For example, the extensive literature on the Arctic shows that changing ice conditions pose risks in terms of access to food and increasingly dangerous travel conditions (Ford et al., 2008, 2009; Hovelsrud et al., 2011;see also Section 28.4.1).

Accordingly, there is a strong research tradition on the impacts of climate change in regions with substantial indigenous populations that focuses on indigenous peoples and their attachment to place. Most studies focus on local, traditional, and rural settings (Cameron, 2012) and hence have been argued to create a knowledge gap regarding new urban indigenous populations. Indigenous peoples are often portrayed in the literature as victims of climate change (Salick and Ross, 2009)

and as vulnerable to its consequences (ACIA, 2005). However, traditional knowledge is increasingly being combined with scientific

understanding to facilitate a better understanding of the dynamic conditions of indigenous peoples (Huntington, 2011; see also Section

12.3.4).

Most of the literature in this area emphasizes the significant challenge of maintaining cultures, livelihoods, and traditional food sources under the impacts of climate change (Crate and Nuttall, 2009; Rybråten and Hovelsrud, 2010; Lynn et al., 2013). Examples from the literature show that traditional practices are already under pressure from multiple sources,

reducing the ability of such practices to enable effective responses to climate variability (Green et al., 2010). Empirical evidence suggests that the efficacy of traditional practices can be eroded when governments relocate communities (Hitchcock, 2009; McNeeley, 2012; Maldonado et al., 2013); if policy and disaster relief creates dependencies (Wenzel, 2009; Fernández-Giménez et al., 2012); in circumstances of inadequate entitlements, rights, and inequality (Shah and Sajitha, 2009; Green et al., 2010; Lynn et al., 2013); and when there are constraints to the transmission of language and knowledge between generations (Forbes, 2007). Some studies show that current indigenous adaptation strategies may not be sufficient to manage the projected climate changes (Wittrock et al., 2011)

Assessments of the cultural implications of climate change for human security illustrate similarities across indigenous peoples. Indigenous peoples have a right to maintain their livelihoods and their connections to homeland and place (Howitt et al., 2012) and it is suggested that the consequences of climate change are challenging this right (Box 12-1; Crate and Nuttall, 2009). Some raise the question whether theWestern judicial system can uphold indigenous rights in the face of climate change (Williams, 2012) and that there is a need for justice that facilitates adaptation (Whyte, 2013). In addition, there are uneven societal consequences related to climate change impacts (e.g., use of sea ice: Ford et al., 2008), which add complexity to adaptation in indigenous societies. Heterogeneity within indigenous groups and differentiated exposure to risk has been found in other contexts, for example, in

pastoralist groups of the Sahel (Barrett et al., 2001).

Much research on indigenous peoples concludes that lack of involvement in formal, government decision making over resources decreases resilience: the literature recommends further focus on indigenous perceptions of risk and traditional knowledge of change, hazards, and coping strategies and collective responses (Ellemor, 2005; Brown, 2009; Finucane, 2009; Turner and Clifton 2009; Sánchez-Cortés and Chavero, 2011; Maldonado et al., 2013).Though providing economic opportunities, tourism development

and industrial activities are particular areas of risk for indigenous peoples when affected populations are not involved in decision making (Petheram et al., 2010). Lack of formal participation in international negotiations may pose risks for indigenous peoples because their perspectives are not heard (Schroeder, 2010). However, there are examples of successful indigenous lobbying and advocacy, as in the case of managing persistent organic pollutants and heavy metals in the Arctic (Selin and Selin, 2008).

**12.3.3. Local and Traditional Forms of Knowledge**

There is high agreement among researchers that involvement of local people and their local, traditional, or indigenous forms of knowledge in decision making is critical for ensuring their security (Ellemor, 2005; Kesavan and Swaminathan, 2006; Burningham et al., 2008; Mercer et al., 2009; Pearce et al., 2009; Anik and Khan, 2012). Such forms of knowledge include categories such as traditional ecological knowledge,

There is also concern, documented in many anthropological studies, that indigenous and traditional knowledge is itself under threat. If local or traditional knowledge is perceived to be less reliable because of changing environmental conditions (Ingram et al., 2002; Ford et al., 2006) or because of extreme or new events that are beyond the current local knowledge and cultural repertoire (Valdivia et al., 2010; Hovelsrud et al., 2010a), then community vulnerability, and the vulnerability of local or traditional knowledge itself, may increase (Kalanda-Joshua et al., 2011). New conditions may require new knowledge to facilitate and maintain flexibility and improve livelihoods (see also Homann et al., 2008). Kesavan and Swaminathan (2006) documented how societal and environmental conditions have changed to the point that local knowledge is supplemented with new technologies and new knowledge in coastal communities in India. A study in the Himalayas found that erosion of traditional knowledge occurs through government regulations of traditional building materials and practices (Rautela, 2005). The social cohesion embedded in such practices is weakened because of a move

toward concrete construction which changes the reliance on and usefulness of traditional knowledge about wood as a building material

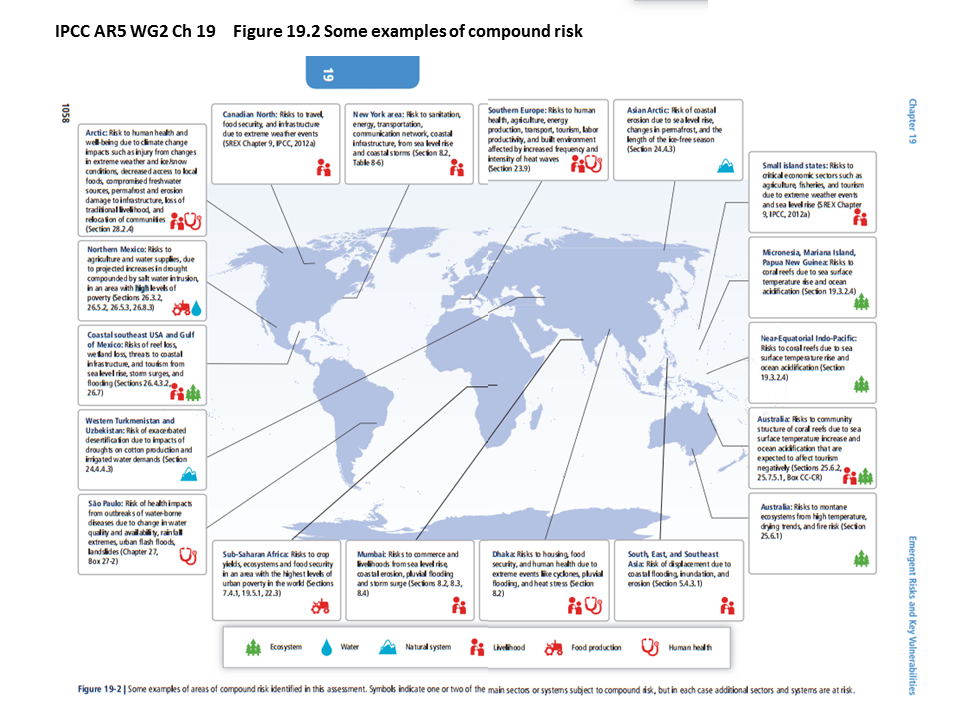
(Rautela, 2005).

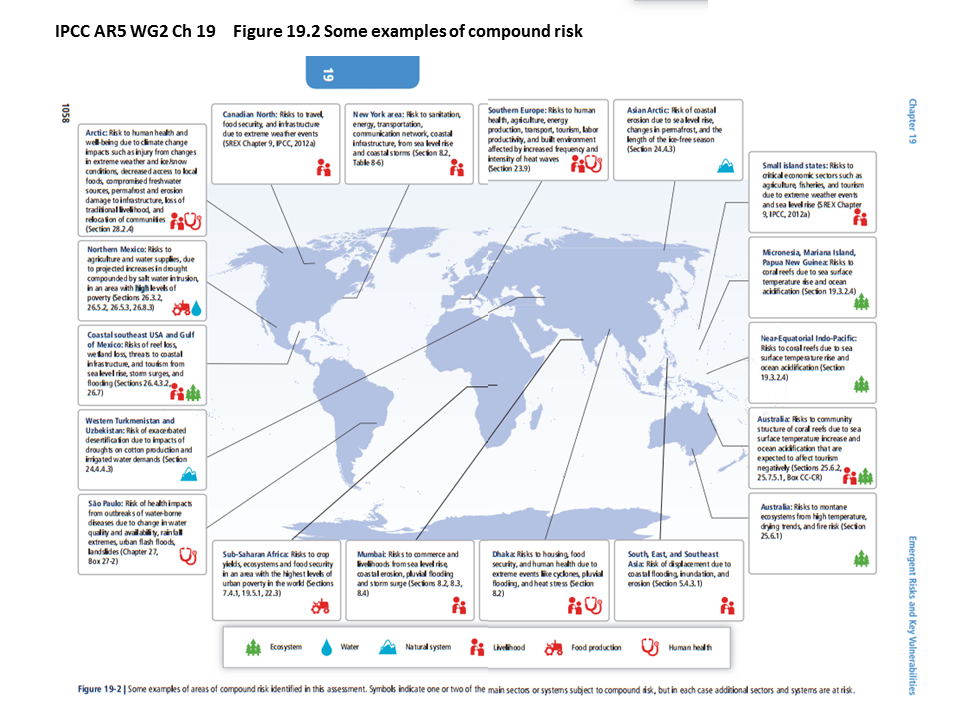
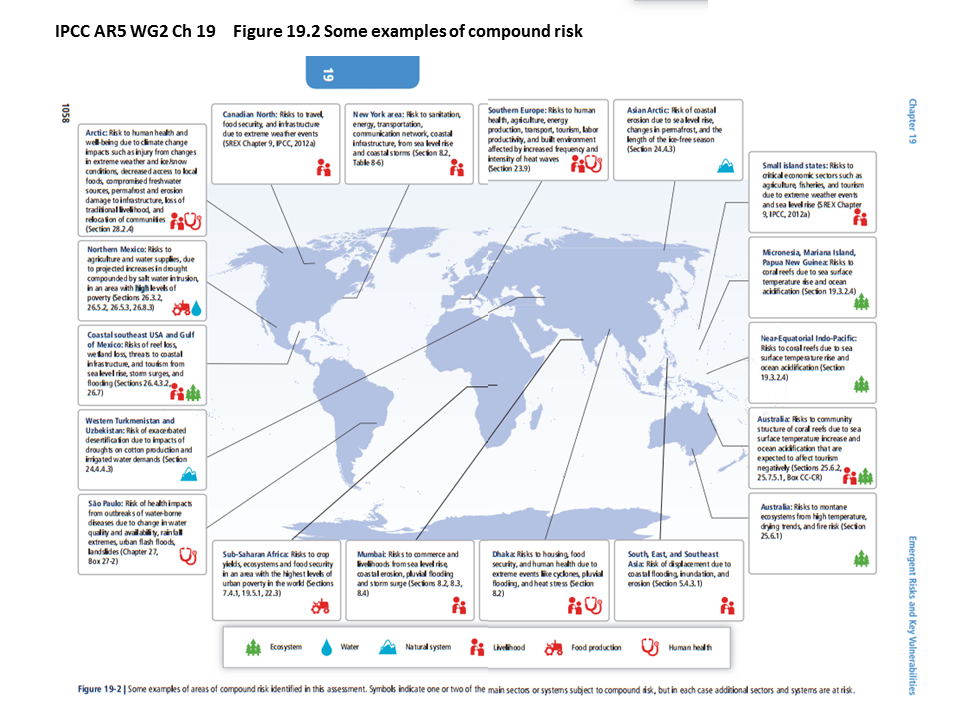
**13.1.3. Inequality and Marginalization**

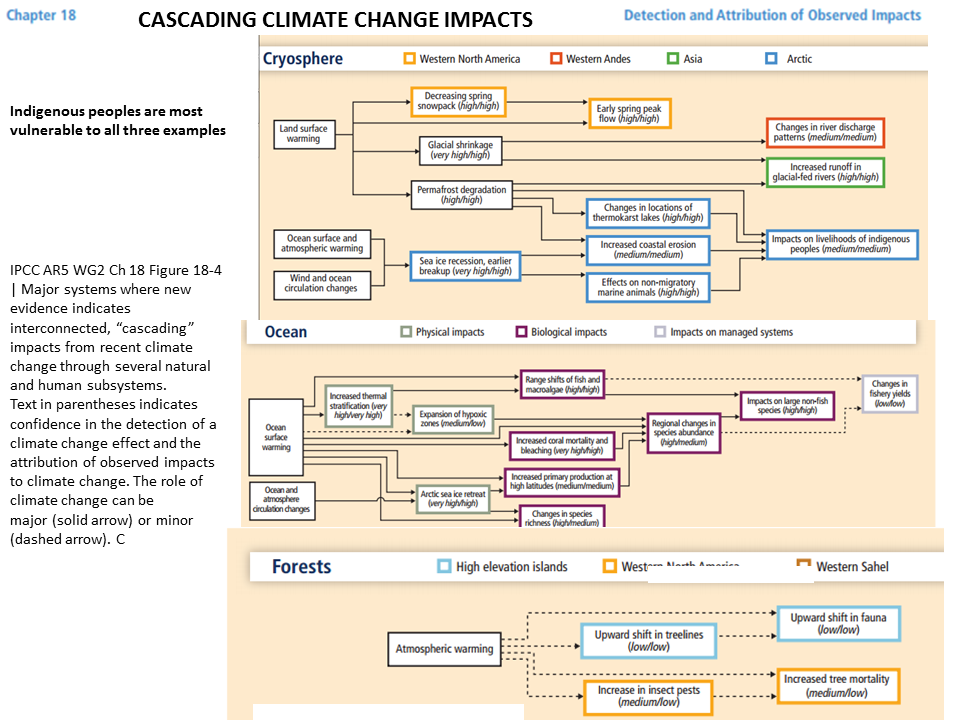
Specific livelihoods and poverty alone do not necessarily make people vulnerable to weather events and climate. The socially and economically disadvantaged and the marginalized are disproportionately affected by the impacts of climate change and extreme events (robust evidence; Kates, 2000; Paavola and Adger, 2006; Adger et al., 2007; Cordona et al., 2012). The AR4 identified poor and indigenous peoples in North America (Field et al., 2007) and in Africa (Boko et al., 2007) as highly vulnerable. Vulnerability, or the propensity or predisposition to be adversely affected (IPCC, 2012a) by climatic risks and other stressors (see also Glossary), emergesfrom the intersection of different inequalities, and uneven power structures, and hence is socially differentiated (Sen, 1999;

Banik, 2009; IPCC, 2012a).Vulnerability is often high among indigenous peoples, women, children, the elderly, and disabled people who experience multiple deprivations that inhibit them from managing daily risks and shocks (Eriksen and O’Brien, 2007; Ayers and Huq, 2009; Boyd and Juhola, 2009; Barnett and O’Neill, 2010; O’Brien et al., 2010; Petheram et al., 2010) and may present significant barriers to adaptation.

Inequality and disproportionate effects of climate-related impacts also occur along the axes of indigeneity and race. Disproportionate climate impacts are documented for Afro-Latinos and displaced indigenous groups in urban Latin America (Hardoy and Pandiella, 2009), and indigenous peoples in the Russian North (Crate, 2013) and the Andes (Andersen and Verner, 2009; Valdivia et al., 2010; McDowell and Hess, 2012; Sietz et al., 2012).







Livelihoods of indigenous people in the Arctic have been identified as among the most severely affected by climate change, including food security aspects, traditional travel and hunting, and cultural values

references (Hovelsrud et al., 2008; Ford et al., 2009; Ford, 2009a,b; Beaumier and Ford, 2010; Pearce et al., 2010; Olsen et al., 2011; Eira, 2012; Crate, 2013; see also Box 18-5, Table 18-9). Impacts of rising temperatures, increased variability, and weather extremes on crops and livestock of indigenous people in highlands were reported from Tibet Autonomous Region, China (Byg and Salick, 2009), and the Andes of Bolivia (McDowell and Hess, 2012).

Box TS.4 | Multidimensional Inequality and Vulnerability to Climate Change

The 2010 Cancun Agreements highlight safeguards for governments to observe in REDD+ implementation, such as respect for the interests, knowledge, rights, and sustainable livelihoods of communities and indigenous peoples.

**Chapter 11 Health**

**11.3.1.4. Race and Ethnicity**

In many countries, race and ethnicity are powerful markers of health status and social disadvantage. Black Americans have been reported to be more vulnerable to heat-related deaths than other racial groups in the United States. (Basu and Ostro, 2008) This may be due to a higher prevalence of chronic conditions such as over-weight and diabetes, (Lutsey *et al.*, 2010) financial circumstances (lower incomes may restrict access to health-protecting air conditioning),(Ostro *et al.*, 2010) or to community-level characteristics (such as local crime rates or disrupted social networks).Indigenous peoples who depend heavily on local resources, and live in parts of the world where climates are changing quickly, are generally at greater risk of economic losses and poor health. Studies of the Inuit people, for example, show that rapid warming of the Canadian Arctic is jeopardizing hunting activities which many in these communities rely on for food. (Ford, 2009) In Australia, indigenous peoples experience higher rates of diarrheal diseases and other climate-sensitive conditions than the remainder of the national population and their general health status is poorer and puts them at additional risk of climate stressors such as heat-waves. (Green *et al.*, 2010)

Climate change will increase the vulnerability of terrestrial ecosystems to invasions by non-indigenous taxa, the majority likely to arrive through direct human assistance, which poses the greatest threat to terrestrial plant and animal communities in the future (high confidence).

**Chapter 28. Polar Regions**

Climate change will increase the vulnerability of terrestrial ecosystems to invasions by non-indigenous taxa, the majority likely to arrive through direct human assistance, which poses the greatest threat to terrestrial plant and animal communities in the future (*high confidence*).

Impacts on the health and well-being of Arctic residents from climate change are projected to be significant and increase – especially for indigenous peoples (high confidence). [28.2.4] Impacts include injury and risk from extreme and unpredictable weather; changing ice and snow conditions compromising safe and predictable hunting, herding, and fishing; food insecurity and malnutrition due to decreased access to local foods; increased social and economic problems due to loss of traditional livelihood and culture; contamination of water and food; increases in infectious diseases; permafrost and erosion damage to homes and infrastructure, loss of homelands and forced relocation of communities. These impacts are expected to vary among the highly diverse settlements which range from small, remote predominantly indigenous to large industrial settlements (high confidence).

Traditional livelihoods and food security of Indigenous Peoples in the Arctic are being impacted by the current rate of climate change and when seen in combination with the effects of globalization and resource development these impacts are projected to increase significantly in the future (*high confidence*). [28.2.7, 28.2.4] These impacts are directly affecting indigenous peoples’ ways of life and access to traditional foods, such as marine mammals, reindeer, fish and shellfish which have provided sustenance, cultural, religious, economic, medicinal, and community health for many generations. However, Arctic Indigenous Peoples have a high adaptive capacity to highly variable conditions and have begun to develop novel solutions to adapt to climate change through developing systems to monitor and predict weather, snow and ice changes; creating Indigenous Arctic observing networks; integrating data into decision and policy-making processes; and co-producing climate studies with scientific partners.

Climatic and other large-scale changes can have potentially large effects on Arctic communities where relatively small and narrowly based economies leave a narrower range of adaptive choices. [28.2.6.1.5] It is projected that there will be significant impacts on the availability of key subsistence foods as climate continues to affect marine and terrestrial species. Increased economic opportunities and challenges for culture, security and environment, are expected with the increased navigability of Arctic marine waters and the expansion of land- and fresh water-based transportation networks (*high confidence*).

**28.2.4. Human Populations**

A warming Arctic and the significant changes in the cryosphere are impacting residents across the region through a complex set of physical, environment, cultural, economic, political, and socio-cultural factors operating on and within Arctic communities, which have important implications for the health and well-being of all Arctic populations. These influences are expected to vary significantly among the highly diverse communities which range from small, remote, predominantly indigenous to large northern, industrial settlements. (Chapin et al, 2005; Larsen and Fondahl, 2010) It is estimated that there are between four and 9 million people living in the Arctic depending upon geographic delineation of Arctic which includes original residents (indigenous peoples) as well as a broad spectrum of more recent settlers ranging from subsistence hunters to oil industry personnel to urban office workers. (Huntington et al, 2005; Hovelsrud et al, 2012) During the past century, the composition of Arctic communities and settlements has been shifting dramatically due to seasonal and permanent immigration into the Arctic driven by the development of resources such as oil and gas, fishing, and gold or the necessity to escape problems in homelands outside the Arctic, including some population declines from 2000 to 2005, especially in Russia. (Huntington et al, 2005; Hovelsrud et al, 2012).

Climate change and globalization, contamination, resource development, plus the new activities and residents competing for lands and resources traditionally used by Indigenous peoples, are especially impacting the Indigenous populations of the North and are projected to increase in the future. (Abryutina, 2009; Larsen *et al.*, 2010). The estimated indigenous populations in the Arctic are between 400,000 and 1.3 million. (Hovelsrud et al, 2012; Huntington et al, 2005) Approximate numbers of Indigenous residents are: Canada, 66,000; Denmark, Greenland, 50,000; Norway, Sweden, and Finland, 50,000; Russia, 90,000; and USA, 110,000 (data from 2002 Census; Galloway, 2010) The percent of the populations of indigenous peoples in the Arctic range from 3-4 % in Russia to 80% in Greenland. (Galloway, 2010) Indigenous peoples have been sustained by the region’s terrestrial, marine and freshwater renewable resources, including mammals, birds, reindeer, fish and plants for sustenance, cultural, religious, economic, medicinal, and community health for many generations. (Nuttall *et al.*, 2005)(Parkinson, 2009) However, the ability of Indigenous peoples to maintain traditional livelihoods such as hunting, harvesting, fishing, and herding is increasingly being threatened by climate change and associated multiple stressors.

The Human Population Section (28.2.4) provides a detailed assessment of the impacts of climate-related changes in snow, ice, permafrost, weather, water temperature, loss of habitat plus additional stressors such as poverty, pollution, and territory encroachment on the health and well-being of Arctic residents, with particular attention to Indigenous populations. The health section describes the primary health impacts which include injury and risk from extreme and unpredictable weather; changing ice and snow conditions for safe and predictable hunting, herding, and/or fishing; food insecurity and malnutrition due to decreased access to sources of local foods; increased social and economic problems due to loss of traditional livelihood and culture; contamination of water and food; increases in infectious diseases; permafrost and erosion damage to homes and infrastructure plus loss of homelands and forced relocation of communities. This section focuses on the more vulnerable Indigenous and isolated populations in the Arctic who live in close association with the land as they are already experiencing health disparities and are likely to be more vulnerable to future climate changes. (Larsen *et al.*, 2010)(Berner et al, 2005)

**Direct impacts of climate on the health of Arctic residents**

Direct impacts of climate changes on the health of Arctic residents include extreme weather events (physical/mental injuries, death, disease), temperature-related stress (limits of human survival in thermal environment, cold injuries, cold-related diseases), and UV-B radiation (immunosuppression, skin cancer, non-Hodgkin’s lymphoma, cataracts). (AMAP, 2009; Berner et al, 2005) Intense precipitation events and rapid snowmelt are expected to impact the magnitude and frequency of slumping and active layer detachment resulting in rock falls, debris flow, and avalanches. (Ford et al, 2010; Hovelsrud et al, 2010) Other impacts from weather, extreme events, and natural disasters are the possibility of increasingly unpredictable, long duration and/or rapid onset of extreme weather events and storms, which, in turn, may create risks to safe travel or subsistence activities, risks to rural and isolated communities, and risk of being trapped outside one’s own community. (Andrachuk and Pearce, 2010)( Laidler et al, 2009; 2010) Changing river and sea ice conditions affect the safety of travel for indigenous populations especially, and inhibit access to critical hunting, herding and fishing areas. (Andrachuk and Pearce, 2010)( Ford et al, 2010; Ford, 2009) For example, reductions in land-fast ice plus increased open water area cause less predictable fog and sea-ice conditions, creating treacherous coastal travel conditions and more difficult communications among communities. (Barber et al, 2008)

**Indirect impacts of climate on the health of Arctic residents**

Indirect effects of climate change on the health of Arctic residents include a complex set of impacts such as changes in animal and plant populations (species responses, infectious diseases), changes in the physical environment (ice and snow, permafrost), diet (food yields, availability of country food), the built environment (sanitation infrastructure, water supply system, waste systems, building structures), drinking water access, contaminants (local, long-range transported), and coastal issues (harmful algal blooms, erosion). (Brubaker *et al.*, 2011; Parkinson and Evengård, 2009)( Berner et al, 2005; Maynard and Conway, 2007) Local and traditional knowledge in communities across the Arctic are observing extremes not previously experienced and increasingly unusual environmental conditions (e.g., Ford, 2009; Laidler et al, 2009; Virginia and Yalowitz, 2012). There also appears to be an increase in injuries related to climate changes among residents of northern communities associated with ‘strange’ or different environmental conditions, such as earlier break-up and thinning of sea ice. (Ford, 2009; Ford et al, 2010).

Underlying all climate change impacts and processes, are the complicated stresses from contaminants such as POPs (persistent organic pollutants), radioactivity, and heavy metals (e.g., mercury) which create additional and/or synergistic impacts on the overall health and well-being of the communities. (UNEP/AMAP, 2011; Berner et al, 2005) Contaminants and human health in the Arctic are tightly linked to the climate and Arctic ecosystems by factors such as contaminant cycling and climate (increased transport to and from the Arctic), exposure to contaminants, the risk of infectious diseases in Arctic organisms, and the related increased risks of transmission to residents through subsistence life ways, especially indigenous peoples. (Kraemer et al, 2005; AMAP, 2010; UNEP/AMAP 2011) The consumption of traditional foods by indigenous peoples places these populations at the top of the Arctic food chain and through biomagnification, therefore, they may receive some of the highest exposures in the world to certain contaminants. (Parkinson, 2009)(UNEP/AMAP, 2011) These contaminants such as POPs are known for their adverse effects on humans, particularly, the developing fetus, children, women of reproductive age and the elderly. Thus, contaminants must be a significant part of any climate impact assessment as their potential health effects include serious conditions such as nervous system and brain development problems, interference with hormones and sexual development, weakened immune systems, organ damage, cardiovascular disease and cancer. (Abryutina, 2009)(UNEP/AMAP, 2011).

There are additional concerns regarding radioactivity and climate change because contamination can remain for long periods of time in soils and some vegetation, and because the terrestrial environment can create high exposures for people. (AMAP, 2010) Furthermore, climate changes not only have the ability to mobilize radionuclides throughout the Arctic environment, but can also potentially impact infrastructure associated with nuclear activities by changes in permafrost, precipitation, erosion, and extreme weather events. (AMAP, 2010) Additionally, there is a very high density of potential and existing radionuclide sources in some parts of the Russian Arctic and the risk for accidents is a significant cause for concern. (AMAP, 2010)

Warming temperatures are enabling increased overwintering survival and distribution of new insects that sting and bite as well as many bird and insect species that can serve as disease vectors and, in turn, causing an increase in human exposure to new and emerging infectious diseases. (Parkinson and Butler, 2005)(Epstein and Ferber, 2011; Parkinson, 2008;). Examples of new and emerging diseases are tick-borne encephalitis (brain infection) in Russia (Ogden et al., 2010)(Tokarerich et al, 2011;) and Sweden (Lindgren and Gustafson, 2001), Giardia spp. and Cryptosporidium spp. infection of ringed seals (Phoca hispida) and bowhead whales (Balaena mysticetus) in the Arctic Ocean. (Hughes-Hanks et al., 2005). it is also likely that temperature increases will increase the incidence of zoonotic diseases that can be transmitted to humans (Revich et al, 2012; Bradley et al., 2005). Many Arctic zoonotic diseases which currently exist in local host species (e.g., tularemia in rabbits, muskrats and beaver, and rabies in foxes can spread through climate-related mechanisms (such as relocation of animal populations) (Revich et al, 2012; Dietrich, 1981). Increasing ocean temperatures have caused an outbreak of a cholera-like disease, Vibrio parahaemolyticusin, in Alaskan oysters (McLaughlin et al., 2005). Finally, there are concerns that the warmer temperatures may raise the possibility of anthrax exposure in Siberia from permafrost thawing of historic cattle burial grounds. (Revich and Podolnaya, 2011)

The impacts of climate change on food security are critical to human health because subsistence foods from the local environment provide Arctic residents, especially, indigenous peoples, with unique cultural and economic benefits necessary to well-being and contribute a significant proportion of daily requirements of nutrition, vitamins and essential elements to the diet (Abryutina, 2009; Ford and Berrang-Ford, 2009)(e.g., Ford, 2009). However, climate change is already posing a serious threat to food security and safety for indigenous peoples and the availability of country food because of the impacts on traditional subsistence hunting, fishing and herding. (Andrachuk and Pearce, 2010)(Ford et al, 2010; Ford, 2009; Galloway-MacLean, 2010; Ford et al, 2009) The decrease in predictability of weather patterns as well as low water levels and streams, timing of snow, ice extent and stability are impacting the possibilities for successful hunting, fishing and access to food sources and increasing the probability of accidents. (Ford and Furgal, 2009; Nuttall et al., 2005) Populations of marine and land mammals, fish and water fowl are also being reduced or displaced by changing temperatures, ice state, habitats and migration patterns reducing the traditional food supply. (West and Hovelsrud, 2010)(Gearheard et al, 2006)

Furthermore, traditional food preservation methods such as drying of fish and meat, fermentation, and ice cellar storage are being compromised by a warming again reducing food available to the community. (Virginia and Yalowitz, 2012; Hovelsrud et al, 2011) For example, food contamination problems are becoming important wherever thawing of permafrost “ice houses” is occurring for communities and families. (Parkinson and Evengård, 2009)(Hovelsrud et al, 2011) These reductions in the availability of traditional foods are forcing indigenous communities to increasingly depend upon expensive, non-traditional and often less healthy western foods, increasing the rates of modern diseases associated with processed food, such as cardiovascular diseases, diabetes, dental cavities, and obesity. (Berrang-Ford *et al.*, 2011)(Ford, 2009; Van Oostdam et al, 2003) A complicating factor in evaluating trade-offs between traditional and market food is that wild foods represent the most significant source of exposure to environmental contaminants.

Climate change is beginning to threaten community and public health infrastructure, most seriously in low-lying coastal Arctic communities (e.g., Shishmaref, Alaska, USA; Tuktoyaktuk, Northwest Territories, Canada) through increased river and coastal flooding and erosion, increased drought and thawing of permafrost, resulting in loss of reservoirs or sewage contamination. (McClintock, 2009) Salt-water intrusion and bacterial contamination may be threatening community water sources. (Virginia and Yalowitz, 2012) Quantities of water available for drinking, basic hygiene, and cooking are becoming limited due to damaged infrastructure and drought. (Parkinson and Butler, 2005)(Virginia and Yalowitz, 2012) Disease incidence caused by contact with human waste may increase when flooding and damaged infrastructure such as sewage lagoons or inadequate hygiene, spreads sewage in villages where the majority of homes have lower water availability because of no in-house piped water source. This, in turn, results in higher rates of hospitalization for pneumonia, influenza, and respiratory viral infections. (Parkinson and Butler, 2005; Parkinson and Evengård, 2009)(Virginia and Yalowitz, 2012) This suggests that reduced water availability because of climate change impacts may result in increase rates of hospitalization among children for respiratory infections, pneumonia, and skin infection. (Virginia and Yalowitz, 2012; Berner et al, 2005(AMAP))

These combined physical, medical, economic, political, socio-cultural, and environmental forces operating on and within Arctic communities today have a important implications for human health and well-being (Curtis *et al.*, 2005)(Ford et al, 2010; Hamilton et al, 2010) The changes in the physical environment which threaten certain communities (e.g., through thawing permafrost and erosion) and which lead to forced relocation of residents or changes or declines in resources resulting in reduced access to subsistence species (e.g., Inuit hunting of polar bear) can be a pathway to rapid and long-term cultural change including loss of traditions. (Anisimov and Vaughan, 2007)(Galloway-MacLean, K., 2010) These losses can, in turn, create psychological distress and anxiety among individuals. (Albrecht *et al.*, 2007; Coyle and Susteren, 2012; Curtis *et al.*, 2005) Additional attention needs to be focused on solutions for the high suicide rates among impacted peoples of the North, particularly, the indigenous populations who are losing the means to practice their traditional customs and maintain their culture, and, therefore, their traditional role in that society. (Albrecht *et al.*, 2007; Coyle and Susteren, 2012)

**28.2.5. Economic Systems**

Outside of the urban areas indigenous people often mix activities of the formal sector (e.g. commercial fish harvesting, oil and mineral resource extraction, forestry, and tourism) with traditional or subsistence activities, which include harvesting a variety of natural renewable resources to provide for human consumption. Hunting and herding, and fishing for subsistence, as well as commercial fishing, all play an important role in the mixed cash-subsistence economies (Crate et al., 2010; Larsen and Huskey, 2010; Nuttall et al., 2005; Poppel and Kruse, 2009)(Rasmussen 2005; Poppel 2006; Aslaksen et al 2009). Renewable harvesting is linked both to the subsistence-based informal economy and to the market economy (Glomsrød and Aslaksen, 2006)(Lindholt 2006). It is projected that there will be significant impacts on the availability of key subsistence marine and terrestrial species as climate continues to change, and the ability to maintain one’s economic well-being may be affected. In the early 1990s – initially in western Canada, and later elsewhere - indigenous communities started reporting climate change impacts (Berkes and Armitage, 2010). According to herders, non-predictable conditions resulting from more frequent occurrence of unusual weather events are the main effect of recent warming (Forbes et al. 2009).

**28.2.6.1.7. Informal, subsistence-based economy**

Inuit and Saami have expressed strong concern about how a rapidly warming climate will affect their respective livelihoods (Forbes and Stammler, 2009). For Inuit, the issues revolve around sea ice conditions, such as later freeze-up in autumn, earlier melt-out in spring, and thinner, less predictable ice in general (Krupnik and Jolly, 2002). Diminished sea ice translates into more difficult access for hunting marine mammals, as well as greater risk for the long-term viability of polar bear populations (Laidre *et al.*, 2008). Since virtually all Inuit communities depend to some extent on marine mammals for nutritional and cultural reasons, and many benefit economically from polar bear and narwhal hunting, a reduction in these resources represents a potentially significant economic loss (Hovelsrud *et al.*, 2008). Among Fennoscandian Saami, the economic viability of reindeer herding is threatened by competition with other land users coupled with strict agricultural norms (Forbes, 2006). Reindeer herders are concerned that more extreme weather may exacerbate this situation (Oskal et al., 2009).

Climate change, which is occurring faster in the Arctic than in other regions of the world, is already affecting the reindeer herding communities through greater variability in snow melt/freeze, ice, weather, winds, temperatures (especially warmer winters), and precipitation, which, in turn are affecting snow quality and quantity – the most critical environmental variables for reindeer sustainability.(Eira *et al.*, 2012)(Magga et al, 2011) Reindeer must forage continually and any significant impediment to their ability to access the plants (e.g. lichens) under the snow cover each day can threaten their very survival. (Kitti *et al.*, 2009)(Magga et al 2011). Increasing temperature variations in wintertime, with temperatures rising above freezing with rain, followed by refreezing (“rain-on-snow” conditions), are becoming more frequent, forming ice layers in the snow which then block the animals’ access to their forage and subsequent starvation. (Bongo *et al.*, 2012; Eira *et al.*, 2012; Maynard *et al.*, 2011). Annual migration patterns between summer and winter pastures are being challenged due to changes in the freeze-thaw cycles of rivers and lakes, with spring thaws occurring earlier and soft ice no longer able to support the reindeer as they try to cross. (Abryutina, 2009; Klein *et al.*, 2005)(Magga et al, 2011) Warmer Arctic temperatures have increased insect harassment causing major interference with foraging. (Kitti *et al.*, 2006) Indirect climate change impacts are also occurring, which also have major implications for reindeer pasture availability and migration routes. With the lack of land-fast ice along the Arctic coasts in recent years, longer summers, and intense pressure to develop oil, gas and minerals in the North, the Arctic regions are becoming far more accessible to humans and industrial development, resulting in additional sources of increasing and irreversible loss of pasturelands. (Bongo *et al.*, 2012; Kitti *et al.*, 2006).

Over the millennia, reindeer herding has developed a strong resiliency to climate change and variability because it is a system which has constantly been subjected to extensive weather-related variations on a day-to-day basis as well as during seasonal migrations. (Klein *et al.*, 2005; Turi, 2008)(Magga et al, 2011) However, in recent years, these successful adaptation strategies which have guided their survival have been challenged by additional external factors such as changing government policies, sharply increasing oil and gas development and mining activities, overall pasture loss, and blocking of migration routes. (Abryutina, 2009)( Magga et al, 2011) The increasing global demand for energy and mineral resources plus an aggressive development of oil and gas fields as well as mining of other resources are encouraging rapid development with its associated infrastructure, pipelines, drill pads, roads, and pollution all across the once-rich pasture lands of the reindeer seasonal migration routes. (Magga et al, 2011; Forbes and Stammler, 2009) In many locations, the associated infrastructure is being built across migration routes in Northern Russia, often blocking pathways to seasonal pastures and eliminating camping and fishing site for herders. (Rees *et al.*, 2008)( Forbes et al, 2009; Degteva et al, 2010)

**28.2.7.1. Indigenous Peoples, Climate Change, and Traditional Knowledge**

Indigenous populations in the Arctic are considered especially vulnerable to climate change, due to their close relationship with the environment and its natural resources for physical, social, and cultural well-being (Nuttall *et al.*, 2005; Parkinson, 2009). Arctic residents in general depend heavily on the region’s terrestrial, marine and freshwater renewable resources, including fish, mammals, birds, and plants (Hovelsrud *et al.*, 2011; Nuttall *et al.*, 2005). However, the ability of Indigenous peoples to maintain traditional livelihoods such as hunting, harvesting, and herding is increasingly being threatened by climate change. The risks are spatially and temporally heteregenous and encompass potential synergies with other, non-climatic drivers, such as general globalization and resource development (e.g., oil and gas extraction, mining), and the prevalence in many indigenous communities of poverty, marginalization, and resulting health disparities. (Abryutina, 2009; Hovelsrud *et al.*, 2011)(Magga et al, 2011).

Indigenous and local communities as well as scientists must therefore think in terms of multiple stressors, since in any one area there may be significant synergies resulting from combinations of rapid climate and/or land use change coupled, in the worst cases, with non-adaptive forms of governance (Forbes, 2006; Kumpula *et al.*, 2011; Sydneysmith *et al.*, 2010; Tyler *et al.*, 2007). In habitats across the Arctic, climate changes are affecting these livelihoods through decreased sea ice thickness and extent, less predictable weather, severe storms, changing seasonal melt/freeze-up of rivers and lakes, changes in snow type and timing, increasing shrub growth, permafrost thaw, and storm-related erosion which, in turn, are causing such severe loss of land in some regions that a number of Alaskan villages are having to relocate entire communities (Bartsch *et al.*, 2010; Bongo *et al.*, 2012; Brubaker *et al.*, 2011; Mahoney *et al.*, 2009; Weatherhead *et al.*, 2010)(Forbes et al. 2009, 2010; Magga et al, 2011; Macias-Fauria et al. in press).

In Deline, Northwest Territories, Canada, there has been an increase of forest fires caused by lightning strikes, which may be the result of long-term climate change rather than just available fuel or weather conditions (Woo, M., Modeste, P., Martz, L., Blondin, J., Kotchtubajda, B., Tutcho, D., Gyakum, J., Takazo, A., Spence, C., Tutcho, J., di Cenzo, P., Kenny, G., Stone, J., Neyelle, I., Baptiste, G., Modeste, M., Kenny, B., Modeste,W., 2009). At Baker Lake, Nunavut, Canada, afternoon temperatures over the last 20 years have fluctuated much more during springtime than they had during the previous 30 years (Weatherhead *et al.*, 2010). In the Canadian Arctic, there is also agreement between Inuit knowledge and scientific studies about the thinning of multiyear sea ice; the shortening of the sea ice season; the declining extent of sea ice cover, with Inuit experts reporting less predictability in the sea ice and more hazardous travel and hunting at ice edges; a decrease in the quantity of multiyear and first-year sea ice; an increasing distance of multiyear ice from the shore; and variability and uncertainty in sea ice during transition months of the year, when freeze-up and breakup occur (Aporta *et al.*, 2011; Department of Environment and Government of Nunavut, 2011; ITK, 2007; Krupnik and Ray, 2007; Laidler, 2006; Nichols, T., Berkes, F., Jolly, D., Snow, N., Sachs Harbour (N.W.T.),T., 2004)( Ford et al., 2009).

Arctic indigenous peoples are facing unprecedented impacts to their lifeways from climate change and resource development (oil and gas, mining, forestry, hydropower, tourism, etc.),

**28.4.1.** **Adaptation and Indigenous Peoples**

There is ample evidence that for millennia indigenous peoples in the Arctic have adapted to changing conditions in myriad ways including resettling amid favourable environments and along the paths of animal migration routes. Indigenous peoples have developed a remarkable array of coping strategies to deal with the extreme natural variability in the region. They have also been innovative and adaptive in the face of cultural and technological change (Bolton et al., 2011). This has been achieved by detailed local knowledge and skills, the sharing of knowledge and flexible social networks which provide support in times of need. Indeed, the sharing of knowledge, food, equipment and other resources is not only an important cultural activity but can also ensure rapid responses to crises (Ford et. al. 2007). In addition values such as patience, persistence, calmness, respect for elders and the environment have been essential for survival in the harsh conditions of the Polar Regions (Takano, 2004).

Unfortunately, the rapid climate and weather changes that have been experienced recently have challenged the reliability of this indigenous knowledge. This has in some cases created a “loss of order in the world” (Turner et.al., 2008) and insecurity on the part of the knowledge keepers (Berkes and Joly, 2002; Chapin III *et al.*, 2006; Hovelsrud and Smit, 2010). In many ways impacts of environmental change are stripping Arctic residents of their considerable knowledge, predictive ability, and self-confidence in making a living from their traditional resources. This may ultimately leave them as strangers on their own land. This may be especially the case of Northern land-based people who depend on their ability to predict weather, judge the snow conditions, and estimate animal movements and distributions; all of which are becoming more difficult. A hunter who cannot make right judgment about what to hunt and where, cannot stay a hunter for long (Berkes, 2002)(339 but also Fox in the same volume 43-45).

Traditional adaptive capacity has also been threatened by the transition from semi-nomadic hunting groups to fixed communities, especially over the last half-century, (Ford et al, 2010) with modern amenities such as television and southern foods that are affecting lifestyles; by wage-earning opportunities in natural resource exploitation leading to frequent job changes and by a desire among the young for a more Western lifestyle. The increasing diversity of employment is leading to the possibility of indigenous people finding multiple jobs, and hence diversified income but can exacerbate social inequalities (Ford et al, 2010). Unfortunately, however, the current levels of skilled labour and formal education often limit the abilities to take advantage of such adaptive opportunities (Furgal C., 2008). Traditional capacity is also affected by the erosion of inter-generational knowledge transfer, land-based skills, and cultural traditions (Bolton et al., 2011). Some communities have put in place strategies to ensure the continued intergenerational transfer of knowledge through school curricula, land camps, and involvement in community-based monitoring programmes (Hovelsrud and Smit, 2010)( Bolton et al., 2011, Ford et. al., 2007). These programs also generate more community well-being and cultural identity. In addition, for traditional societies landscapes assume symbolic significance and changes brought about by climate change may have profound implications which can act as a barrier to adaptation (Adger et. al. 2009). Forced migration as a response to threats to infrastructure is an adaptation option that has been shown to have deep cultural impacts.

Harvesting of renewable resources (which is often critically dependent on the climate conditions) is still a significant component of Arctic livelihoods in many Polar Regions contributing to food security. With climate change however hunting has become a riskier undertaking. Adaptive responses include taking more supplies when going hunting such as additional warm clothing and extra food; constructing more permanent shelters on the land as refuges from storms; building improved infrastructure to communicate; greater use of global positioning systems (GPS) for navigation; SAR to provide estimates of sea-ice conditions (Laidler *et al.*, 2011), and the use of larger or faster vehicles (Ford et al, 2010). However, in some instances, this can lead to increased risk exposure (Aporto et.al. 2005) and over harvesting (Chapin et al. 2005b). Avoiding dangerous terrain can result in longer and time-consuming journeys which can be inconvenient to those with wage-earning employment (Ford et.al. 2007). These adaptive responses have in part been made possible by the increased incomes mentioned above.

Herding, such as reindeer, has also adapted to changes in the climate by moving herds to better pastures (Bartsch *et al.*, 2010), providing supplemental feeding(P. and M., 2008); (Forbes and Kumpula, 2009) and ensuring an optimal herd size (Forbes et al., 2009). Some Eurasian reindeer herders have created new international, multicultural initiatives which combine traditional knowledge with scientific studies to improve their adaptation strategies. One such initiative, the EALAT (“Reindeer Pastoralism in a Changing Climate”), illustrates a forward-looking adaptation strategy in which reindeer herders are now creating and distributing “co-produced” datasets to improve real-time decision-making and herd management to adapt to the effects of the changing climate plus the increasing human development and changing social conditions and policies. (Bongo *et al.*, 2012)(Magga et al, 2011).

Small scale fishers have adapted to changing climate by targeting different species and diversifying income sources (Hovelsrud et al 2010b) . Climate change will however exert pressures on quota systems and the requirements of multi-agency co-management institutions (Ford *et al.*, 2006)(Ford et. al. 2010).

In some Arctic countries indigenous peoples have won land claims rights and have become key players in addressing the issue of climate change. In some instances this has given rise to tensions over land use such as the contested land uses for traditional livelihoods (e.g. reindeer herding) and new opportunities (e.g. tourism and natural resource extraction) (Forbes, 2006; Hovelsrud and Smit, 2010). Some territorial governments in Northern Canada have developed climate change strategies that promote further adaptation such as providing hunter support programs (Ford *et al.*, 2006)(Ford et. al., 2010). Many communities are already adapting in a reactive manner to climate change (Aporta and Higgs, 2005; Gearheard *et al.*, 2010; Gearheard *et al.*, 2011; Laidler *et al.*, 2011). Many studies have noted the importance of combining scientific knowledge and traditional knowledge in an effort to understand climate change, its impacts and local responses. (Furgal C., 2008; LAFORTUNE *et al.*, 2004; Tyler *et al.*, 2007)( Huntingon 2005; Bolton et al., 2011).

The health of indigenous people is being disproportionately affected by the interactions of ongoing changes in human, economic and biophysical systems, as discussed above, exacerbated by changes in climate (Chapin III *et al.*, 2005). Food security is a particular concern, especially with changes in the availability of traditional foods. The transition to store-bought foods can be expensive and is a concern for health such as obesity. However, with declining sea-ice there is the possibility of access to more fresh foods and warmer weather may also make greenhouse production more viable. Both these possibilities will benefit the health of these people. The factors that influence communities’ ability to adapt vary significantly between small, remote, predominantly indigenous communities, regional centres and larger northern municipalities. Adaptation responses include the distribution of traditional foods between communities and the use of community freezers (Ford et al, 2010). Bolton et al. (2011) identified a need for research and policy priorities to be placed on assessing/addressing health factors which may predispose communities to negative impacts of climate change.

Even though the influx of wage employment may enhance the possibilities for adaptive capacity, greater involvement in full time jobs will continue to threaten social and cultural social cohesion and mental well-being by disrupting the traditional cycle of land-based practices (e.g. (FURGAL *et al.*, 2002); Berner et al., 2005), erosion (Furgal C., 2008).