

OVERVIEW:

Changing Landscapes, Changing Lives: Exploring climate change impacts in the Nechako Watershed, and implications to natural resource development

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Forward to overview

The purpose of this overview is to provide a brief summary of the full report (*which has the same title and can be found at <http://nhg.unbc.ca/> and at <http://www.fraserbasin.bc.ca/>*). Both the overview and the full report aim to increase awareness about the changes that have occurred, are occurring and are expected to occur in the Nechako River Basin (NRB). With assistance and feedback from the Nechako Watershed Alliance (NWA)¹ we have attempted to create a summary that is accessible and engaging to a wide audience.

The Nechako River and Nechako Watershed:

The Nechako River begins in the Coast Mountains of western British Columbia (BC) and flows eastward until it meets the Fraser River at the City of Prince George (Hartman, 1996). The original undammed River was 440 km long. The Nechako River Basin (NRB) spans an area of 52,000 km² (Benke and Cushing, 2005). The Stuart River, which flows southeast from the Coast Mountains, is the biggest tributary of the Nechako River (Figure 1). The Nechako is in turn the second biggest tributary of the Fraser River. The Fraser River is the third largest River in Canada (by flow volum) (FBC, 2009) and is the largest intact (i.e., undammed) river in North America (Benke and Cushing, 2005).

Most of the land within the Nechako basin is dominated by coniferous forests. The large tracks of mature forests have made it well-suited for logging (BC MoF, 1998). Many birds and mammals live in the NRB including moose, bears, wolves and great horned owls (BC MoF, 1998). The Nechako River is home to many fish species including rainbow trout and a genetically unique population of white sturgeon. It supports a large chinook salmon run, and two major runs of sockeye salmon in the Stuart river system (Benke and Cushing, 2005). The Nechako sturgeon population is classified as ‘critically imperilled’ (Benke and Cushing, 2005), which means that the species is facing a very high risk of extinction.

BC has been home to a large and diverse population of aboriginal peoples. The Indigenous group that has lived throughout the entire Nechako Watershed for thousands of years is known as the Carrier (Or Dakelh) people (Attili and Sandercock, 2010; CSTC, 2011). The Carrier people were generally semi-nomadic, relying principally on trout, salmon, moose and deer for food.

¹ The NWA is a group of stakeholders concerned about the Nechako Watershed. It includes representatives from all four levels of government, Non-Governmental Organizations, academia, health organizations and the general public.



Figure 1 Settlements in the Nechako River Basin.

The rivers in the region (including the Nechako, Stuart, Stellako, Nautley and Tachie) were important for transportation and food (Wood, 2013). There are a large number of First Nations communities within the Nechako Watershed (Figure 1), including:

- The Tl'azt'en First Nation
- The Nak'azdli First Nation
- The Saik'uz First Nation
- The Takla Lake First Nation
- The Stelat'en First Nation
- The Lheidli T'enneh First Nation
- The Cheslatta First Nation
- The Nadleh Whut'en First Nation
- The Ts'il Kaz Koh First Nation
- The Wet'suwet'en
- The Nee Tahi Buhn

In the early 1800s Europeans began settling in the area. Fort St. James grew into a major trading and government centre, and may be the oldest European settlement on the BC mainland. Throughout the 1800s there were many changes in northwestern BC. During this time there were many terrible colonial disease outbreaks that traditional people were subjected to, such as influenza, measles and small pox (CSTC, 2011; Wood, 2013). In the 1900s there was continue change and agriculture, forestry and hydro-development grew in the NRB.

There have been tremendous changes in BC in a relatively short period of time. Between 1867 and 2008, BC's population increased 100 fold (BC MoFML, 2010). This vast area is still quite sparsely populated. The population of the Nechako watershed is estimated at approximately 105,000, (with approximately 83,000 of these people living in greater Prince George). The major non-First Nations settlements are as follows (Figure 1):

- Prince George (pop. 76,000)
- Fort St. James (pop. 4,500)
- Vanderhoof (pop. 4,000)
- Fraser Lake (pop. 1,200)
- Burns Lake (pop. 2,000)

Climate Change in the NRB:

Climate change refers to shifts in patterns of weather (such as increases temperature, precipitation and/or the number of events or extremes) over a period of time of at least 30 years. The Intergovernmental Panel on Climate Change (IPCC) recently released their fifth assessment report from Working Group I, which focuses on the evidence of climate change, and observed and expected changes (IPCC, 2013). The report concludes that earth's climate system is undoubtedly warming, noting significant warming trends over recent decades. It also states that humans are the primary cause of the warming, and that warming and changes in precipitation will continue even if humans substantially reduce their greenhouse gas (GHG) emissions. This means that we will have to plan to adapt to changes, even if we actively undertake mitigation actions.

Climate change has been identified a concern and research-need in the watershed. For this research, the results of a total of nine studies were analyzed in detail. These studies were:

- I. Climate change and forestry in Vanderhoof (Williamson et al., 2008).
- II. Climate change adaptation in Prince George (Picketts et al., 2013).
- III. Climate change research with the Stellaquo (Sanderson et al., In press).
- IV. Omineca region climate overview (PCIC, 2013).
- V. Hydrologic impacts of climate change on the Fraser River Basin (Shrestha et al., 2012).
- VI. Snow budget research (Kang et al., 2014).
- VII. Flood analysis (Albers et al., In review)
- VIII. Ecosystem restoration in Vanderhoof (LMFRS, 2011).
- IX. Impacts on salmon migration in the Fraser Basin (Padilla et al., in press).

Past climate changes

The results from the research studies reveal clear trends in the NRB. The basin has been warming at a rate of 1.3°C - 1.9°C per century since the early 1900s, and the rates of warming have been much greater in recent decades. The basin is warming more quickly in the winter than in the summer, and minimum temperatures (or night-time lows) are increasing faster than maximum temperatures (or day-time highs). Precipitation trends are much less consistent and less clear, which is not surprising as precipitation varies more from year to year and from location to location. Precipitation appears to have increased over the last century, but this may be due more to cycles of climate variability than climate change. One clear trend is that there has been increasing rainfall and decreasing snowfall throughout the watershed. As a result, stream-flow levels are typically increasing in the winter and decreasing in the summer.

Future climate projections

A number of the NRB research studies included future climate projections as part of their research and analysis. Climate projections are typically generated by analyzing the outputs of Global Climate Models (GCMs). Future projections are usually represented as a change from baseline conditions, which were average conditions from 1961-1990. Projections should not be thought of as definite predictions of what will happen.

Looking into the future the NRB is expected to become approximately 2°C warmer than baseline conditions by the 2050s. Similar to the past trends, precipitation projections are less consistent. A clear trend of increasing precipitation is evident, and less precipitation will be falling as snow. Changes in annual discharge (increases) and snow water equivalent (SWE) (decreases) mean that there will be major alterations in the flow patterns of the Nechako and its tributaries.

Climate impacts in the Nechako Watershed

All of the research studies analyzed discuss climate impacts from a variety of perspectives. Together, these studies provide a rich overview of climate change effects on natural and human-made systems in the NRB. The outputs of all of the studies are grouped into four broad categories of impacts. An overview of these categories follows:

A– Forest and aquatic ecosystems: Climate change is changing the way that ecosystems function, and changing hydrological (water), plant, animal and other patterns and cycles (Smith & Smith, 2009).

The two categories of ecosystems relevant to the NRB are:

- I. *Forest ecosystems:* Climate change may lead to more productive (i.e., faster-growing) trees, more disturbances (from pests and fires) and a shift in what types of species are suitable for the region's climate.
- II. *Aquatic ecosystems:* Increases in water temperatures and decreases in summer flow rates have important implications for the health and viability of aquatic ecosystems in the area. There are major concerns about sturgeon and salmon populations.

B–Water supply: Water supply in the NRB is being affected by a large number of factors including decreasing snowfall, increasing total winter precipitation (i.e., more winter rain), decreasing soil moisture, forest pests outbreaks and warming temperatures. These have led to a change in the annual discharge in the basin, with an earlier peak flow and lower flows in late summer. Future projections indicate that precipitation will increase overall, snowfall will continue to decrease, the spring freshet will continue to come earlier and summer flows may continue to decrease. It is uncertain how these changes will affect flooding, but winter flood events may increase. First Nations people are particularly susceptible to impacts associated with water supply due to their particular spiritual and cultural relationship to water, dependence on fish for food and the poor state of drinking water on many reserves (Assembly of First Nations, 2008)

C–Agriculture and food security: A warming climate can increase growing seasons in more northerly latitudes, and decrease capabilities in hot and arid regions. Although some anticipate longer growing season in northern climates, an increase in extreme weather events (that can spoil or damage crops and farm infrastructure) may offset these positive changes (Walker and Sydneysmith, 2009). Both positive and negative impacts related to climate change have been noted in the NRB: including positive implications related to longer growing season and negative implications related to losses of traditional foods. The changes outlined in the other three categories all interrelate closely with agriculture and food supply.

D–Community well-being: People in communities that are healthy, economically viable, well-built, and sustainable tend to be happy and productive (MEA, 2005), and climate change has influences on all these factors. There are direct health effects associated with climate changes such as heat waves, extreme events (such as floods and forest fire) and water supply (USGCRP, 2009). There are also more subtle and indirect impacts on community well-being that are related to the economy, the physical (natural and built) environment and social networks (MEA, 2005). Climate change has direct effects on all components of the ecosystem and many sectors of the economy such as agriculture, forestry and tourism. Climate influences on human health, pollution and natural ecosystems also indirectly impact the economy (IMF, 2007).

Resource Development and climate change in the NRB

Since the 1800s, Settlers in BC have been engaging in resource-related activities that have dramatically changed the landscape of the NRB. These activities initially related to fur trading but now focus more on hydro-electric power, forestry, agriculture, mining and oil and gas. In this section we overview some important forms of resource development with a focus on their interrelationships with climate change. These activities are briefly discussed in turn below with a focus on the interrelationships with the impacts of climate change. Other resource based human activities that have occurred, and continue to occur, in the NRB that are not summarized in detail include fishing, hunting and trapping, renewable energy development, recreation and tourism. A simple rating system (Table 1) is used to provide an approximation of the degree of interaction, overlay or

interrelationship between the types of resource development and the major climate impacts. This rating system is used for Tables 2-6.

Table 1 Rating system for estimating the degree of interaction between resource development and climate impacts in the NRB.

Scale	Rating	Description
1	Minimal or not applicable (N/A)	No or minimal interaction and/or consequence
2	Low	Some interaction, low consequence or priority
3	Medium	Clear interaction with some consequence
4	High	Direct interaction with consequence: a priority
5	Very high	Direct interaction: very high consequence and priority
6	Extreme	Top priority for concern and action

It is important to keep in mind that these ratings are preliminary and somewhat subjective. The ratings were proposed by the main author, updated by a small group of experts, and discussed and finalized during a workshop with a group of approximately 20 stakeholders representing the NWA.

Hydro-electric power

The hydro-electric development that has occurred in the Nechako has led to profound changes in the region. Of particular significance is the Kemano development project (Hartman, 1996; Wood, 2013), which includes the Nechako Reservoir, the Kenney dam and the Skins Lake Spillway. The changes brought to the Nechako River by the Kemano project have had many significant and long lasting environmental, social and cultural impacts. Many of these impacts are permanent and cannot be reversed: decision makers can only move forward and manage the present system responsibly. There was a second stage of development planned called the Kemano Completion Project (or Kemano II), which would have doubled power generating capacities, but the BC Government cancelled the Kemano Completion Project in 1995. The interrelationships and impacts associated with hydro-electric power generation and climate change are obvious. A summary of key linkages between hydro-electric power and climate impacts in the NRB is included as Table 2.

Table 2 Interactions between climate impacts and hydro-electric power impacts.

Climate Impact	Relation to Hydro-electric Power	Discussion
A: Ecosystems	Very High*	Hydro developments have changed the natural flow regime of the Nechako; Hydro developments lead to changes in water temperatures and flow rates, which impact fish.
B: Water Supply	Very High*	Hydro development has led to a significant reduction in flow in the Nechako, and has permanently altered the flow regime.
C: Agriculture and Food Security	Medium*	Agriculture and hydro-electric power both place demands on water supply; Hydro developments impact traditional food sources.
D: Community Well-being	Very High	Displacement of the Carrier people from the Kemano project has permanent implications; Hydro projects can lead to jobs, and is considered to be a low-carbon form of power.

**projected to increase in the future*

Forestry

Forests and forestry are focal to central BC, as the forests here are very large and many of the communities in the region are heavily reliant on the forest industry. The mountain pine beetle has had a substantial effect on the forests in the NRB. In response to the mountain pine beetle epidemic the Annual Allowable Cut (AAC), or maximum permissible amount of timber that can be harvested, was substantially increased in many TSAs near the NRB (BC MoFLNRO, 2012). Although forestry has had such a major role in central BC's (and the entire Province's) economy, recently the industry has fallen on tougher times, and these trends are expected to continue as the AACs decrease (BC MoFML, 2010). There are many clear interrelationships between forests, forestry and climate change. An overview of key linkages between forestry and climate impacts in the NRB follows in Table 3.

Table 3 Interactions between climate impacts and forestry impacts

Climate Impact	Relation to forestry	Discussion
A: Ecosystems	Very high	Changes related to the mountain pine beetle and forest fires are closely linked to climate change and forestry; Changes affect soil moisture, hydrology and water quality.
B: Water Supply	High*	Logging and the mountain pine beetle epidemic have many implications related to peak flows and flooding; Forest composition changes impact hydrological cycles.
C: Agriculture & Food Security	Medium	Agriculture may to offset declines in forestry; Forest health has strong linkages to the availability of traditional foods (e.g. moose and salmon).
D: Community Well-being	Very High	Forests and forestry are vital to the viability of communities in the NRB; Urban-interface forests fires are a major community risk; Forests are a crucial carbon sink.

**projected to increase in the future*

Agriculture

The Nechako watershed is known for areas of land that are agriculturally productive. This is especially true of the land area around Vanderhoof, and agriculture remains a vital part of the economy in Vanderhoof and the surrounding areas. Climate change and agriculture have very complex interrelationships. Not only are the significant linkages between climate impacts, adaptation and agriculture, but there are major links between GHGs, mitigation and agriculture as well. Agriculture is a major source of GHG emissions: however, sustainable practices and buying food locally can significantly reduce the number of GHGs and ecosystem impacts associated with what we eat. A summary of linkages between agriculture and climate impacts in the NRB follows in Table 4.

Table 4 Interactions between climate impacts and agricultural impacts

Climate Impact	Relation to agriculture*	Discussion
A: Ecosystems	Medium	An increase in agriculture could mean more natural areas converted into farmland and/or more waste that can affect natural ecosystems.
B: Water Supply	High*	Agriculture can require large amounts of water; Agricultural outputs (or wastes) can affect water quality.
C: Agriculture & Food Security	Very high	Warmer temperatures lead to longer growing seasons; Droughts, extreme events and unpredictable weather negatively affect agriculture and traditional sources of foods.
Community Well-being	High	Agriculture is an important source of jobs in many communities in northwestern BC.

**projected to increase in the future*

Mining

Although mining has not recently been a major economic driver in BC, many people expect that mining will replace forestry in the future as the economic driver of northern BC. There are several molybdenum, gold, silver and copper mines and mining projects located within and near to the Nechako watershed. There has also been a lot of exploration in the region. A summary of linkages between mining and climate impacts in the NRB follows in Table 5.

Table 5 Interactions between climate impacts and mining impacts

Climate Impact	Relation to mining*	Discussion
A: Ecosystems	Medium	Mining operations can damage and contaminate aquatic and terrestrial ecosystems.
B: Water Supply	Medium*	Mining can require large amounts of water; Mining effluents or wastes can affect water quality.
C: Agriculture & Food Security	Low*	Mining and agriculture cannot typically coexist on the same (or often adjacent) lands; Mining operations can impact traditional food sources.
Community Well-being	High*	Mining can be an important source of community employment, revenue and economic diversification. Depending on the locations, communities may be influenced by presence/absence of work-camps.

Oil and gas

There has been limited exploration in the Nechako Basin; however, it has substantial oil and gas deposits (Ferri, 2004). One activity proposed on the landscape is the Enbridge Northern Gateway project. If it is constructed the pipeline would travel directly through the Nechako Watershed, which (if it goes forward) may attract more oil and gas exploitation in north-central BC. There are many relationships between climate change and oil and gas exploration, exploitation, transportation and use. Most notably is the fact that the burning of fossil fuels is the main driver (or cause) of climate change (IPCC, 2013). An overview of linkages between oil and gas and climate impacts in the NRB follows in Table 6.

Table 6 Interactions between climate impacts and oil and gas impacts

Climate Impact	Relation to oil and gas*	Discussion
A: Ecosystems	Low*	Oil and gas operations (and spills) affect the landscape that they take place upon, and can contaminate ecosystems.
B: Water Supply	Low*	Some oil and gas activities can demand large amounts of water, and can contaminate water.
C: Agriculture & Food Security	Low*	Pipelines, wells and other oil and gas facilities can impact traditional food sources;
D: Community Well-being	Med*	Oil and gas can be an important source of community employment, revenue, economic diversification and socio-demographic change; Oil and gas is the main driver of climate change.

**projected to increase in the future*

Discussion and conclusions

Climate change (and climate impacts) is an incredibly complex subject and challenge. Resource development (and development impacts) is an equally complex subject and challenge. Therefore it is exceedingly difficult to look at how these two sets of impacts interact with each other. The tables in sections 5.1 to 5.6 have provided an assessment of the degrees of interaction. We also attempted to visualize these interrelationships in spider diagrams in the full report that also illustrate how some interactions may increase in the future. (For the purposes of this exercise the future is defined as the period around 2050).

Thinking about the ‘*big picture*’ can be challenging. For many people climate change is a strange idea and/or distant, global phenomenon that is so ‘*big*’ and so confusing that it is hard to imagine how it impacts their daily lives. This report has focused on ‘*grounding*’ the realities of climate change within the practical day-to-day realities of changing landscapes of the Nechako River Basin. We have explored ways in which climate change has the potential to affect everything around those of us who live and work within the NRB. Climate change directly influences what is important in our daily lives via impacts to ecosystems, water supply, agriculture and food security, and community well-being.

Through this exercise we have begun to better understand what is at risk, how we can proactively minimize negative impacts and how we can capitalize on any opportunities. It can also serve to help prioritize short term and long term actions. This is an exploratory exercise: therefore, these topics have to be further analyzed and studied. Moving forward there needs to be further engagement and research to identify and prioritize thresholds and acceptable levels of change. This information should be applied and built upon by citizens, scientists and managers to strengthen the understanding of what the cumulative effects of resource development and climate change may be, and to plan accordingly. Decision makers must be proactive in thinking about how change, growth and development in the region can and should proceed so that the Nechako Watershed is environmentally, socially, culturally and economically sustainable.

References

- Albers, S. J., Déry, S. J. and Petticrew, E. L. In Review. Flooding in the Nechako River Basin of Canada: A random forest modeling approach to flood analysis in a highly regulated reservoir system, submitted to Canadian Water Resources Journal.
- Assembly of First Nations. 2008. Climate change and water: impacts and adaptations for First Nations communities (Assembly of First Nations Environmental Stewardship Unit) http://www.afn.ca/uploads/files/env/08-03-27_climate_change_and_water_research_paper_final.pdf
- Attili, G. and Sandercock, L. 2010. Finding our way (*documentary film*). (Vancouver: Moving images)
- Benke, A.C. and Cushing, C.E. 2005. *Rivers of North America*. 295 (New York: Elsevier Academic Press).
- British Columbia Ministry of Forests (BC MoF). 1998. The ecology of the sub-boreal spruce zone (Victoria: BC Government) <http://www.for.gov.bc.ca/hfd/pubs/docs/Bro/bro53.pdf>
- British Columbia Ministry of Forests, Mines and Lands (BC MoFML). 2010. The state of British Columbia's forests: third edition (Victoria: BC Government) http://www.for.gov.bc.ca/hfp/sof/2010/SOF_2010_Web.pdf
- British Columbia Ministry of Forests Lands and Natural Resource Operations (BC MoFLNRO). 2012. Mid-term timber supply: Lakes Timber Supply Area. (Victoria: BC Government) http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/mid-term-timber-supply-project/Lakes%20TSA.pdf
- Carrier Sekani Tribal Council, 2011. About CSTC: chronology. (Prince George: Carrier Sekani Tribal Council) <http://www.carriersekani.ca/about-cstc/chronology/>
- Déry, S.J., Hernández-Henríquez, M. A., Owens, P. N., Parkes, M. W., Petticrew, E. L., 2012. A century of hydrological variability and trends in the Fraser River Basin. *Environmental Research Letters*, 7, 024019.
- Ferri, F. 2004. Nechako Basin (Victoria: BC Ministry of Energy, Mines and Petroleum Resources) http://www.empr.gov.bc.ca/OG/oilandgas/petroleumgeology/ConventionalOilAndGas/InteriorBasins/Documents/neco_hako_basin.pdf
- Fraser Basin Council (FBC). 2009. State of the Fraser Basin Report. Sustainability Snapshot 4, The Many Faces of Sustainability. (Vancouver: Fraser Basin Council) http://www.fraserbasin.bc.ca/Library/Comm_Indicators/report_ss4_2009.pdf
- Hartman, G.F. 1996. Impacts of growth in resource use and human population on the Nechako River: A major tributary of the Fraser River, British Columbia, Canada. *Geojournal*. 40:147-164.
- International Monetary Fund (IMF). 2007. World economic outlook: globalization and inequality - world economic and financial surveys. (Washington, DC: IMF)
- IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The Physical Science Basis – Summary for policymakers (Cambridge UK, Cambridge University Press) http://www.ipcc.ch/report/ar5/wg1/docs/WGIAR5_SPM_brochure_en.pdf
- Kang, D. H., Shi, X., Gao, H. and Déry, S. J. 2014. On the changing contribution of snow to the hydrology of the Fraser River Basin, Canada. *Journal of Hydrometeorology*, in press.
- LM Forest Resource Solutions (LMFRS). 2011. The Vanderhoof ecosystem restoration strategic plan. (Vanderhoof: Vanderhoof Ecosystem Restoration Steering Committee) <http://www.for.gov.bc.ca/dva/Other%20Documents/Vanderhoof%20ER%20Strategic%20Plan.pdf>
- Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. (Washington, DC : Island Press) <http://www.maweb.org/documents/document.356.aspx.pdf>
- Pacific Climate Impacts Consortium (PCIC). 2013. Regional climate summaries. (Victoria: University of Victoria) <http://www.pacificclimate.org/news-and-events/news/2013/regional-climate-summaries>
- Padilla, A., Rasouli, K. and Déry, S.J. in press. Impacts of variability and trends in runoff and water temperature on salmon migration in the Fraser River Basin, Canada. *Hydrological Sciences Journal*. Available online (available online). doi: 10.1080/02626667.2014.892602
- Picketts, I.M., Curry, J., Déry, S.J. and Cohen, S.J. 2013. Learning with practitioners: climate change adaptation priorities in a Canadian community. *Climatic Change*, 118, 321-337.
- Sanderson, D., Picketts, I. M., Déry, S. J., Fell, B., Baker, S., Lee-Johnson, E., and Auger, M. 2014. Climate change and water at Stellat'en First Nation, British Columbia, Canada: Insights from western science and traditional knowledge, *The Canadian Geographer*, accepted pending revisions.
- USGCRP (United States Global Change Research Program) (2009). *Global Climate Change Impacts in the United States*. (New York, Cambridge University Press) <http://www.epa.gov/climatechange/impacts-adaptation/health.html>
- Walker, I. J. and Sydneysmith, R. 2008. British Columbia, in: D. S. Lemmen, F. J. Warren, K. Lacroix & E. Bush (Eds) *From Impacts to Adaptation: Canada in a Changing Climate*. (Ottawa: Government of Canada) 329–386.
- Williamson, T.B., Price, T.B., Beverley, J.L., Bothwell, P.M., Frenkel, B., Park, J. and Patriquin, M.N. 2008. *Assessing potential biophysical and socioeconomic impacts of climate change on forest-based communities: a methodological case study*. (Edmonton: Natural Resources Canada) http://publications.gc.ca/collections/collection_2009/nrcan/Fo133-1-415E.pdf
- Wood, J. 2013. Home to the Nechako – the river and the land. (Toronto: Heritage House).