Knowledge, Use, and Change in the Saskatchewan River Delta: Assessing the Changing Livelihoods of Cumberland House Métis and Cree Nation

A Thesis Submitted to the College of
Graduate and Postdoctoral Studies
In Partial Fulfillment of the Requirements
For the Degree of Doctor of Philosophy
In the School of Environment and Sustainability
University of Saskatchewan
Saskatoon, Canada

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ABSTRACT

Ecosystem functions and processes yield a flow of vital goods and services essential for human well-being. Changes, therefore, in the capacity of ecosystems to provide these goods and services can have implications for human well-being. In the Canadian north, many large freshwater deltas lie downstream from hydropower dams that have altered the deltas' hydrology over the past 50 years. Since natural flow and flood regimes are crucial for biological processes in riverine landscapes, alteration of these regimes has implications for the downstream deltas and the Indigenous communities that depend on the ecosystems for their livelihoods and cultural meanings. Interestingly, however, the extent and magnitude of the social-ecological changes stemming from the changes in hydrology are unknown. This knowledge gap remains for two main reasons: first, few studies have assessed the long-term impacts of hydro-dams on northern communities, and, second, post-project impact assessments/research in Canada are not very common. This research investigated the long-term hydro-ecological changes in the Saskatchewan River Delta (SRD) and explored the implications of these changes for the well-being and adaptation of the Indigenous peoples of Cumberland House who reside there. Research strategies included long-term engagement with residents of Cumberland House, involving field observations, oral histories, and semi-structured interviews. These strategies were complemented by archival research and data collected on environmental change using scientific instruments. The objectives for the study were as follows: (a) to examine the long-term hydro-ecological changes in the SRD by drawing on Western scientific and Indigenous knowledge systems; (b) to assess the cultural and spiritual values derived from the SRD and explore how changes in the delta have affected the local interpretations of ecosystem services and well-being; and (c) to examine the adaptive strategies of the people of Cumberland House to the changing social-ecological system.

Results revealed reductions in populations of all species of wildlife and some species of fish, alterations of travel routes, changes in lake and river levels, reductions in outfitting opportunities, and changes in the duration of berry-growing seasons and the growth patterns of berry plants. All of these changes have directly affected the livelihoods and the cultural meanings that residents derive from the delta. The results also revealed that Cumberland House residents have developed culturally adaptive responses to the changes in the delta. This research adds to the few studies on the impacts of hydro-dams in Canada and speaks to the need for more

post-project impact assessments/research of already-built dams, especially those constructed before environmental impact assessments were required. The findings of this research also make valuable contributions to policies on land use and development. Finally, the research makes suggestions for how Indigenous people can be engaged in decision-making and adaptation planning that affect their lives.

ACKNOWLEDGEMENTS

I would like to sincerely thank the residents of the Northern Village of Cumberland House (NVCH) and Cumberland House Cree Nation (CHCN), who shared their stories and experiences to make this work possible. Your Indigenous knowledge is valuable to you, and so I greatly appreciate your willingness to share it with me. Thank you to the students, teachers, staff, and the principal and vice principal of Charlebois Community School for opening your doors to me and for contributing logistics. To all the residents of Cumberland House, I say thank you for your hospitality during my stay in the community. I am particularly grateful to Stepan Tulchynsky for hosting me throughout my fieldwork and to Kelvin Fiddler, James Cook, Kelly Crane, Grant Laliberte, Angus Sewap, Travis Buck, Rob Patterson, and Kelvin McKay for taking me out on the delta. I will never forget our time out on the land and the experiences we had with the boat. You all made my stay in Cumberland House a memorable one. To Gary and Karen Carriere, Clifford and Lily Carriere, and Solomon and Renee Carriere, words cannot describe your support for me during my stay in Cumberland House. You took me in as your son and made me feel at home in Cumberland House. I am also grateful to Pierrette Settee for her early support and assistance during the fieldwork.

I am indebted to my supervisor, Dr. Maureen G. Reed, for her continued guidance and support. I am grateful for the incredible work environment she created for me during my study period. Her mentorship and encouragement will continue to motivate me to strive for academic excellence. I would also like to sincerely thank the members of my advisory committee, Dr. David Natcher, Dr. Timothy Jardine, Dr. Bonita Beatty, and the chair, Dr. Kenneth Belcher, for their support and the unique perspectives each brought to make this work a success. Thanks as well to Merle Massie for her support and assistance with the archival work, and to Heather McWhinney for her help with final editing.

Funding for this research came from the Canada Excellence Research Chair in Water Security, the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Social Sciences and Humanities Research Council of Canada (SSHRC). I also thankfully acknowledge the Arctic Institute of North America (AINA) for providing a grant to support my fieldwork. I am grateful to the University of Saskatchewan and the Saskatchewan Government for the Saskatchewan Innovation and Opportunity Scholarship, to the College of Graduate and Postdoctoral Studies for the International Dean's Scholarship, and to the School of Environment

and Sustainability for the Service Award and Graduate Teaching Fellowship that supported my study. I also acknowledge the Gwenna Moss Centre for Teaching Effectiveness for providing me the opportunity to learn and develop teaching and learning skills through the Teacher Scholar Doctoral Fellowship during my PhD program.

I would also like to offer a heartfelt thanks to family, friends, and colleagues for their support and encouragement throughout the research process. To my family – Mr. and Mrs. Oduro, Eric, Naomi, Alaa, David (K), Razak, Opoku – thank you. To my SENS colleagues – Felicitas Egunyu, Colleen George, Jania Chilima, Arcadio Viveros Guzman, Ayodele Olagunju, Ana-Maria Bogdan, Sandra Betancur Vesga, Bimala Khanal, Heidi Walker, Tegan Brock, and Chris Matzke – thank you. To my friends – John Boakye-Danquah, Festus Boamah, Boabang Owusu, and Roggers Okrah – thank you for your care and advice. And finally, thanks to the SENS staff, especially Irene Schwalm, Sharla Davidiuk, Charlotte Hampton, Tracey McHardy, and Meagan Hinter, for making my time at SENS a successful one.

DEDICATION

To Afia Tawiah and Razak Akwasi Oduro: You taught me to believe in myself and not to give up; you never doubted that I could attain this height.

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LIST OF ABBREVIATIONS

CHCN	Cumberland House Cree Nation
DDN	Delta Dialogue Network
DNR	Department of Natural Resources
DNS	Department of Northern Saskatchewan
DUC	Ducks Unlimited, Canada
ES	Ecosystem Services
GIS	Geographic Information Systems
HBC	Hudson Bay Company
IK	Indigenous Knowledge
IPCC	Intergovernmental Panel on Climate Change
MA	Millennium Ecosystem Assessment
MEB	Multiple Evidence-Based
NVCH	Northern Village of Cumberland House
PFRA	Prairie Farm Rehabilitation Administration
SAB	Saskatchewan Archives Board
SRD	Saskatchewan River Delta
WMZ	Wildlife Management Zone
WS	Western Science

CHAPTER 1 – INTRODUCTION: ENVIRONMENTAL CHANGE AND INDIGENOUS PEOPLES IN CANADA

1.1 Background

Ecosystem functions and processes yield a flow of goods and services including food, water, timber, and aesthetic enjoyment. These goods and services enrich human lives, contributing to economies, security, and human well-being in a number of ways (Costanza et al. 1997; Daily et al. 2000; Millennium Ecosystem Assessment (MA) 2003; Schuyt and Brander 2004). Any changes, therefore, in the capacity of an ecosystem to continue producing its goods and services, most commonly due to human interference, can affect the well-being of people who derive their livelihoods and cultural meanings from the landscape. Altered ecosystems can affect fish and wildlife production through habitat destruction or habitat loss (Cain et al. 2011), water quality and availability through pollution, withdrawal, and/or diversion (Schindler and Donahue 2006), and plant productivity and quality through nutrient loss and other factors (Cain et al. 2011). Complex ecosystems such as wetlands provide multiple goods and services; hence, alterations in such systems can negatively affect the livelihood systems of human located near them (Turner et al. 2003; Adger 2000).

In the Canadian north, many large freshwater deltas lie downstream from hydropower dams that have altered the deltas' hydrology over the past 50 years or more. Because natural water flow and flood regimes are crucial for biological processes in riverine landscapes (Poff et al. 1997), alteration of these regimes has profound implications for the downstream delta ecosystems. What is more, these inland deltas are inhabited mostly by Indigenous peoples; hence, the biophysical changes have consequences for the deltaic communities (Berkes 1981; Loney 1987; Waldram 1988; Windsor and McVey 2005; Liénafa and Martin 2010; Angell and Parkins 2011). One complex inland delta is the Saskatchewan River Delta (SRD) in the central lowlands of Canada. This wetland ecosystem contains diverse and abundant plant, fish, and wildlife species and provides valuable goods and services for Indigenous communities located near it. However, since the 1960s the operation of three large upstream dams – the E. B. Campbell dam (formerly Squaw Rapids dam), the Gardiner dam, and the Nipawin Hydro dam – has potentially affected the delta, changing its natural functions. These changes, coupled with varied climate regimes, challenge the sustenance and the livelihoods of Indigenous peoples

living in the delta region who still rely heavily on its renewable resources. Since the E. B. Campbell dam began operations in 1963, the people of the community of Cumberland House downstream from the dam have expressed numerous social-ecological concerns, including unpredictable water levels, reduced access to harvesting sites, and destruction to local outfitting business (Waldram 1989).

Interestingly, however, the extent and magnitude of the social-ecological impacts stemming from these changes in hydrology are unknown. Few studies have been done on the long-term impacts of hydro-dams on northern communities in Canada (Waldram 1989). As well, post-project impact assessments in Canada are uncommon, and the few that do exist are recent (e.g., Noble and Storey 2005; Storey and Noble 2005; Noble and Birk 2011). Therefore, more post-project impact assessments and research are needed to evaluate both hydro-ecological and socio-economic impacts of already-built dams. However, a deeper understanding of the extent of changes and effects will depend, in part, on the knowledge system of Indigenous peoples who almost every day interact with the environment and observe things firsthand (Usher 2000; Turner et al. 2000). A promising development is the recent understanding among scholars that Indigenous knowledge (IK) systems can complement Western science (WS) and, together, provide valid and useful knowledge to enhance understanding of long-term environmental change (Riedlinger and Berkes 2001; Tsuji and Ho 2002; Berkes 2012). What is needed, however, is "to develop functioning mechanisms for legitimate, transparent, and constructive ways of creating synergies across [the] knowledge systems" (Tengö et al. 2014: 579).

IK is needed for deeper understanding of long-term environmental change and impacts because scholars now recognize that WS, for a long time the only accepted knowledge for expanding western society's understanding of environmental change (Wonders 2003), is limited in the information it can provide. Researchers, for instance, have noted that to understand long-term environmental change, scientific information from instrumental observations and documentary records may provide long-term accounts of change but may also contain significant temporal and spatial gaps (Riedlinger and Berkes 2001; Nichols et al. 2004). In their studies on climate change in the Canadian Arctic, for example, Riedlinger and Berkes (2001) noted that systematic collection of meteorological data for the area did not begin until 1947; hence, data prior to 1947 were based only on fragmentary short-term records. Similarly, studies of land-use change documented in Geographic Information System (GIS) platforms have only been available

since the 1970s. Moreover, surviving files contained in government archives are fragmented and partial, containing information only up to the year they were created. These files are records created by politicians and officials and their representatives (Roche 2005). As a result, they reflect the outlooks, understandings and power relations of groups that were dominant at the time they were created (Roche 2005). Given these deficiencies in instrumental and documented data, IK, which is produced continually over several generations and passed from generation to generation through cultural transmission, can often confirm the temporal accuracies of these data (Riedlinger and Berkes 2001).

In addition to providing a check on WS, IK provides evidence of deeper meanings and complexities of environmental change. These meanings can, in turn, lead to long-term cultural change and adaptation. IK, therefore, can supply evidence and interpretations of change that can help put a cultural valuation on ecosystem services (ES) and make policy decisions and manage the environment. Hence, there is an opportunity to advance our understanding of environmental change and impacts by drawing on the knowledge and interpretations of people who directly derive livelihoods and cultural meanings from the landscape. The drawback, however, of IK – that it cannot pinpoint the potential causes of change (Ignatowski and Rosales 2013) – has meant that both WS and IK should complement or even partner (Pooley 2013) with one another to aid ecological understanding.

Living and interacting with the environment almost every day, Indigenous peoples have always had to accommodate and respond to environmental changes (Berkes and Jolly 2001; Turner and Clifton 2009; Turner and Spalding 2013). There is evidence that effective response and adaptation opportunities exist in Indigenous communities (Nickels et al. 2002; Kofinas et al. 2010). Knowing how Indigenous peoples respond and adapt to change can also provide insights to guide decision-making and adaptation planning more generally (Boissière et al. 2013).

To sum up, evidence suggests that IK is needed to better understand long-term environmental change, including the cultural dimensions of change (Adger et al. 2013); that scholars must find functional mechanisms for using both IK and WS together (Tengö et al. 2014); and that they must also find new platforms to engage with the cultural dimensions of environmental change (Adger et al. 2013). Several questions emerge from the evidence: (a) how can we bring IK and WS together while respecting the integrity of each, and the differences between them, and maintaining the opportunities for them to enrich one another?, (b) how can

we understand how environmental change affects Indigenous peoples' interpretations of the cultural values they derive from the landscape and their conceptualization of well-being?, and (c) how can we know how Indigenous peoples' responses to environmental change are constructed when they seek to secure the continuation of their livelihoods and well-being? This research contributes to addressing these questions.

1.2 Research Purpose and Objectives

In Western Canada, three large freshwater deltas – the Peace-Athabasca, Slave, and Saskatchewan – lie downstream from hydropower dams that have altered the hydrology of these places; however, there is considerable uncertainty and debate about the resultant social-ecological effects of these changes (Timoney 2002; Brock et al. 2010; Beltaos 2014). Given the unknown extent and magnitude of social-ecological changes stemming from these changes in hydrology, this research draws on changes in the SRD, caused partly by the operation of the E. B. Campbell dam, as a case study. The purpose of this research, therefore, is to investigate the long-term hydro-ecological changes in the SRD and to explore the implications of these changes for the well-being and adaptation of the Indigenous Peoples of Cumberland House who reside there. In 1984, Waldram investigated the socio-economic impacts of the E. B. Campbell dam on the people of Cumberland House (Waldram 1989). This research follows up on Waldram's work, looking at the changes in continuity in resource use thirty years later and extending our understanding of the long-term changes, socio-cultural impacts, and adaptations in the delta's social-ecological system. Furthermore, as Waldram did not consider the cultural services that have been derived from the SRD, this research explores how cultural and spiritual values of the delta have changed and the consequences of these changes to the well-being of local peoples. The specific objectives of the research are as follows:

1. To examine the long-term hydro-ecological changes in the SRD by drawing on Western scientific and Indigenous knowledge systems;
2. To assess the cultural and spiritual values derived from the SRD and explore how changes in the delta have affected the local interpretations of ecosystem services and well-being; and
3. To examine the adaptive strategies of the people of Cumberland House in relation to the changing social-ecological system.

1.3 Study Site

1.3.1 The Saskatchewan River Delta (SRD)

The SRD is located in the central lowlands of Canada and straddles the border of the provinces of Saskatchewan and Manitoba (Fig. 1.1). Rivers draining the eastern slopes of the Canadian Rocky Mountains and crossing the high plains of Alberta and western Saskatchewan feed into the SRD (Partners for the Saskatchewan River Basin 2008). The SRD is the largest inland delta in North America, covering an area of about 10,000 km^2 (Smith et al. 1998; Partners for the Saskatchewan River Basin 2008). A complex area of mainly varied wetlands with active and abandoned channels, the delta contains diverse and abundant plant, fish, and wildlife species (Kew 1962; Bicentennial Committee 1974). The Cumberland Marshes in the delta are internationally designated as an important bird area (Schmutz 2001).

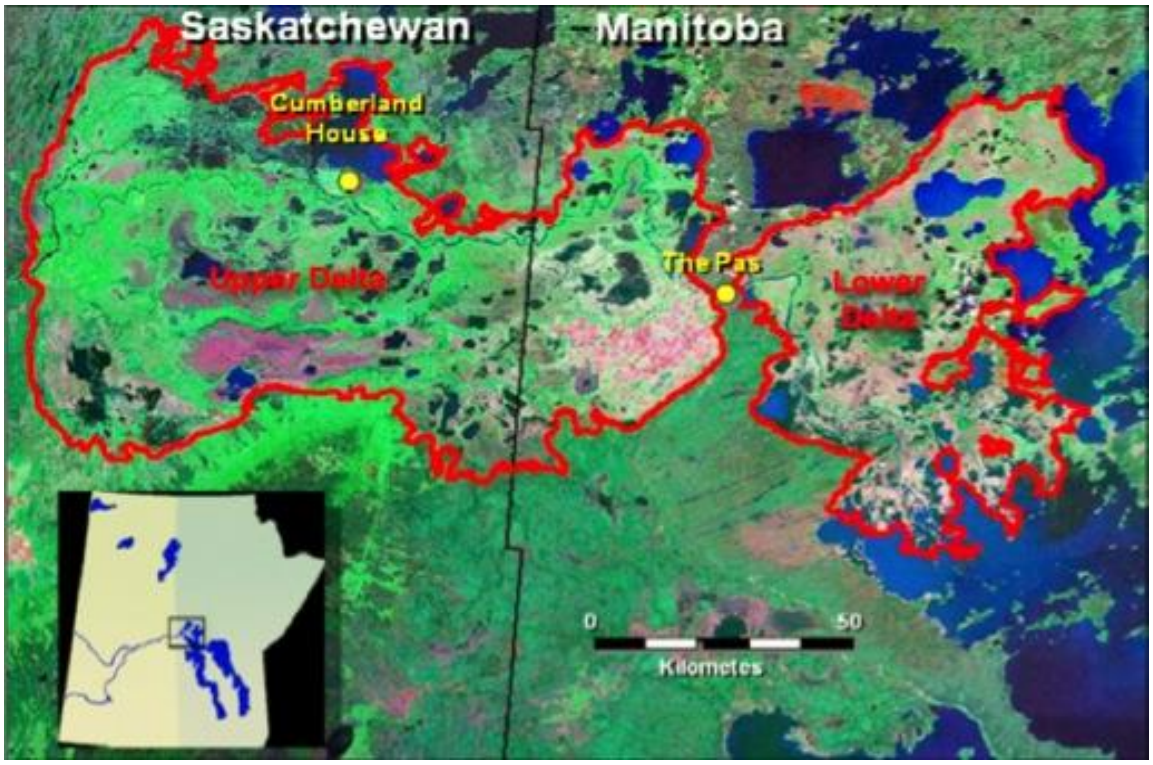

Figure 1.1: The Saskatchewan River Delta [Source: Ducks Unlimited Canada 2006]

Located downstream in the Saskatchewan River basin, the delta is impacted by many upstream developments, which have altered its hydrology, physiography, health, and biological diversity (Partners for the Saskatchewan River Basin 2008). In the 1870s, for instance, an

avulsion – the diversion of flow out of an established channel into a new course – of the Saskatchewan River, probably caused by an ice jam, diverted most of its flow from the single main Old Channel, forming a new series of smaller channels (Smith et al. 1989; Partners for the Saskatchewan River Basin 2008; Smith et al. 1998). Today, the Old Channel, which was the Saskatchewan River's course up to the 1870s, is slowly being abandoned (Smith et al. 1998). It now carries only about 5-10% of the annual flow (Smith and Perez-Arlucea 2008). Flows through many formerly active channels have now consolidated into a single channel known today as the New Channel of the Saskatchewan River (Smith et al. 1989; Smith and Perez-Arlucea 2008). Sediment and peat have filled many channels abandoned by the avulsion (Partners for the Saskatchewan River Basin 2008). The avulsion has also affected Cumberland Lake – the largest lake in the delta. Increased deposition of silt from new channels has caused the lake level to drop from previously six meters deep to less than two meters now (Smith et al. 1989; Smith et al. 1998).

Three large dams impact the delta: the E. B. Campbell dam (formerly Squaw Rapids dam) (constructed in 1963 and forming Tobin Lake reservoir), the Gardiner dam (constructed in 1967 and forming Lake Diefenbaker), and the Nipawin Hydro dam (constructed in 1985 and forming Codette Lake). These upstream facilities have altered the natural functions of the delta. For instance, the impoundment of the Saskatchewan River, which created Tobin Lake as a reservoir to run the E. B. Campbell dam in 1963, dropped water levels throughout the delta (Saskatchewan Archives Board (SAB) R78-129 R-369). The population of fish and wildlife, particularly aquatic fur-bearers, also dropped after the dam was built (Waldram 1989). The E. B. Campbell dam operates as a peaking facility, meaning water is held and released as needed for power generation. This process results in extreme fluctuations of the river's flow, sometimes daily or hourly (Waldram 1989). In terms of seasonal flows, the dams have created unnatural patterns where there is now a decreased peak summer flow and irregular high winter flow (Waldram 1989). Variable river flows have also led to changes and loss of important fish and wildlife habitats (Partners for the Saskatchewan River Basin 2008).

There are many other water control structures – dikes, canals, and small dams – in the delta, some of which were created by provincial governments, Ducks Unlimited Canada (DUC) and Tom Lamb, an entrepreneur from Manitoba, with the aim of raising and lowering water levels for increased muskrat (*Ondatra zibethicus*; *Wācask* in Cree) production and wetland

integrity (Bicentennial Committee 1974; Partners for the Saskatchewan River Basin 2008). Ducks Unlimited, for instance, has operated and managed the Cumberland Marsh area of the delta since the 1940s, building many control structures in the river system (www.ducks.ca). The Prairie Farm Rehabilitation Administration (PFRA) also has a history of draining about 100 km^2 of the delta region intended for agricultural purposes (Partners for the Saskatchewan River Basin 2008). All these interventions add to the human-induced modifications of the delta's hydrology.

The delta was noted for annual summer flood events, which local residents traditionally viewed as natural and important for the ecosystem's health and diversity (Hlady and Price 1967; Waldram 1989; Partners for the Saskatchewan River Basin 2008). Fresh inundations of water prevented lakes and streams from drying up, willows from encroaching, fish from dying, and wildlife and fur-bearing animals from disappearing (Bicentennial Committee 1974; Waldram, 1989). However, the situation has changed and residents now complain about recent floods. They indicate that recent floods are not natural, making predictions and preparations for them difficult. As an example, residents of Cumberland House were evacuated for major floods that occurred in 2005 and 2013.

1.3.2 Cumberland House

Cumberland House is the oldest settlement in Saskatchewan; its establishment dates back to 1774 when Samuel Hearne of the Hudson's Bay Company (HBC), which traded in furs, deemed the area as an ideal location for the company's inland trading post (Kew 1962; Bicentennial Committee 1974). Situated in the heart of the SRD, Cumberland House stands on Pine Island at the south end of Cumberland Lake (Kew 1962; Waldram 1989). It has a growing Indigenous population of Métis – people with mixed North American "Indian" and European ancestry – and status "Indians" or First Nations, who are descendants of Swampy Cree people (Waldram, 1989). Cumberland House is a Cree "n" dialect community. The Cree "Indians" signed an adhesion to Treaty No. 5 in 1876, which put them on Pinebluff Reserve, 25 miles west, but they were subsequently relocated in 1960 to a reserve land adjacent to the larger Métis community (Kew 1962; Bicentennial Committee 1974; Waldram 1989). Thus today, Cumberland House is made up of two politically distinct settlements: the Northern Village of Cumberland House (NVCH) – a municipal entity of the Province of Saskatchewan – and the Cumberland House Cree Nation (CHCN) – an "Indian" Reserve. An elected Band Council

politically represents the reserve population, whereas a local community authority represents the Métis and non-status residents (Waldram 1989). Although the two communities are separated politically, they are integrated socially (Waldram 1989), and the cultures and identities of both are rooted in their land-based practices.

Cumberland House's population has remained largely Indigenous. Without any industry, the community lacks job opportunities, and high unemployment is a long-time characteristic. A 1980 Labour Force Survey revealed an unemployment rate more than seven times the provincial average (Damas and Smith 1980). This unemployment disparity persists today. The lumber industry (sawmill) that used to employ a segment of the population has collapsed, and the few available jobs are concentrated at the school and the Band and Municipal offices. Residents, thus, have deep ties to the land-based activities that go back generations (Bicentennial Committee 1974).

The delta remains an important resource for residents of Cumberland House and other communities within the region as it was in the past. Lori Lathlin, a member of the Opaskwayak Cree Nation at The Pas, the largest community within the delta region, metaphorically indicated the delta's importance: "The delta is our grocery store, it is also our drug store, and it provides most of our needs and nourishment" (Partners for the Saskatchewan River Basin 2008:138). Both local economic and cultural connections to the delta are characterized by fish, wildlife, plant, medicine, and berry harvesting on a seasonal and annual basis. Changes, however, in the rivers and lakes, as well as in the health and diversity of the ecosystem, have created ongoing problems for local residents.

1.4 Overview of Methodology

1.4.1 A model of community-based and archival research

This study employs a mixed methodology, combining community-based fieldwork and archival research. As part of a larger collaborative and policy-oriented project with the community of Cumberland House, the study was designed to reflect the priorities and perspectives of the local people and premised on long-term interaction they have had with the delta. The residents were an integral part of the study, providing evidence of change and impacts on their traditional use of the delta. The study follows the tradition of Berkes who, when referring to his own research, revealed that he had shifted away from the "expert-knows-best

science toward accepting traditional knowledge as a partner and complement" (Berkes 2012:173). Through meetings with community members, we determined the objectives, approaches, and rules of conduct of the research, and adjusted the interview questions to reflect relevant concerns and priority issues. The language of the interview guides was also checked to ensure understanding. After a preliminary analysis of the field data, I returned to the community to present, discuss, and verify the results. I also shared a draft of the dissertation with research participants and sought direct feedback on what I had written. As a way of respecting local rights to knowledge, I duly acknowledged my research participants in all my publications.

Although I believed that local people could provide historical perspectives on long-term use and change in the delta through memories, recall, and oral traditions, I understood that they might not remember every historical event within the interview period. I agree with Harris (2001) that, while the near past can be approached ethnographically, it is only in the archives that much of the period between archaeological and ethnographic evidence of many places, landscapes, and human-environment relationship can become known. In other words, some information is unlikely to be accessible based on field interviews and observation alone. I, therefore, relied on archival records to obtain historical information valuable to the research. To complement my on-site data, I used historical reports such as government-commissioned hydrological studies on the delta, fish, and wildlife surveys, as well as many regulatory policies by various past governments. Valuable resources for the study included documents such as the 1988 Cumberland House agreement with the Province of Saskatchewan and the Saskatchewan Power Corporation (the Crown corporation responsible for power generation in the province) and a 1984 study by James Waldram used by the community of Cumberland House to reach an agreement with the Government of Saskatchewan in 1989 for compensation of losses caused by the E. B. Campbell dam. During fieldwork, I also obtained personal letters, photographs, newspapers, and private documents from research participants.

I planned the study so that much of the archival work was done before the fieldwork. By so doing, the fieldwork partly served as post-archival work. Hence, the drawback of archival research – as records of those in positions of authority that often reflect their outlook and understanding (Roche 2005) – was confronted, since information that emerged from the archives

was compared and discredited or nuanced through oral history interviews with Elders[1] for extended understanding.

1.4.2 Data collection methods

Multiple methods were used to collect data to address the research objectives (Table 1.1). Historical documents were obtained mainly from the Saskatchewan Archives Board (SAB). Field data collection involved the use of qualitative strategies of semi-structured interviews, oral histories, and participant observation over a period of eight months – February to September 2014. The methods and approach were approved by the Research Ethics Board of the University of Saskatchewan, and all the processes of data collection were found to correspond with guidelines set by the university's Behavioural Research Ethics Board (see Appendix D: Research Certificates and Instruments).

Table 1.1: Research objectives and data collection methods used to address each

Objective	Data collection method
1. To examine the long-term hydro-ecological change in the SRD by drawing on WS and IK systems.	Oral histories, semi-structured interviews, participant observation, document review, instrumental observation
2. To assess the cultural and spiritual values derived from the SRD and explore how changes in the delta have affected the local interpretations of ecosystem services and well-being.	Semi-structured interviews, oral histories, participant observation
3. To examine the adaptive strategies of the people of Cumberland House to the changing social-ecological system.	Semi-structured interviews, oral histories, participant observation

I chose most of the study's participants based on recommendations from community members; the strength of this approach lies in the selection of respected local knowledge experts as interviewees (Davis and Wagner 2003). The rest of the participants were recruited through contacts I established during the period of the fieldwork. Interviews focused on Elders as well as active hunters, fishers, trappers, and plant harvesters. To understand the perspective of young

[1] In this paper, I use 'Elders' to refer to those people recognized and respected in the community because of wisdom, skill, and, ceremonial placement.

people, I also interviewed some youth engaged in these traditional activities. Interview participants included both males and females. All but one of the interviewees were of Indigenous ancestry and were from both NVCH and CHCN. In all, 42 people were interviewed (Table 1.2).

Table 1.2: Summary description of interview participants

Socio-demographic characteristics	Number of participants
Sex	
Male	29
Female	13
Sub-total	42
Age	
Maximum	93
Average	53
Minimum	17
Ancestry	
Indigenous	41
Non-Indigenous	1
Sub-total	42
Land-based activity*	
Hunting	22
Trapping	19
Fishing	27
Plant harvesting	6
Outfitting	4
Guiding	6

* The majority of the participants were engaged in more than one activity

1.4.2.1 Oral history interviews with Elders

I carried out oral history interviews with eight Elders from NVCH and CHCN, recording their personal experiences, memories, and perceptions of the long-term changes in the social-ecological system. Oral history is a form of interview conducted in an informal format with a person who has first-hand knowledge of a subject of interest (George and Stratford 2005). This type of interview explores hidden histories and geographies, telling what happened, how, why, and what it was like from a personal perspective, and allowing the interviewer and the interviewee to track and understand changes across spatial scales as well as temporal ones (George and Stratford (2005). Oral history differs from the semi-structured interview in that it is historical in intent, aims to record as natural, rounded, and complete a story as possible, and may be completed over several sessions (Shopes 2011; George and Stratford 2005). Oral histories

were necessary to obtain first-hand knowledge and memories of Elders about key historical events in Cumberland House settlements and the delta, especially in the pre-dam era, that might not have been documented in historical records. These details were relevant to fill information gaps in archival data and/or to complement it. The interviews were done in an unstructured manner, allowing the Elders to express themselves in their own terms and at their own pace with minimal interruptions. This approach also permitted the free flow of information to prompt unanticipated questions. The conversations revolved around stories and experiences of life on the land, such as growing up on the trap-line. I conducted four of the interviews personally in English. The other four were done in Cree, as those interviewees (Elders) preferred to speak in the local language. I hired a local resident as an interpreter to assist me.

1.4.2.2 Semi-structured interviews with active harvesters

In my discussions with active fishers, hunters, trappers, and plant harvesters, I was particularly interested in their perceptions of the effects of changes in the delta on their land-based activities. I asked questions on a range of topics, including species populations, water transportation and safety, harvesting locations, as well as harvesting effort and cost. I spent almost two months in the community before the interviews began, so I was able to test the interview guide in many ways through informal conversations and interactions. I met with many people, including my interview participants, at least once, if not many times, before the actual interviews took place. Although the interviews followed a pre-determined guide, I also followed new leads, as I wanted my participants to freely tell me what they knew and thought was important. I showed interest and explained that I wanted to learn from them by listening to what they had to say about changes in the delta. In all, 34 interviews with active harvesters in both settlements were conducted. As mentioned, most of these participants were recruited based on recommendations from community members. The intention was not to obtain a statistically-representative sample of community members but rather to elicit observations and meanings of socio-ecological changes they had experienced while living in the region.

1.4.2.3 Participant observation

Indigenous peoples value researchers who spend considerable time in their community, getting to know them and involving them in their research. Gearhead and Shirley (2007:63) note that Inuit refer to researchers as *siksiks* – ground squirrels in Inuktitut – because they "appear suddenly, usually in the summer months, scurry around on the tundra doing who-knows-what, and then disappear just as quickly without anyone's knowing exactly what they were up to." Indigenous peoples, thus, dislike parachute researchers who fly-in and out to collect data at a time of their choosing with little to no communication before, during, and after the study (Castleden et al. 2012). Many researchers may have neither the time nor the logistics to commit to researching for a long period, but given its importance for the success of community-based research, time spent in research communities must be considered. As a graduate student, I could commit to living in Cumberland House for eight months. This time commitment was acceptable to the residents, who were glad that I had not tried to complete the research in a month or less but would learn from them by living among them and participating in their traditional activities.

As a young man from Africa researching Canadian Indigenous culture, I was aware of, and considered, my positionality – aspects of my identity shaped by my unique mix of race, class, gender, nationality and other identifiers (Mullings 1999; Smith 2010) – the difference that it made, and the bearing it had on how I did the research. In living among the Indigenous peoples of Cumberland House, I was sensitive to the local customs and respected the cultural and physical environments I encountered. In my interactions, I exhibited respect and genuine interest in learning about the people and tried not to give offence, seeking connections as well as differences throughout the research process (see Smith 2010). I was privileged by my identity as an African because residents and I had a shared assumption that came from a common background of having been once colonized by the British. This common heritage made it easier for me to build rapport, trust, and to be granted interviews. My motives for conducting research with the people were viewed as non-threatening, and this attitude helped me gained access to privileged viewpoints or information that probably would not have been given to a White researcher. For instance, based on the assumption of our mutual colonized positionalities, I was seen as a confidant for sensitive information. Some participants could tell me to switch off the tape-recorder during an interview because what they were going to say was just between them and me.

Moreover, because they perceived me as a complete outsider, participants assumed that I lacked knowledge of Indigenous ways of life as well as of the protracted Indigenous and Euro-Canadians relations. This view of me allowed them to open up and share information freely. Because I was an outsider, the people considered that I had a genuine interest in their stories, and some people agreed to be interviewed, so they could tell me about the rich history and tradition of Cumberland House people. My presumed lack of knowledge also meant that the people did not view me as a researcher with a powerful and influential position. As mentioned, many researchers are viewed in this way, and this can interfere with data collection (see Mullings 1999; Smith 2010). Because they viewed me as a partner, residents felt empowered to share candid opinions as well as information. However, when necessary, I asked questions that demonstrated my awareness of issues. When the participants realized that I was, in fact, well-informed, they afforded me a level of credibility and respect. My obvious identity as an outsider, however, did not give me full participation in the community. As a young black man affiliated with the University of Saskatchewan, I was not welcome in some residents' homes as they were uncomfortable with my presence and thus did not open their homes to me.

In a setting where there are complex interactions between people and their land, I concur with Thomson's (2011:13) argument that "It is only by firsthand experience of 'being there' for an extended period of time, watching what happens, listening to what is said, and asking questions that the complex dynamics of [social-ecological] interactions can be explored." Living in the Cumberland House community and participating in harvesting trips gave me first-hand exposure to the reality of the day-to-day life of the people. These harvesting trips enabled the people and me "to develop common referents, so that discussions could begin with phrases like 'As we saw the other day at…'" (Huntington et al. 2011:439). Furthermore, the experience in the wilderness gave me an understanding of the traditional way of life and what it feels like to be in the bush. From the point of view of local residents, my experience was also important because, for them, being out on the land is the appropriate way to learn about the environment (Nadasdy 2003). My stay in Cumberland House also gave me the opportunity to encounter and interact daily with people, many of whom did not take part in my interviews. Such casual conversations offered insights into local perceptions of changes in the socio-ecological system that did not emerge in the formal interview settings. I attended community meetings and participated in festive events such as Samuel Hearne's day, cultural week, and kids' Cree camps. My

observations at these kinds of events and meetings were instrumental to the interpretation of the data.

1.4.2.4 Review of historical documents

Oral history interviews provided a local historical perspective on the delta and traditional lifestyle in Cumberland House before and after the construction of the E. B Campbell dam. However, as mentioned, to complement the field data and to generate a broad historical understanding of the changes in the delta and impacts on traditional use, information from a variety of archival materials and previous research was also used. For instance, the Department of Natural Resources (DNR) and Department of Northern Saskatchewan (DNS) documents at the Saskatchewan Archive Board (SAB) consist of information on various Saskatchewan government policies on northern resources, such as harvesting permits and quotas, open seasons for harvest, payment for furs, trapper programs, fish and wildlife surveys, and water regulations. Some of the information dates back to the years before the opening of the E. B. Campbell dam in 1963. Moreover, the environment files of various deputy ministers at the SAB contain specific correspondence between government officials (e.g., game commissioners and resource officers) on concerns about water levels and game in the delta region. These files also contain petitions and letters from local authorities in Cumberland House raising concerns about the damaging effects of the E. B. Campbell dam on traditional activities. In helping me to determine the resource-use patterns in the delta, these documents were a valuable supplement to the interview data. I also obtained reports on work completed in the SRD by various bodies such as the Committee on Saskatchewan River Delta Problems and the Saskatchewan River Delta Development Committee. I reviewed all these reports to better understand the changes in the SRD.

1.4.3 Data analysis

All the semi-structured and oral history interviews were audiotaped, transcribed verbatim, and, together with the field notes, coded and analyzed by theme using *NVivo 10*, a qualitative analysis software program. A number of codes were descriptive and emerged from the field notes because they concerned issues that people talked about frequently during field

conversations. A few codes were analytic; these came later in the coding process as they were connected to the frameworks of the study. In analyzing the interviews with harvesters, themes were organized to determine the kind of changes made in traditional activities – hunting, fishing, trapping, plant gathering – and to identify factors that account for such changes. Regarding the oral history interviews, the analysis focused on determining how the social-ecological system changed during the pre- and post-dam periods. The analysis of historical documents located specific information like harvest records and water level changes, but documents were also analyzed to compare historical information with reports of local people, both to identify consistencies and to fill gaps.

1.5 Practical Contributions of the Research

Studies have shown that Indigenous peoples want to use their knowledge to inform on-going policies related to resource use (see Turner et al. 2008; Turner et al. 2013). IK, however, is context-specific and dependent on each case of environmental change and impacts. Through collaborative design with the people of Cumberland House, this research was completed at a time when the Saskatchewan Power Corporation (SaskPower) is negotiating its re-licensing for the E. B. Campbell dam. The findings of this study, therefore, may help inform discussions about the re-licensing process. However, none of the work or findings of this research constitute any form of consultation that might be required by SaskPower as it pursues renewal of its license.

Furthermore, little is known about the impacts of the E. B. Campbell dam on the livelihoods of communities located downstream from the dam. Regarding the community of Cumberland House, the most recent study is the 1984 work by James Waldram used by the community to reach an agreement with the Government of Saskatchewan in 1989 for compensation of losses caused by the dam (Waldram 1989). However, in the thirty years since Waldram's work was published, many changes have occurred. This study follows Waldram's work in recording impacts and adaptations over the last three decades.

Lastly, much of the research on ecosystem services has focused on monetary contributions to well-being. Approaches to understanding the value of cultural ecosystem services using non-monetary metrics are just beginning to emerge. Articulations of these dimensions are particularly important for people who derive their livelihood and cultural meanings from the landscape, yet there has been relatively little attention given to how

Indigenous peoples describe and experience cultural ecosystem services. Since Waldram's 1984 research did not capture the cultural values that Cumberland House residents derive from the SRD, the current study responds to the need to develop approaches specifically for valuing cultural services and shows both the changes in cultural values derived from the SRD and the implications of these changes for local well-being.

1.6 Ensuring Reliability and Validity of Research

Reliability, sometimes known as consistency (Creswell 2009), refers to "the extent to which research findings can be replicated" (Merriam and Tisdell 2016:250). Validity, on the other hand, sometimes known as credibility or authenticity (Creswell 2009), refers to the truthfulness of research findings (Mansvelt and Berg 2005). To ensure consistency and authenticity of this research, a variety of strategies were used. First, I collected data from multiple sources and with different methods, thus ensuring data triangulation and enhanced credibility of the research findings. As an example, I drew on IK, archival records, and instrumental observations to understand long-term changes in the delta. Each of these diverse knowledge sources confirmed the accuracy of the others, and the many areas of corroboration across the sources increased confidence in the findings.

Second, I took important steps to build rapport and trust with my research participants to ensure that I obtained authentic responses from them. Before conducting interviews, for instance, I spent several weeks in the community, establishing a trusting relationship with community members. I, therefore, gained the trust of my interview participants. Moreover, informed largely by community-based research, my research was directed by the community partners, who also provided evidence of change and impact; hence, the responses reflected local priorities and perspectives. Importantly, by following the community members' recommendations for interviewees, I ensured that knowledge-holders in the community were interviewed. I conducted the number of interviews necessary to reach saturation, defined as the point where no new evidence emerged (Morse 2015).

Third, I conducted archival research before conducting the interviews, which allowed for information that emerged from the archives to be compared and validated in the interviews. This process ensured authenticity of the research findings. Moreover, since I had participated in

several harvesting trips, some of the questions I asked during the interviews were based on things that I had personally observed while on the land. Being on the land was also essential to ensuring data quality because, for Indigenous people, being on the land is the appropriate way to learn about the environment. Additionally, the unstructured manner of the oral history interviews with the Elders permitted a free flow of information on their own terms and at their own pace. I also followed new leads in my interviews with active harvesters, allowing them to freely tell me what they perceived as relevant. In many cases, to assess the consistency of the information given, I posed the same questions to different participants.

Lastly, I returned to Cumberland House to present my preliminary analysis and to receive feedback from the participants. The community meeting, held at the village hall of the NVCH, allowed participants to comment on the accuracy of descriptions and themes generated during data analysis. With their consent, participants' names were attached to quotations from their interviews that I planned to use in this thesis. Participants easily identified with their interviews and were happy to see their names by their quotations. Compiled as a document (Appendix A), copies of the quotations with participants' names were distributed to members at the meeting. This process ensured that the information was not sensitive in nature and could be made public. However, in this thesis (Appendix A), I have replaced participants' full names with their initials so that, while they can still identify themselves with their quotations, people from the outside cannot identify them. The meeting offered the opportunity for community members to hear what others had told me and to also confirm what I was told. This ensured consistency and credibility of the results. Where available, scientific and Cree names for plant and animal species are provided.

1.7 Thesis Structure

This thesis is presented as a "manuscript-type dissertation", comprised of three publishable manuscripts (Chapters 2, 3, and 4) as required by the College of Graduate and Postdoctoral Studies. It contains five chapters, including a general introduction (Chapter 1) and a general conclusion (Chapter 5), which bookend the three manuscripts. I am the lead author of all the manuscripts, as I collected the data, conducted the analysis, and took a leadership role in

conceptualizing and writing all the chapters. The appropriate citations of the manuscripts are as follows:

Abu, R., Reed, M.G., and Jardine, T. (submitted 2017). Demonstrating how to bridge Western science and Indigenous knowledge systems for sustainability. Under review by *Regional Environmental Change*

Abu, R., Reed, M.G., and Belcher, K. (submitted 2017). "We are craving for muskrat": Integrating Indigenous Well-being into Cultural Valuation of Ecosystem Services. Under review by *Ecosystem Services*

Abu R., Reed, M.G., (submitted 2017). Adaptation through bricolage: Indigenous responses to long-term social-ecological change in the Saskatchewan River Delta. Under review by *The Canadian Geographer*

The first manuscript (Chapter 2), entitled "Demonstrating How To Bridge Western Science And Indigenous Knowledge Systems For Sustainability," examines the long-term change in the SRD. Using two-eyed seeing – a metaphor proposed by Indigenous (Mi'kmaq) Elder Albert Marshall – this chapter brings together WS and IK for an enhanced understanding of long-term change in the delta. The chapter draws on and evaluates IK, instrumental observations, and archival records to look for synergies, disparities, and knowledge gaps among them. The chapter reveals complementary information across the knowledge sources on topics such as alterations in seasonal flow, shrinking lakes and rivers, the declining muskrat (*Ondatra zibethicus*; *Wācask* in Cree) population, and the migration of moose (*Alces alces*; *Mōswa* in Cree) to southern areas. Disparities, however, were observed between IK and instrumental records on topics such as water quality and spring inundation. Additionally, information on topics such as the duration of berry-growing seasons was found only in one of the knowledge sources, highlighting the need for bringing multiple knowledge systems together for an enhanced understanding. All three knowledge sources were necessary in developing a coherent narrative of long-term social-ecological change in the SRD.

The second manuscript (Chapter 3) is entitled '"We Are Craving For Muskrat': Integrating Indigenous Well-being Into Cultural Valuation Of Ecosystem Services." Based on reported changes in the SRD in Chapter 2, this chapter explores the implications of these changes on local well-being. The chapter brings together cultural valuations and Indigenous conceptualization of well-being to provide a revision to the Millennium Ecosystem Assessment (MA) framework that links ecosystem services (ES) to human well-being. The MA framework has been criticized for being too general, especially its aggregated perspective of humans and their well-being (e.g., Boyd and Banzhaf 2007; Daw et al. 2011). It also does not reveal specific details of how ES translate into personal and societal well-being (Polishchuk and Rauschmayer 2012), yet studies reveal both that different stakeholders make different uses of ES and that people use different ideals to evaluate their well-being (e.g., Snyder et al. 2003; Chan et al. 2012; Bieling 2014). These differences call into question how, in specific contexts, the MA's list of constituents of well-being reflects locally identified well-being constituents (Duraiappah 2011). This chapter, therefore, aims to revise the MA framework to better account for Cumberland House residents' interactions with the SRD, showing how their conceptualization of well-being influences the interpretation of the delta's services and their contributions to well-being. The chapter's findings give rise to a revised assessment framework with a set of well-being constituents specific to Indigenous cultures not previously included in ES frameworks.

The third manuscript (Chapter 4) is entitled "Adaptation Through Bricolage: Indigenous Responses To Long-term Social-ecological Change In The Saskatchewan River Delta." This chapter follows up on local observations of change and impacts and investigates the adaptive capacity of the community of Cumberland House to address these changes. The chapter develops and applies the concept of bricolage to demonstrate *how* local adaptations are constructed. The bricolage concept is novel in revealing "a complex and underappreciated dynamic between human resistance and adaptation to environmental change" (Sayles and Mulrennan 2010:1). The chapter reveals that Cumberland House residents improvise, hybridize, negotiate, and contest existing practices to create different kinds of arrangements for adapting to changes in the delta. The chapter's findings are helpful in dispensing with the perception of Indigenous peoples as "helpless victims of changes beyond their control" (Salick and Ross 2009:137).

In the concluding chapter, I highlight the main lessons learned throughout the study, consider its broader contributions to the body of research, especially work on Indigenous peoples, and suggest some areas for future research.

PREFACE TO CHAPTER 2 – DEMONSTRATING HOW TO BRIDGE WESTERN SCIENCE AND INDIGENOUS KNOWLEDGE SYSTEMS FOR SUSTAINABILITY

Chapter 2 explores the long-term changes in the SRD. It demonstrates a comprehensive understanding of change in the social-ecological system by bridging WS and IK. The chapter draws on two-eyed seeing – a metaphor proposed by Indigenous (Mi'kmaq) Elder Albert Marshall, which suggests seeing together from Indigenous and Western scientific lenses, drawing on the strength of each, to appreciate the differences that each brings for a wider and deeper view to better understand a phenomenon. Using this two-eyed seeing approach, the chapter evaluates three sources of evidence – IK, instrumental observations, and archival records – to search for synergies, disparities, and knowledge gaps. The chapter reveals many areas of corroboration across the knowledge sources but also identifies instances where the knowledge systems differed. All the knowledge sources revealed complementary information on topics such as alteration of seasonal flow, shrinking lakes and rivers, declining muskrat population, and migration of moose to southern areas. Disparities, however, were observed between IK and instrumental records on topics such as water quality and spring inundation. The high level of corroboration increased confidence in understanding, but instances of disparities underscored the need to combine knowledge systems to check the accuracy of the other and promote further exploration. The chapter further revealed areas where information was found only in one or two of the knowledge sources. For example, only IK provided information on the duration of berry-growing seasons. Instances such as this one highlight the need for bringing multiple knowledge systems together for an enhanced understanding of long-term change.

CHAPTER 2 – DEMONSTRATING HOW TO BRIDGE WESTERN SCIENCE AND INDIGENOUS KNOWLEDGE SYSTEMS FOR SUSTAINABILITY

Abstract: Understanding long-term change in complex and dynamic social-ecological systems requires strategies to bridge diverse knowledge systems. Although academics have advocated several approaches for doing so, explanations have been conceptual rather than empirical. By contrast, this paper demonstrates *how* to gain understanding of change in social-ecological systems by bridging WS and IK. Using two-eyed seeing – a metaphor proposed by Indigenous (Mi'kmaq) Elder Albert Marshall – we drew on and assessed IK, instrumental observations and archival records to explain long-term social-ecological change in the Saskatchewan River Delta in northern Canada. We considered the inherent knowledge gaps of each source and searched for synergies and disparities among them. We discovered many areas of corroboration across sources, a few different interpretations, and some instances where a single source was the only one that documented change. All three sources were necessary in developing a coherent narrative of long-term social-ecological change. Our research reveals that two-eyed seeing overcomes the power relations that underpin previous efforts to integrate or incorporate WS and IK. Moreover, when coupled with a commitment to community-based research, two-eyed seeing makes it possible for outsiders to Indigenous communities to use WS and IK in an appropriate way that demonstrates respect for both knowledge traditions.

2.1 Introduction

Understanding long-term change in complex and dynamic social-ecological systems requires strategies to bridge diverse knowledge systems (Brondizio et al. 2016; Lang et al. 2012; Brandt et al. 2013). Much has been written on the contributions of Indigenous knowledge (IK) to understanding environmental change. These writings have raised questions that relate to how and by whom knowledge is created (e.g., Turner and Spalding 2013; Nichols et al. 2004; Reidlinger and Berkes 2001; Turner et al. 2000). Other questions relate to how dominant groups in environmental management have supported existing power relations through the validation of scientific knowledge and epistemologies to the detriment of marginalized peoples (e.g., Nadasdy 2003; Spak 2005; Stevenson 2006). Frequently, those marginalized are Indigenous peoples

whose knowledge systems and pathways are not well understood or recognized by researchers using Western scientific methods. Efforts to address this imbalance initially focused on ways to "incorporate" (Stevenson 1996; Usher 2000; Witt and Hookimaw-Witt 2003) or "integrate" knowledge systems (Raymond et al. 2010). Recently, however, metaphors have shifted towards those of bridging (Rathwell et al. 2015; Aikenhead and Mitchell 2011), weaving (Tengö et al. 2017), and braiding (Kimmerer 2013). In this paper, we prefer to use the term bridging, as it implies the knowledge system fills in the gaps that the other leaves behind, while the integrity of each is maintained.

The distinctions between the old and new metaphors are important. The new metaphors suggest that researchers typically steeped in different knowledge traditions should collaborate with their research participants as partners (Pooley 2013) to maintain the integrity and agency of multiple knowledge holders and ways of knowing – in short, to engage in epistemological pluralism (Miller et al. 2008). Initial attempts to collaborate suggested that IK be evaluated through Western scientific lenses to determine its reliability and credibility (e.g., Nadasdy 2003). However, this strategy has been criticized for being presumptuous, being blind to its own biases, and maintaining the power relations that have supported the dominance of Western science (WS) (see Gilchrist et al. 2005; Brook and McLachlan 2005). Tengö et al.'s (2014:580) alternative is a multiple evidence-based (MEB) approach in which "indigenous, local, and scientific knowledge systems are viewed to generate different manifestations of valid and useful knowledge," thus contributing to an enriched understanding that includes the identification of complementarities, synergies, and contradictions. Others have suggested direct knowledge co-production, where knowledge is generated, exchanged, and validated through collective research practices (Dale and Armitage 2011).

Despite multiple examples of "methods and processes" (Rathwell et al. 2015), empirical examples showing how to undertake and support epistemological pluralism are sparse. Indeed, Rathwell et al. (2015) describe only a handful of conceptual articles, after which they conclude that empirical examples are necessary. Tengö et al.'s (2014) proposal for MEB is also conceptual; Tengö and others have since teamed up to provide one example at the policy level (Tengö et al. 2017). Similarly, Zanotti and Palomino-Schalscha (2015) indicate a need to recognize the plural co-existence of knowledge but do not illustrate a clear pathway for doing so. Hence, as Kealiikanakaoleohaililani and Giardina (2016) emphasize, processes, methods,

curricula, and demonstrations of practical use of multiple knowledge systems together need to be supported, expanded, and documented. In this context, then, we seek to provide an empirical example to explain the following "how" questions:

a. How can we learn about long-term social-ecological change from diverse knowledge sources?
b. How can we provide for the plural co-existence of knowledge while engaging in its respectful critique?
c. How can we know the relative contribution or evidence that each knowledge system provides and how each helps to fill in the gaps that the other leaves behind?

This paper, thus, contributes to the sparse empirical examples of *how* to successfully bridge diverse knowledge systems. We operationalize epistemological pluralism by using "two-eyed seeing" (described below), an approach we suggest offers a practical and appropriate framework for bringing IK and WS together by drawing on the strength of each. We demonstrate this two-eyed seeing to understand long-term social-ecological change in the SRD in northern Canada and its impacts on the Indigenous peoples of the principal community of Cumberland House. The SRD is a complex area of over two centuries of interactions and feedback among people, wildlife, and water (Bicentennial Committee of Cumberland House 1974). The area has been disturbed by many external forces such as upstream dams, resulting in significant changes in the delta's natural flow regime.

We begin by describing various approaches to bridging knowledge systems offered by academic scholars and Canadian Indigenous leaders. Next, we describe the study site, research methods, and data sources, before systematically documenting changes in hydrology, fish and wildlife, and vegetation according to three types of data. We then discuss the relative contributions of each of the knowledge sources. Finally, we reflect on the implications of our approach for future studies of social-ecological systems.

2.2 Approaches for Bridging Knowledge Systems

The rejection of earlier approaches of knowledge incorporation or integration has coincided with researchers advocating for approaches that can make different knowledge

systems interact while respecting the integrity of each and maintaining the opportunities for them to enrich one another. Miller et al.'s (2008) epistemological pluralism approach recognizes and accommodates the plurality of multiple valuable ways of knowing in any given research context. The authors note three metaphors of knowledge – mechanistic, contingent, and narrative – that may be present in a given research project. Similarly, Zanotti and Palomino-Schalscha (2016) emphasize the concept of plural co-existence as a model for cross-cultural research that acknowledges and respects both Indigenous and Western science perspectives. They propose this model for non-Indigenous academics working at the interface of Indigenous and non-Indigenous knowledge, but they do not clearly show the pathway for adopting the model.

Alternatively, Tengö et al. (2014) have developed a multiple evidence base (MEB) approach, which presents multiple knowledge systems as parallels that, through complementarities, provide different valid and useful insights for an enhanced understanding. The authors suggest that, in this approach, evidence from multiple sources are positioned beside each other on a common issue, enabling triangulation of information across the knowledge systems. Although Tengö et al. (2014) suggest MEB brings knowledge systems together through collective process in an equal and transparent manner, how to empirically use this model has yet to be fully determined. In another strand of thinking, Rathwell et al. (2015) present four types of setting – the epistemological arena, methods and processes, brokerage mechanisms, and governance/institutional arrangements – that can facilitate the bridging of knowledge systems. Although the authors provide clarity on specific settings and opportunities in which knowledge bridging might occur, whether these settings function independently or in synergy is yet to be illustrated with empirical cases. Thus, while academics have advocated several approaches for bridging diverse knowledge systems, thus far, no one has tested these approaches empirically.

Indigenous leaders in Canada have offered parallel approaches – the two-row Wampum belt and two-eyed seeing – that provide a suggestion for *how* to bring together knowledge systems. The Wampum belt is a beaded Indigenous belt of the Iroquois people that represents a treaty between European and original peoples in North America. The belt has a two-row pattern that describes a friendly relationship between Dutch vessels and Iroquois canoes traveling side by side on separate paths and assisting one another but not interfering with each other (Doubleday 1993; Stevenson 2006). The metaphor drawn from the belt's imagery has been taken up by academic researchers to symbolize WS and IK moving in parallel and enriching one

another while respecting and maintaining the integrity of each (see Berkes 2012; Rathwell et al. 2015). More recently, Mi'kmaq Elder Albert Marshall proposed two-eyed seeing as a metaphor that suggests seeing together from Indigenous and Western scientific lenses, drawing on the strength of each, to appreciate the differences that each brings for a wider and deeper view to better understand a phenomenon (see Hatcher et al. 2009; Bartlett et al. 2012).

Both the two-row Wampum and two-eyed seeing suggest that WS and IK are parallel and complementary sources of knowledge. In this paper, we show how a two-eyed seeing approach brings us closer to an enhanced understanding of long-term change in a social-ecological system. This approach considers the two knowledge systems equally and avoids the situation in which one dominates or undermines the contributions of the other (Bartlett et al. 2012). Two-eyed seeing recognizes, however, that in a particular set of circumstances, one may have greater analytical purchase and is, therefore, more called upon than the other, but as circumstances change the relative merits can easily switch (Hatcher et al. 2009; Bartlett et al. 2012). Hence, this approach provides for a continuous weaving back and forth between the two knowledge systems. Two-eyed seeing stresses the partiality and limitations that accompany seeing the world through one eye only, and the importance of appreciating the differences that each eye can offer when both eyes are used together (Martin 2012). In other words, seeing with two eyes, and not one, provides a means for one to assist the other in gaining a wider and deeper view that might help us to better understand – a result that could not emerge if we looked through one eye only (Iwama et al. 2009; Martin 2012).

To demonstrate how to engage in two-eyed seeing and to better understand long-term social-ecological change in the SRD, this paper draws on and evaluates three sources of evidence – IK, instrumental observations, and archival records. Using these sources, we search for synergies, disparities, and knowledge gaps. Consistent with Rathwell et al.'s (2015) typology, the setting for our knowledge bridging activity is the epistemological arena, demonstrating how two different ways of seeing the world – from Indigenous and Western scientific perspectives – can empirically be brought together for better understanding of a social-ecological system. We also show how bundled "methods and processes" have facilitated bridging of knowledge systems within our project, supporting the argument that the settings for knowledge-system bridging are not mutually exclusive.

2.3 Materials and Methods

2.3.1 Inland deltas

There are three large freshwater deltas in Western Canada: the Peace-Athabasca, Slave, and Saskatchewan. All these deltas lie downstream from hydropower dams that have altered their hydrology over the past 50 years. Yet there is considerable uncertainty and debate about how these changes may or may not propagate to other elements of these social-ecological systems (Timoney 2002; Brock et al. 2010; Beltaos 2014). Given the unknown extent and magnitude of social-ecological change stemming from these developments in hydrology, we used changes in the SRD, as revealed by our two-eyed seeing approach, as representatives of changes in other freshwater deltas in the region (Timoney 2013; Mantyka-Pringle et al. 2017).

The SRD is located in the central lowlands of Canada and straddles the border of the provinces of Saskatchewan and Manitoba (Fig. 2.1). The SRD is the largest freshwater delta in North America, covering an area of about 10,000 km^2 (Smith et al. 1998). A complex area of wetlands with active and abandoned channels, the delta contains diverse and abundant plant, fish, and wildlife species (Kew 1962; Bicentennial Committee of Cumberland House 1974). The Cumberland Marshes in the delta are internationally designated as an important bird area (Schmutz 2001). Three large dams potentially impact the delta: the E. B. Campbell dam (formerly Squaw Rapids dam) (constructed in 1963 and forming Tobin Lake reservoir), the Gardiner dam (constructed in1967 and forming Lake Diefenbaker), and the Nipawin Hydro dam (constructed in 1985 and forming Codette Lake). The most immediate upstream dam (the E. B. Campbell dam) operates as a peaking facility, meaning water is held and released as needed for electricity generation.

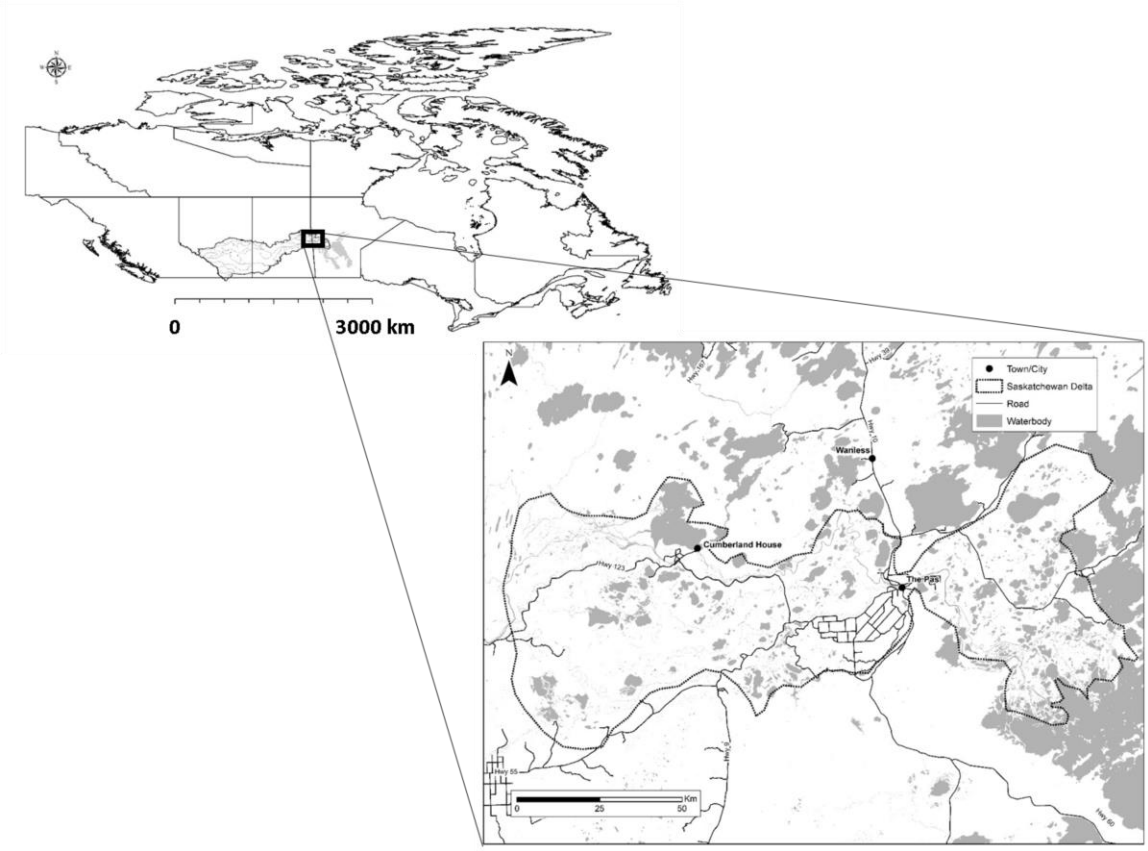

Figure 2.1: The Saskatchewan River Delta in central Canada

2.3.2 Cumberland House

Cumberland House is the oldest community in Saskatchewan, established in 1774 as a fur trading post by the Hudson's Bay Company (HBC) (Kew 1962; Bicentennial Committee of Cumberland House 1974). The community has a growing Indigenous population of Métis – people with mixed North American "Indian" and European ancestry – and status (Treaty No. 5) "Indians" or First Nations, who are descendants of Swampy Cree people (Waldram 1989). Today, Cumberland House is made up of two politically and municipally distinct settlements: the Northern Village of Cumberland House (NVCH) – a municipal entity of the province of Saskatchewan – and Cumberland House Cree Nation (CHCN) – an "Indian" Reserve. An elected Band Council politically represents the reserve population, whereas a local community authority represents the Métis and non-status residents (Waldram 1989). Although the two communities are separated politically, they are integrated socially (Waldram 1989).

2.3.3 A model of community-based and archival research

This study was conducted as part of a larger collaborative project between the community of Cumberland House and an interdisciplinary research team from the University of Saskatchewan seeking to understand the links between changing conditions for water, wildlife, and people in the SRD. Over several meetings, the community helped design the study to ensure it reflected local priorities and perspectives while also allowing for data gathering through archived documents, instrumental observations, oral history, and semi-structured interviews. The lead author carried out oral history interviews with Elders and semi-structured interviews with active harvesters. In the oral history interviews, the Elders provided first-hand knowledge about key historical events, especially in the pre-dam era, which might not have been documented in historical records. Our discussions with active harvesters – fishers, hunters, trappers, and plant harvesters – revolved around changes they had observed in the delta and their perceptions of impacts of such changes on their land-based activities. The interviews were carried out over eight months from February to September 2014, during which time the lead author lived and participated in the community and observed the local context. He spent almost two months in the community before commencing interviews and met with many people, including interviewees, more than once. Forty-two persons (both males and females) were interviewed, all but one of whom were of Indigenous ancestry and all of whom had lived in Cumberland House for most of their lives.

Data from the SAB provided harvest records, long-term flows and water level data, fish and wildlife surveys, and pre- and post-dam biophysical and sociological studies about hydro-ecological change and resource use patterns. We also obtained past files from the Ministry of Environment, containing information on harvesting permits and quotas, open seasons for harvest, payment for furs, water regulations, as well as petitions and letters of concern about the impacts of the E. B. Campbell dam sent by local authorities in Cumberland House. We refer to archival information as qualitative or quantitative, depending on whether the information is in words or figures.

All the interviews were audiotaped, transcribed, and, together with field notes, coded and analyzed by theme using NVivo 10, a qualitative analysis software program. Descriptive codes emerged from the interviews; analytic codes were derived from the framework of the study. An analysis of historical documents compared historical information with local narratives, so as to

identify similarities and to fill gaps. Community observations or IK are those narratives that were shared in interviews or informal meetings with the lead author during his stay in the community. We have omitted those statements that were not cross-validated by multiple participants, not because they lack credibility but because, in principle, the IK of a community includes observations of phenomena that others have also experienced.

For instrumental and archival quantitative data, we examined change through time. A Water Survey of Canada gauge (Saskatchewan River at The Pas, 05KJ001) was used to reconstruct daily flows between 1913 and 2015, and a second gauge (Saskatchewan River below Tobin Lake, 05KD003) was used to examine water-level fluctuations emerging from the reservoir (Tobin Lake), which is immediately upstream of the SRD. Fur harvest records were obtained from the Government of Saskatchewan, using two fur blocks located in the SRD (N28 and N90, the latter which has also been referred to as 'Delta'). These records date back to 1947. Fish landing data were obtained from Saskatchewan's Commercial Fish Information System for an area defined as Cumberland Lake and the Saskatchewan River, from a longitude of 103 10' W to the Manitoba border. This area effectively represents the western half of the SRD, and the area in which Cumberland House residents fish regularly.

2.3.4 Comparing IK with scientific (instrumental and archival) records

Our results are organized under three main themes – hydrological change, fish and wildlife change, and vegetation change, all of which directly affect the livelihoods of Cumberland House residents. We compared the IK of Cumberland House with scientific (instrumental and archival) records in four categories under different socio-biophysical themes (c.f. Jackson et al. 2014): "consistent (+)," where IK and science corroborate each other or where each adds new knowledge or expands on information from the other; "inconsistent (–)", where IK and science differ or disagree or where each says different things about a particular phenomenon; "no science knowledge (O)," where there was IK but no science; and "no IK (Ø)," where there was science but no IK.

2.4 Results

2.4.1. Hydrological changes

Our data showed that daily and hourly fluctuations of flows below Tobin Lake reservoir have changed significantly from pre-dam figures. The IK of Cumberland House was consistent with, extended, or complemented archival records and instrumental observations of this change (Table 2.1; Table A.1 in Appendix A). A report by the Committee on Saskatchewan River Delta Problems (1972) indicated that, since the E. B. Campbell hydro-generating station had been used for peaking power, releases from Tobin reservoir in the winter months resulted in higher hourly fluctuations than under natural conditions. A comparison with the Water Survey of Canada gauge (05KD003) showed daily discharges in 2014 fluctuated as much as 260 to 1140 m^3/s in a single day. Cumberland House residents corroborated these fluctuations, reporting that, during spring and fall, they might be in about three feet (0.9 meters) of water when out in the wilderness pursuing their traditional activities, but by the end of the day they might only have a foot of water in which to travel back home.

Table 2.1: Scientific (archival and instrumental) records and community observations of hydrological changes in the Saskatchewan River Delta

Hydrological change	IK from field interviews	Archival records		Instrumental observations
		Qualitative	Quantitative	
Daily and hourly fluctuations and unpredictable water levels	+	+	+	+
Lakes and rivers are getting shallower, shrinking, and drying out	+	+		+
No occurrence of ice jam; less deep ice breaks	O			
Avulsion in 1870s		Ø		
Low water during dam construction†	+	+		
Less water in the delta; freezes to the bottom†	+	+		
More silt has filled lake bottoms†	+	+		
Five fishing lakes are no more	O			
Altered seasonal flow; low in summer, high in winter	+	+		+
Less spring inundation	–	–		–
2005, 2011, and 2013 floods replenished the delta†	O			
No natural occurrence of flows and floods; recent floods are not natural	+	+		
Cumberland Lake is far now, no longer visible to the community	+	+		
Cumberland Lake is shrinking, less deep	+	+	+	+
Depletion of oxygen†	+	+		+
Higher oxygen level in Cut Beaver, Waspisew and Redearth Lakes in winter†		Ø		
Exposed sandbars†	+		+	
Ice no longer floats†	+	+		
Sunlight gets to lake bottom†	O			
Water in the marsh is stagnant, not fresh, and stinks†	+	+		+
Water is dirty, polluted, and unsafe for drinking	–		–	–

†See Table A.1 in Appendix A for detailed information

Categories are: consistent (+) when IK and science corroborate or when each added new knowledge or expanded the information of the other; inconsistent (–) when IK and science differ/disagree or when each say different thing about a particular phenomenon; no science knowledge (O) when there was IK but no science; no IK (Ø) when there was science but no IK. The full table is given in Table A.1 in Appendix A.

IK, archival records, and instrumental observations also collectively showed that many lakes and rivers have shrunk and become shallower because less water is entering the delta. A study by Sagin et al. (2015) using hydrometric gauge data and remote sensing indicated a reduction in average summer flooded areas from 13% to 6% between 1913 and 2013. Local residents mentioned that they could still see outlines of where some lakes used to be. A very important observation was the reduction in the width and depth of Cumberland Lake, the largest

lake in the delta. The lake, which used to be close and visible to the community, is now about three miles (4.8 km) farther away. It has also decreased from an average depth of 20 feet (six meters) to an average less than six feet (1.8 meters). Before 2011, the maximum daily water level of the lake in a given year was declining, but high water years in 2011, 2013, and 2014 have reversed this trend (Figure B.1 in Appendix B).

We found that the operation of upstream dams also altered the seasonal flow and flood regimes of the delta. IK was consistent with, extended, or complemented archival records and instrumental observations of this change (Table 2.1). Many reports, including Godwin (1968), the Committee on Saskatchewan River Delta Problems (1972), Iverson (1977), and Waldram (1989), indicated that under natural conditions, flows and floods were high in the summer and low in the winter. Summer flows, however, have been stored at Lake Diefenbaker and Tobin reservoir and are released during winter to meet peak power demands, resulting in decreased summer flows and increased winter flows. The gauge at The Pas showed reduced summer flows and elevated winter flows in the post-dam era (Figure B.2 in Appendix B). Observations made by Cumberland House residents also indicated a reversal of natural flows. Residents now experience high water in January and low water in June and July, as opposed to in the past when they would normally have spring and summer floods and low water in January.

The IK of Cumberland House and archival (qualitative) records indicated that there has been less spring inundation in the post-dam era. However, we found information from instrumental records that differed from IK and archival records in this respect (Table 2.1). Local residents mentioned that deep ice breaks and ice jams during springtime in the pre-dam era had caused water to flood the delta and fill the creeks and river channels. In the post-dam era, however, as a result of holding back spring runoff, residents said they now observed more shallow ice-breaks and limited ice jamming and, thus, less spring inundation. Reports by the Committee on Saskatchewan River Delta Problems (1972), Iverson (1977), and Waldram (1989) indicated that spring flooding was more frequent in the past. Instrumental observations partially concur, showing that spring flow peaks occur at a similar time (~day 120, late April) but average ~1000 m^3/s compared with ~1300 m^3/s in the pre-dam era. This means that spring snowmelt peaks have not been reduced to the same extent as summer peaks, which have been cut from an average of ~1500 m^3/s in the pre-dam era to ~800 m^3/s in the post-dam era.

The IK of Cumberland and archival (qualitative) records also indicated that floods no longer occur naturally because current floods in the delta are unnatural. Since this type of change is difficult to quantify, no instrumental observation was available (Table 2.1). We heard many times from local residents that the days are gone when sediment-carrying rivers overflowed their banks and replenished the delta. Their observations in the post-dam era showed that water only goes overland when a large amount is released from the E. B. Campbell Dam.

Local residents spoke about a reduction in the quality of water in the delta. Prior to the dam construction, residents collected drinking water from the delta. They mentioned that the water used to be a clear, light green colour and was safe for drinking. However, since the dam's construction, the residents said they have observed the water in the delta to be muddy and a brownish colour, making it "scary and unsafe for drinking." Water quality data from the 1970s to the present, however, consistently show that nutrients and pesticides in the water are extremely low and are often undetectable (data not shown).

2.4.2 Fish and wildlife changes

A common feature in all three of our data sources is that the populations of all species of wildlife and some species of fish have generally declined since the dams were built (Table 2.2; Table A.2 in Appendix A). A pre-dam study conducted by Kew (1962) in 1960 described the delta as rich in wildlife and furbearing animals, particularly moose (*Ondatra zibethicus*; *Wācask* in Cree) and muskrats (*Ondatra zibethicus*; *Wācask* in Cree) and the swamps and lakes as providing the best nesting and feeding areas for many species of waterfowl, as well as spawning areas for sturgeon (*Acipenser fulvescens*; *Naméw* in Cree) and goldeye (*Hiodon alosoides*; *Wípicísis* in Cree). However, many reports completed in the late 1960s and 1970s, including Dirschl et al. (1967), Committee on Saskatchewan River Delta Problems (1972), The Lower Saskatchewan Basin Task Force (1979), and files in the SAB (S-DNS1 I.A.368) indicated that the delta's productive fish and wildlife community had declined since the 1960s. Cumberland House residents talked about the high numbers of almost every species in the delta in the days before the dams. Today, however, local observations showed that there has been a multi-decadal decline in wildlife populations, sturgeon has been declared a species of special concern, and there is no longer any fishing for goldeye.

Table 2.2: Scientific (archival and instrumental) records and community observations of fish and wildlife change in the Saskatchewan River Delta

Fish and wildlife change	IK from field interviews	Archival records		Instrumental observations
		Qualitative	Quantitative	
No muskrats	+		+	+
Meat tastes different†	+	+		
Fish are contaminated with mercury†	+	+		+
Muskrats and beavers freeze to death†	+	+		
More suckers; lots of pikes	–	–		–
Sturgeon is endangered; production declined after 1973	+	+	+	+
Declining habitats, less hospitable and less accommodating	+	+		
Declining moose population	+		+	+
Decline in waterfowl nesting in the western portion of the delta		Ø		Ø
Whitefish in Cumberland Lake is no more grade "A"	O			
Geese and ducks leave early now	O			
No more fishing in the Old Channel	+	+		
Waterfowl nest and rest in Tobin Lake reservoir†		Ø		
Most productive area was the Old Channel			Ø	
Fall spawning is disturbed†	O			
Non-native birds are nesting†	O			
Demise of goldeye fishery	+		+	+
Moose are moving down south	+	+		+
Disrupted fish migration; fish get trapped at the dam during floods†	+	+		
More fish in Tobin Lake; excellent for sport fishing†	+	+		
Smaller deer antlers†	O			
Change in fish taste†	+	+		
Beavers are thriving†	+		+	
The three floods [in 2005, 2011 and 2013] affected non-aquatic animals†	O			
Wildlife are slowly coming into the community†	O			
Few swans and less geese	O			
Deformed fish are being caught†	O			

†See Table A.2 in Appendix A for detailed information

Categories are as in Table 2.1. The full table is given in Table A.2 in Appendix A.

IK was consistent with archival (qualitative) records in indicating that habitat requirements of wildlife are not being met, resulting in habitats that are less hospitable and less accommodating. There was no instrumental observation on this habitat change (Table 2.2). Instrumental observation, however, complemented IK and archival records on the limited muskrat production (Table 2.2). Local residents said that whereas in the pre-dam era they could harvest 100-150 muskrats a day in the springtime, "there're no muskrats now." Many trappers have not seen muskrats in their trap-lines for over three years. Archival (quantitative) and

instrumental observations provided that the muskrat harvest in N28 and N90 Fur Blocks have declined to less than 100 per year from historical highs of >10,000 per year (Figure B.3A in Appendix B).

IK was also consistent with, extended, or complemented archival (quantitative) and instrumental observations on a declining moose population (Table 2.2). Archival and instrumental records show that delta moose densities declined from an average of $2/m^2$ ($5.17/km^2$) in the 1960s (Dirschl et al. 1967) to $0.08/m^2$ ($0.21/km^2$) in 2004 (Wilson and Kowal 2004). Cumberland House residents revealed that it is harder for them to see moose now than in the past when they used to see many moose everywhere in the delta. Our knowledge sources corroborated these observations, indicating that, as a result of declining habitats, moose are moving away from the delta area to the southern areas of the province. In 2014, of 45 Wildlife Management Zones (WMZs) across the province, the success rate of moose hunters in WMZs 60 and 61 (the delta areas) were the third lowest (26%) and lowest (17%), respectively.

One area in which we found IK to fill in information gaps in archival and instrumental records was the category of whitefish (*Coregonus clupeaformis*; *Atíkamég* in Cree) caught in Cumberland Lake. In 1960, Kew (1962) noted that the whitefish caught mainly in Cumberland Lake were classed as "A" fish, meaning they were free of the fish parasite *Triaenophorus crassus*. However, local residents told us that whitefish in the lake were no longer classed as "A" fish. Instead, whitefish in nearby Suggi Lake (outside of the SRD) were classed as "A" fish, and Cumberland House residents go to Suggi Lake to commercial fish for whitefish. No archival and instrumental observations were available to corroborate this change.

IK was consistent with archival (qualitative) records regarding the production of northern pike (*Esox lucius*; *Wícégãpís* in Cree) and sucker (*Catostomus commersoni*; *Namépin* in Cree). However, we found that information from instrumental observation differs from or disagrees with IK and archival records in this respect (Table 2.2). Observations made by Cumberland House residents showed that "when the water goes down that's when [suckers] lay eggs," and "there is always that northern pike where you can't get rid of." Waldram's (1989) study reported that, while other fish species have declined, suckers and pike have thrived in the deteriorating water conditions. However, instrumental records showed that the pike commercial harvest has declined to near zero (Fig. B.4B in Appendix B).

Local residents reported that geese (*Branta canadensis*; *Niska* in Cree) and ducks leave the delta earlier now than before. Although there was IK about this change, neither archival records nor instrumental observations existed (Table 2.2). Local observations showed that geese stayed till November, but now they leave by October 15. Residents indicated this change as a significant loss to their livelihoods.

Another area in which IK filled in the gaps of archival and instrumental records was fishing in the Old Channel. Reports in the 1960s (e.g., Reed 1962; Brown and Werner 1969) indicated that the most diversified fish faunas were found in the water bodies that had direct access to the Old Channel. However, Cumberland House residents said that they could no longer fish in the Old Channel as "that river dried up now." After Reed's (1962) and Brown and Werner's (1969) studies, we did not find any studies on fishing in the Old Channel that indicate low production. Regarding flows in the Old Channel, instrumental observations showed that flows from E. B. Campbell of 850 m^3/s correspond to only 65 m^3/s entering the Old Channel (Saskatchewan Water Security Agency 2003).

2.4.3 Vegetation changes

Our data sources indicated that, to a varying degree, the vegetation types have been affected by changes in the flood regimes of the delta. Reduced summer floods in the post-dam era have affected the marshy vegetation, particularly increasing vegetation growth on the lakes' shorelines due to low water levels in the lakes. All three data sources complemented or extended each other on this change (Table 2.3; Table A.3 in Appendix A). Local observations showed that the dams have lowered the level of the lakes, allowing new vegetation to gain hold of the exposed lake beds. Instrumental observations based on aerial photos showed about a 22% reduction in the Cumberland Lake area between 1957 and 2002 (N. Smith, unpublished data). The result, as indicated by Willard et al. (1978) and Waldram (1989), is the establishment and encroachment of willow communities in the extensive shore and delta regions. Wilson and Kowal (2004:10) described the delta like this: "The delta is in a state of succession from marsh to more terrestrial-like features."

Table 2.3: Scientific (archival and instrumental) records and community observations of vegetation changes in the Saskatchewan River Delta

Vegetation change	IK from field interviews	Archival records		Instrumental observations
		Qualitative	Quantitative	
More vegetation growth on lake shorelines	+	+		+
No burning in the past 20 years	+	+		
Overgrowth of emergent aquatic vegetation	+	+		
Changes in berries seasons	O			
Fewer gooseberries and chokecherries	O			
Blackberries are disappearing	O			
Fewer chestnuts	O			
Tiger lilies are disappearing†	O			
More dead willows and grass†	O			

†See Table A.3 in Appendix A for detailed information

Categories are as in Table 2.1. The full table is given in Table A.3 in Appendix A.

Aside from reduced water levels, the suppression of burning was provided as a reason for vegetation overgrowth in the delta. We found IK to be consistent with archival records in this respect, but no instrumental observations were available. Local residents indicated that the traditional practice of controlled burning on their trap-lines allowed fresh vegetation growth. Both IK and archival records (e.g., Wilson and Kowal 2004) indicated that the provincial policy of wildfire suppression allowed vegetation to mature and contributed to the drying up of the delta.

Another area in which we found IK to be consistent with archival records was the overgrowth of emergent aquatic vegetation. Again, there was no instrumental observation available on this change (Table 2.3). A study by Royer (1966) provided that emergent aquatic vegetation such as phragmites and bulrush had begun to form an almost solid stand of vegetation and had become so profuse in some lakes as to make boat travel almost impossible. Residents corroborated this finding, suggesting that, in the past, "You could move in the river with motors, but now the vegetation is growing in the river [making it] difficult to travel."

IK provided information about berries; however, no archival records or instrumental observations were available. Regarding berry seasons, local residents recalled that in one summer, "We were picking Saskatoons [(*Amelanchier alnifolia*; *Sâskatômina* in Cree)] in July instead of June. And then we were picking raspberries (*Rubus idaeus*; *Âyôskana* in Cree) in August [instead of mid-July]. And even strawberries (*Fragaria virginiana*; *otamen* in Cree), one time, we were picking them late." Residents indicated that there used to be lots of gooseberries

(*Ribes uva-crispa*; *Sâpômina* in Cree) and chokecherries (*Prunus virginiana*; *Takwahimina* in Cree) in the delta, but they do not see many of them now. They also mentioned that they have not found blackberries (*Rubus spp.*) for many years, and they do not see very many chestnuts (*Castanea dentata*) in the delta anymore. The connection of these changes to the hydrology of the delta remains unknown.

2.5 Discussion

Our two-eyed seeing approach found many areas of corroboration among our diverse knowledge sources. For instance, complementary information on topics such as alteration of seasonal flow, fluctuating water levels, shrinking lakes and rivers, declining whitefish, sturgeon, and muskrat populations, and migration of moose to southern areas was available from IK, archival records, and instrumental observations. IK and archival (qualitative) records provided qualitative information on these topics, and instrumental and archival (quantitative) records complemented or expanded the qualitative information with measured trends and specific figures as well as explanations of "physical or biological causes of a particular trend" (Ignatowski and Rosales 2013:296). For example, whereas residents told us that lakes are becoming smaller and that they can see the original outline of lakes, hydrometric gauges and remote sensing gave measured trends by indicating a reduction in the average summer flooded area from 13% to 6% between 1913 and 2013 (Sagin et al. 2015). Similar to Jackson et al. (2014) and Service et al. (2014), this high level of corroboration increases confidence in our understanding of environmental and ecological phenomena.

While disparities amongst information sources were rare, there were instances where the knowledge systems differed. In these cases, we consider each as "checking" the accuracy of the other and promoting further exploration. For example, disparities in water quality observations between IK and instrumental records highlight the need for continued data collection and discussion (Mantyka-Pringle et al. 2017). Likewise, whereas IK and archival (qualitative) records indicated that northern pike are thriving in the deteriorating water conditions, information from instrumental records showed that the pike commercial harvest has declined to near zero. This decline may, however, simply be due to a lack of commercial fishing effort

directed at this species. In both of these cases, we see potential limitations in the accuracy of the instrumental record as well as the IK and archival (qualitative) records.

On topics where information was found only in one or two of the knowledge sources, we considered these sources as filling in the gaps that the other left behind. Our clearest example was IK holders' descriptions of changes in the duration of berry-growing seasons, as well as in growth patterns of some flowering and berry plants, which were not as abundant as they had been. No such knowledge appears in archival and instrumental records. In this case, IK fills an important information gap in archival and instrumental records. Instances such as this one highlight the need for bringing multiple knowledge systems together for an enhanced understanding of long-term change.

The IK of Cumberland House and archival (qualitative) records further reveal the local impacts of change, which instrumental observations do not detect and which carry our observations further into the realm of socio-hydrology and social-ecological systems. Changes in reduced outfitting opportunities and alterations of travel routes, among others, are concerns that will not appear in instrumental records. IK, however, includes these local effects alongside observations of physical change (Ignatowski and Rosales 2013). Hence, bringing IK together with instrumental observation provides evidence of the social impacts of hydro-ecological change. Where archival records revealed social impacts, their methodologies included IK and in-depth interviews of ethnographers (Ignatowski and Rosales 2013). This is the case especially with Waldram's (1989) work, which employed a qualitative, ethnographic approach and highlighted change between 1963 and 1984. This qualitative approach explains why most of the archival information is consistent with local observations from our field interviews. Much additional change, however, has occurred in the thirty years since Waldram's work.

Another advantage of embracing IK is ensuring that information is recorded at sites and times that are representative of areas used by local residents. In such a complex hydro-ecological system, many water level gauges in the delta are sited in areas that residents do not use for their traditional activities. For instance, and as Waldram (1989) noted, the location of the water level gauge that measures Cumberland Lake level is actually on the Bigstone River, not Cumberland Lake; hence, the extent to which it accurately reflects the level of the lake and its associated wetlands is questionable. Moreover, the Bigstone River is used only for travel to resource areas further upstream, and so the levels read by this gauge do not necessarily reflect levels

downstream in areas used by residents for their traditional activities. IK knowledge holders can provide information on actual sites used by the community and, thus, report accurate impacts of change. In addition to this spatial dimension, there is also a temporal component. The archival lake gauge records report daily water levels, but IK knowledge holders report hourly water level changes. Therefore, an interpretation of impacts through the gauge records alone might not be able to fully describe water level fluctuations. IK, together with measurements from this gauge, can reveal the real experience of water level changes in Cumberland Lake.

IK also provides evidence of the deeper meanings of environmental change, which leads to long-term cultural change and adaptation. For instance, a report by the Committee on Saskatchewan River Delta Problems (1972) stated that on a monthly basis the regulation of Tobin Lake had only a minor effect on the level of Cumberland Lake, the maximum effect being a lowering of the lake by up to half a foot in June and July. Local interpretation, however, indicated that a water drop or rise of half a foot has serious repercussions on resource use and, therefore, constitutes much more than a "minor effect," as stated by the Committee (Waldram 1989). Archival (quantitative) and instrumental observations do not generate specific information on the meaning of change, such as the inability to pursue traditional activities and less harvesting of wild food. Yet evidence of the meaning of change is important for effective adaptation planning (Ignatowski and Rosales 2013). The IK of Cumberland House shows that residents have already adapted to changes in the delta. These adaptations include travelling longer distances to southern communities to hunt for moose (*Alces alces*; *Mōswa* in Cree) and buying from the store to supplement the reductions in traditional foods.

The temporal gaps in archival and instrumental observations limit understanding of long-term change from these knowledge systems alone. In some cases, inconsistencies between IK and instrumental or archival records appear to have arisen simply from temporal gaps. For example, the earlier classification of Cumberland Lake whitefish as "A" fish (Kew 1962) was clearly out of date. Now only whitefish from Suggi Lake obtain this designation, and fishers from Cumberland House travel to this lake to commercially fish for this species. We would not have observed this change with archival or instrumental records alone. In other cases, limited ongoing monitoring or follow-up studies create gaps in data records. Studies like Waldram's (1989) have not been replicated, so there is no record of impacts and adaptations over the last

three decades. Embracing IK thus enables a more temporally detailed account (Service et al. 2014) than archival and instrumental records alone can provide.

IK, however, is limited in providing information about specific levels of change and drivers of change; such information is well generated through archival (quantitative) and instrumental observations. For example, while IK holders could only report that the Old Channel is drying up, instrumental and archival (quantitative) records showed that flows from E. B. Campbell dam of 850 m^3/s correspond to only 65 m^3/s entering the Old Channel (Saskatchewan Water Security Agency 2003). This specific information may be useful for predicting future flows to the Old Channel under different water release scenarios.

2.6 Conclusion

In this paper, we demonstrated one approach for undertaking epistemological pluralism. Using the metaphor of two-eyed seeing, we drew from three different knowledge sources – IK, archival records, and instrumental observations – to derive a comprehensive understanding of long-term change in a complex social-ecological system. These different knowledge sources were found to have inherent strengths and limitations: archival records provided historical accounts of change but were fragmented and partial; instrumental observations offered specific figures and measured trends necessary to establish patterns of change but did not attach meaning to change; IK provided generational observations of change and attached meaning to change but was unable to convey specific levels of change and identify drivers of change. Together, however, the strengths of each were drawn upon to overcome the limitations of others.

Furthermore, each of the data sources provided information at certain spatial and temporal scales, and our effort at combining them has demonstrated the complementary nature of the different knowledge systems. For instance, instrumental observation from the hydrometric gauge (Saskatchewan River at The Pas, 05KJ001) provided data on a relatively longer temporal scale (between 1913 and 2015), but these measurements were made at one point in space; hence, the data were spatially limited. Likewise, whereas archival quantitative data from fur harvest records (dating back to 1947) provided a relatively short historical record, archival qualitative information from publications, government files, and previous studies provided more historical depth. However, these archival sources were isolated records, which were, thus, spatially limited.

On the other hand, through historical recall, oral tradition, and living memory, IK provided information that spanned from the present to the past, demonstrating a longer temporal scale. Information from IK also applied to the whole upper delta (N28 and N90 Fur Blocks). Thus, given the context of the study, IK covered a relatively wider spatial scale than other sources. By combining these multiple sources, therefore, this paper has contributed to demonstrating how different knowledge systems work together to form a coherent narrative of long-term social-ecological change.

We argue that two-eyed seeing provides a more accurate description of long-term change than any single knowledge system could do alone and overcomes the power relations that underpin previous interpretations of WS and IK as incorporation and integration. Additionally, when coupled with a commitment to community-based research, two-eyed seeing makes it possible for outsiders – those who are not from Indigenous communities – to use WS and IK in appropriate ways that demonstrate respect for both knowledge traditions. Thus, a "working partnership" (as described by Pooley 2013:1483) between WS and IK rather than integration will help both to avoid subsuming one knowledge to the other and to concentrate the understanding rather than diluting it. We acknowledge, however, that the existing power dynamics may still limit the update of IK.

In conclusion, we make three key observations. First, our approach to epistemological pluralism revealed that it is not possible, even if it were desirable, to judge data records using singular criteria. This kind of evaluation is unworkable because even within certain types of data sources, research traditions and expectations are different or might have changed. For example, those who provided oral history for earlier government work in the delta might not have shared the lead authors' commitment to community-based research. As well, instrumentation accuracy and protocols for use may change over time. Since we are dealing with long-term change, we have appropriately drawn on data sources collected at different times and spanning different time frames. Our approach is, thus, useful because of the way we evaluated the data sources and then searched for complementarities, consistencies, and contradictions.

Second, we recognize that Indigenous peoples are also engaged in two-eyed seeing. They are not opposed to scientific knowledge and evidence. In fact, they ask for it and they apply it, where applicable, to their own understanding of long-term change. Our community partners frequently asked for scientific evidence to compare with their own observations and to advance

their interests in maintaining the sustainability of the delta. For example, one resident has worked with a University of Nebraska scientist in the delta for over thirty years, connecting his IK with the scientific information for deeper insights about the delta and using both to advocate for changes in policies and practices of government agencies.

Lastly, while our approach has offered one strategy, our research suggests that there is no single way of bridging knowledge systems. However, we agree with Rathwell et al. (2015) that whatever strategies are used, bridging activities requires time and continuous deliberation. Typically, such activities go beyond the capacity of a single individual or project. As mentioned in the introduction, this paper is one part of a much larger piece that has employed bundled methods and processes of engagement and collaboration over a number of years. We have built trust with our community partners (including Elders, school children and their teachers, IK holders, and governing authorities) over a long period, and we will continue to have obligations in this region. Furthermore, all three of the co-authors have been part of a larger Delta Dialogue Network (DDN) that has brought together researchers, policy and decision-makers, and communities in the three aforementioned inland deltas to work across cultural and knowledge divides towards a common set of actions. To spread messages about the deltas to policy and decision-makers, the DDN has used both Western and Indigenous knowledges together in creative ways, including documentary films and a traveling exhibit to delta communities and government legislatures. These calls for epistemological pluralism demand multiple strategies over multiple years that are not likely to be achieved by a single researcher or project. Hence, the efforts reported here are but one contribution to a multi-faceted and on-going set of relationships and practices.

PREFACE TO CHAPTER 3 – "WE ARE CRAVING FOR MUSKRAT": INTEGRATING INDIGENOUS WELL-BEING INTO CULTURAL VALUATION OF ECOSYSTEM SERVICES

The previous chapter evaluated multiple sources of evidence to gain a comprehensive understanding of long-term change in the Saskatchewan River Delta (SRD). Results suggested that the populations of all species of wildlife, and some species of fish, have declined, many lakes and rivers have shrunk and become shallow, and changes have occurred in the duration of berry-growing seasons and growth of berry plants. Significantly, all these changes directly affect the livelihoods and cultural meanings that Cumberland House residents derive from the land. The next chapter follows up on these reported changes in the delta, examining their impacts on local well-being. The chapter integrates the Indigenous concept of well-being into cultural valuation of ecosystem services, demonstrating a new approach to re-thinking the Millennium Ecosystem Assessment (MA) framework by clarifying how Indigenous peoples experience cultural ecosystem services. This new approach provides a revised assessment framework with a set of well-being constituents specific to the context of Indigenous cultures. The revised framework is demonstrated to better understand specific contexts involving Indigenous peoples as compared to the MA framework, which is too general to offer clarity about cultural ecosystem services.

CHAPTER 3 – "WE ARE CRAVING FOR MUSKRAT": INTEGRATING INDIGENOUS WELL-BEING INTO CULTURAL VALUATION OF ECOSYSTEM SERVICES

Abstract: Although much of the ecosystem services (ES) research has focused on monetary contributions to well-being, approaches that characterize values of cultural ES using non-monetary metrics are just beginning to inform an understanding of how people derive livelihood and cultural meanings from the landscape. The Millennium Ecosystem Assessment (MA) explicitly linked ES with well-being but was not well-suited to clarifying how Indigenous peoples experience cultural ES. This paper provides a revision to the MA framework to advance our understanding of cultural ES by bringing together cultural valuations and Indigenous concepts of well-being. Our framework draws on Naomi Adelson's work on Cree conceptualizations of health and well-being – translated as "being alive well" – and applies it to help understand the cultural values of Indigenous peoples living in the Saskatchewan River Delta (SRD), Canada. Our application of the framework draws on personal interviews, narratives, and field observations to elicit perceptions and meanings. Our findings give rise to a revised assessment framework with a set of well-being constituents specific to Indigenous cultures not previously included in ES frameworks. Hence, we argue for a revised framework that accounts for cultural valuation of ES through explicit attention to Indigenous values and interpretations of social and ecological change.

3.1 Introduction

The ecosystem services (ES) framework is explicitly human-centered such that it is structured around the concept of human well-being, with the work of Daily (1997) and Costanza et al. (1997) representing important foundational concepts to the framework. Over the past few years, the Millennium Ecosystem Assessment (MA 2003) has advanced the conceptual debate on the linkage between ES and human well-being by categorizing four types of services and linking them to five constituents of well-being. However, the MA framework has been criticized for being too general (e.g., Boyd and Banzhaf 2007), especially its aggregated perspective of humans and their well-being (Daw et al. 2011); for concealing effects of the full range of personal and societal factors that influence ecosystem use (Polishchuk and Rauschmayer 2012); and, as a consequence, for its limited capacity to understand how ES contribute to the well-being

of different groups (Daw et al. 2015; Pascual et al. 2017). In particular, scholars such as Duraiappah (2011) have questioned how the MA framework might be applied in specific contexts. We argue that if we consider how some specific groups like Indigenous peoples, who derive livelihoods and cultural meanings from the land, interpret ES, we can better understand the diverse ways in which ecosystems contribute to the well-being of different groups, as well as the specific details behind the translation of ES into personal and societal well-being. Such a focus on specific context can also reveal locally identified well-being constituents missing from the MA framework.

Drawing on a concrete case, this paper aims to revise the MA framework to better account for Indigenous peoples' interactions with ES. We explore how Indigenous peoples living in a northern Canadian setting conceptualize well-being and investigate how their conceptualization influences the interpretation of ES and the contributions of ES to well-being. We draw on Naomi Adelson's (2000) work on Cree conceptualizations of health and well-being – translated as "being alive well" – to present a framework for valuing cultural ES. Like the ES concept, the concept of "being alive well" is multi-dimensional, and thus offers a particularly useful set of constituents to include in a new framework.

We apply our framework to gain an understanding of the interconnections between ES and well-being in the Saskatchewan River Delta (SRD) in northern Canada. For more than two centuries, Indigenous peoples have interacted with the delta's complex wetland systems, procuring food and water, and practicing their cultural and spiritual activities. They are strongly connected to the land, as trapping, fishing, hunting, and plant use remain central to their lives and livelihoods. Over the past five decades, however, many external forces (e.g., upstream dams) have disturbed the delta's region, resulting in severe changes in its socio-hydro-ecological systems. Our research focuses on how long-term hydro-ecological change in the SRD has affected the valuation of the delta's services and well-being, as expressed by the people who live there – the community of Cumberland House.

We begin by describing valuation of ES, explaining why we focus only on the category of cultural services. We then give an overview of Indigenous conceptualization of well-being, the study site, and the research methods employed. Next, we document the values of the SRD under six themes identified through our research – traditional way of life, maintenance of Indigenous culture, closeness to nature, physical strength, sense of peace, and fun and games –

and describe the impacts of cultural value change on these themes. Our discussion provides a revision to the MA framework and concludes with contributions made by developing and applying the revised framework.

3.2 Conventional and Indigenous Conceptualizations of Ecosystem Services

3.2.1 Valuation of ecosystem services

The MA framework that links ES and human well-being identifies three direct categories of ES: provisioning services (products obtained from ecosystems, e.g., food and water); regulating services (benefits obtained from regulation of ecosystem processes, e.g., climate regulation and flood regulation); and cultural services (nonmaterial benefits obtained from ecosystems, e.g., spiritual and recreation) (Fig. 3.1). The fourth category – supporting services – undergirds the production of the other three services, and, therefore, primarily affects human well-being indirectly.

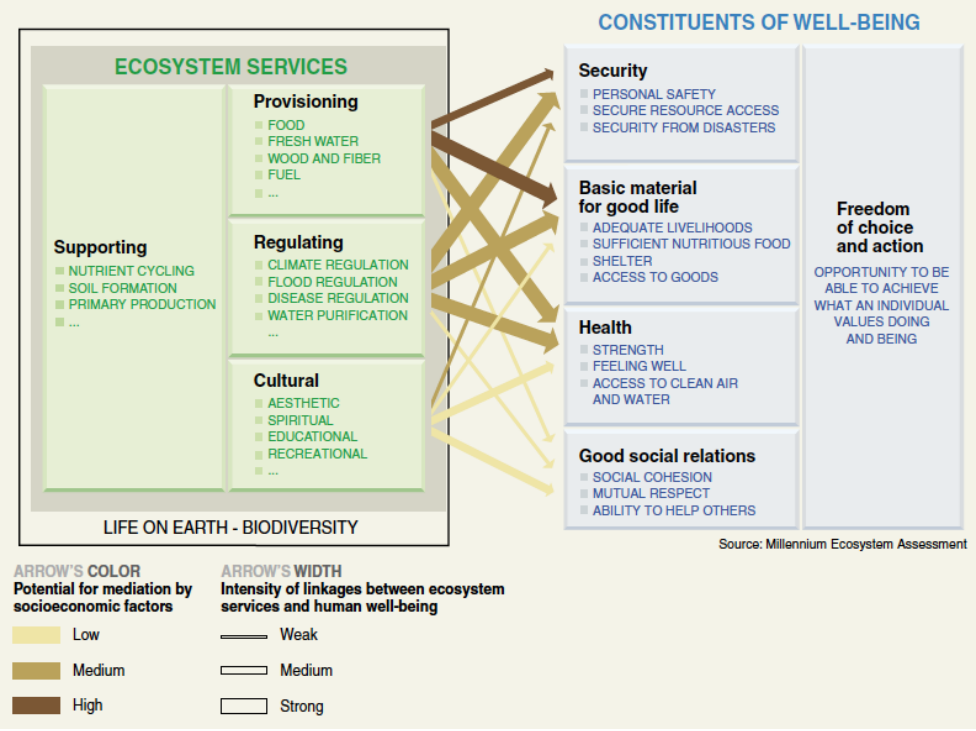

Figure 3.1: The Millennium Ecosystem Assessment framework that links ecosystem services to human well-being (MA 2003)

The MA also identifies five constituents of human well-being (Fig. 3.1): security, basic material for a good life, health, good social relations, and freedom of choice and action. The last component – freedom of choice and action – is placed aside from the other four, demonstrating it as a condition for the achievement of the other four. The framework depicts the linkage between the three direct ES categories and each of the four components of well-being by one-way arrows of different shades of colour and width, to illustrate potential for mediation and intensity of linkages respectively.

Although the MA framework is widely used, there are inherent deficits that make its operationalization and applicability in every context problematic. In particular, some scholars (e.g., Riechers et al. 2016; Chan et al. 2012; Daw et al. 2011) have recognized the overlap of cultural services with other categories of service, especially provisioning services. The framework also does not reveal specific details of how ES translate into personal and societal well-being (Polishchuk and Rauschmayer 2012); yet studies reveal that different stakeholders make different use of ES, and that people use different ideals to evaluate their well-being (e.g., Snyder et al. 2003; Izquierdo 2009; Chan et al. 2012; Bieling 2014). Hence, who defines and identifies well-being constituents that make a group or one's life valuable is a matter of concern (Polishchuk and Rauschmayer 2012). The MA's list of constituents of well-being thus calls into question how, in specific contexts, the list would reflect locally identified well-being constituents (Duraiappah 2011).

In response to the identified limitations of the MA framework, there is a call to examine ES through approaches that offer multi-dimensional perspectives for human well-being (Polishchuk and Rauschmayer 2012; Duraiappah 2004) or to use pluralistic approaches to recognizing the diversity of values underpinning nature-human relationships (Pascual et al. 2017). Such an effort, these scholars argue, will reveal the diversity of ways in which ES contribute to people's ability to lead lives that are valued, and will also open up a richer debate on the different ways well-being is perceived and conceptualized. Here, we revise the MA framework to include Indigenous conceptualizations of well-being and to elucidate how Indigenous peoples express and realize environmental values.

We limit our discussion to only cultural services not because we seek to downplay the importance of the other services but because our study focuses on Indigenous well-being. Our reasons are as follows. First, we see that for Indigenous peoples cultural benefits are associated

with many services and not just cultural ES (Chan et al. 2012). In other words, Indigenous peoples attach cultural meanings to most, if not all, of the benefits they obtain from the land whether provisioning or regulating or cultural. Second, we realize from the MA that unlike, say, the perceptions of the importance of food production (a provisioning service), which might be shared among all persons, perceptions of cultural benefits are more likely to differ among persons and communities, particularly for Indigenous peoples. Such distinctive valuations regarding cultural services have not been fully recognized in the MA framework (Bieling 2014; Chan et al. 2012). Yet adequate valuation of cultural ES can provide meaningful understanding, representation, and analysis of how human well-being might change when there is ecological change (Chan et al. 2012). Finally, we see that cultural ES is the only category with little, if any, substitutability (MA 2003); hence, its impacts on Indigenous peoples who are strongly connected to their land are extensive when their ecosystem is altered. For these reasons, we believe that we need to better understand Indigenous well-being and how it is affected by changes in ES. This understanding can then inform cultural valuation of ES.

3.2.2 Indigenous conceptualization of well-being: "being alive well"

As Mathews and Izquierdo (2009) note, different societies have different culturally constructed conceptions of what it means to be well, healthy, happy, or satisfied. Studies of First Nations, Inuit, and Métis in Canada (e.g., Adelson 2000; Wilson 2003; Parlee et al. 2005; Richmond et al. 2005; Turner et al. 2009) and other Indigenous groups worldwide (e.g., Izquierdo 2009; Heil 2009) reveal that well-being, as articulated by Indigenous peoples, is linked to lives lived on the land. Linguistically, Indigenous peoples have no word that directly translates into English as *health* or *well-being*. Among the James Bay Cree of northern Quebec in Canada, for instance, Adelson (2000) found the concept of *miyupimaatisiiun*, translated as "being alive well," as the closest concept to health and well-being. Similarly, Izquierdo (2009) found the concept of *shinetagantsi*, translated as "becoming happy," as being closest to well-being among the Matsigenka of the Peruvian Amazon. For the Swampy Cree in Saskatchewan, the concept that closely represents well-being is *mino pimacihisowin*, translated as "good way of life" (see Cardinal and Hildebrandt 2000; Goulet 2008).

Because our study focuses on the Cree in Canada, we draw on the meaning of the concepts of *miyupimaatisiiun* and *mino pimacihisowin* to understand Canadian Indigenous peoples' sense of well-being. Adelson (2000:97) recounts that conversations about *miyupimaatisiiun* – what it means to "be alive well" as a Cree person – often evoked "a past that was characterized by living on the land, for the most part unencumbered by Whiteman's interferences, foods, and illnesses." *Miyupimaatisiiun* or *mino pimacihisowin* thus goes well beyond the Western construction of health as the absence of disease or the simple statement that one is without infirmity, as it is "less determined by bodily functions than by the practices of daily living and by the balance of human relationships intrinsic to Cree lifestyles" (Adelson 2000:15).

Thus for the northern Cree, well-being has everything to do with life on the land, and more broadly with being Cree. To "be alive well," as Adelson (2000) details, means that one is able to hunt, pursue traditional activities, eat Cree foods, and (given the harsh northern winters), keep warm. Other studies of Indigenous notions of well-being elsewhere in Canada reveal similar findings. Parlee et al. (2005), for instance, tell of how berry harvesting connects Teetl'it Gwich'in women in the Northwest Territories to their mental, emotional, physical, and spiritual selves, and to each other and their land. Turner et al. (2009) describe the high nutritional and medicinal value of, and the physical work involved in, the Nuxalk Nation traditional food system that keep the natives healthy, active, and fit. Kuhnlein et al. (2009:47) report that Gwich'in Elders specifically told them, "Caribou blood gives strength and warmth."

Indigenous notions of well-being are also expressed through an immersion in a closed network of kin, in the social obligations of sharing and providing for each other (Adelson 2000; Turner et al. 2012; Richmond and Ross 2008). Heil (2009) uses the phrases "embodied selves" and "social selves" to describe how Indigenous peoples make reference to individual well-being in relation to the well-being of others. Engaging in traditional and social practices, providing for others, and responding to kin and social obligations are all prerequisites for being well (Heil 2009). Adelson's (2000) study on the James Bay Cree reveals that the distribution and redistribution of bush food maintain and strengthen the social bonds that exist in the society.

Added to social relationships is the connection to healthy ecosystems, meaning Indigenous well-being is also a reflection of the assertion of relations with environmental health and a proper sense of place (see Windsor and McVey 2005; Snyder et al. 2003). Using the notion

of therapeutic landscapes, Wilson (2003) explored how First Nations peoples' connection to the land and meanings of place maintain their physical, emotional, mental, and spiritual health and identity. The health of the land and the health of the people are considered inseparable (Parlee et al. 2005). The Cree people in Saskatchewan, for instance, describe themselves as *Iyiniwak*, a Cree term meaning "people made healthy by the land" (Cardinal and Hildebrandt 2000). Adelson (2000) recounts that one Elder summarized the Cree conception of well-being by saying, "If the land is not healthy then how can we be?" As she recalls, when asked about "health," people were always talking about the land, the animals, and their lives in the bush. This is because for the northern Cree, a healthy land not only supports an ability to harvest food but also defines who they are, their cultural identity, and thus part of their life (e.g., Brightman 1993). There is, therefore, the obligation to respect and look after the land and the resources (e.g., Turner et al. 2013). Such a reciprocal relationship of benefits and obligations is crucial to their well-being (Parlee et al. 2005).

Ecosystem loss or "environmental dispossessions," to use Richmond and Ross's (2009) term, therefore has negative consequences for Indigenous well-being. Richmond et al. (2005), for instance, noted a strong link between reduced access to environmental resources and declining 'Namgis First Nation's health and well-being. Loney (1987) and Windsor and McVey (2005) documented that, when Chemawawin First Nations in Manitoba and The Cheslatta T'En First Nations in British Columbia, respectively, were displaced from their traditional territory and could not hunt, fish, or trap, they resorted to drugs and alcohol, some contracted tuberculosis due to their poor diet, and many took their own lives. Both studies also reported the effects of the loss of both place and sense of place on the well-being of the native people.

In sum, the Indigenous concept of well-being – *miyupimaatisiiun* or *mino pimacihisowin* – focuses on the ability to live off the land, the nature of social and environmental relations, and cultural identity. From Adelson's (2000) work, the following can be identified as the main constituents of Cree well-being: the ability to pursue traditional activities; to eat Cree food; to keep warm; to maintain physical strength; and to sustain good relations with animals and other animate objects, including humans, through sharing and providing for others. These constituents, then, form part of the non-material benefits derived from ES that are deeply rooted in Indigenous cultures of Canada's northern Cree inhabitants (Fig. 3.2).

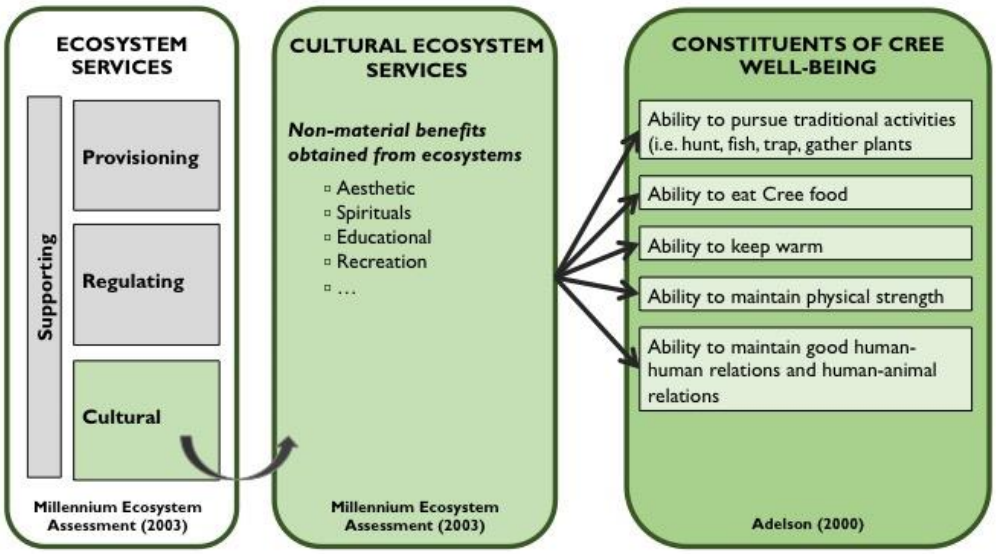

Figure 3.2: Linkage between cultural services and constituents of Cree well-being

3.3 Applying our Framework to Cumberland House in the SRD

Our application focuses on Cumberland House in northern Saskatchewan, established in 1774 as a fur trading post by the Hudson's Bay Company (HBC) (Kew 1962; Bicentennial Committee of Cumberland House 1974). Traditionally, the people of Cumberland House are hunters, fishers, trappers, and plant harvesters. Like any other Indigenous community in Canada, the local economy is mixed – reliant on wage employment and traditional economic activities. The community has a growing Indigenous population of Métis – people with mixed North American "Indian" and European ancestry – and status (Treaty No.5) "Indians" or First Nations, who are descendants of Swampy Cree people (Waldram 1989).

Cumberland House is situated in the SRD. The delta is in the central lowlands of Canada and straddles the border of the provinces of Saskatchewan and Manitoba (Fig. 3.3). A complex area of wetlands with active and abandoned channels, the delta contains diverse and abundant plant, fish, and wildlife species (Kew 1962; Bicentennial Committee of Cumberland House 1974), and provides important livelihood and other benefits to the community of Cumberland House.

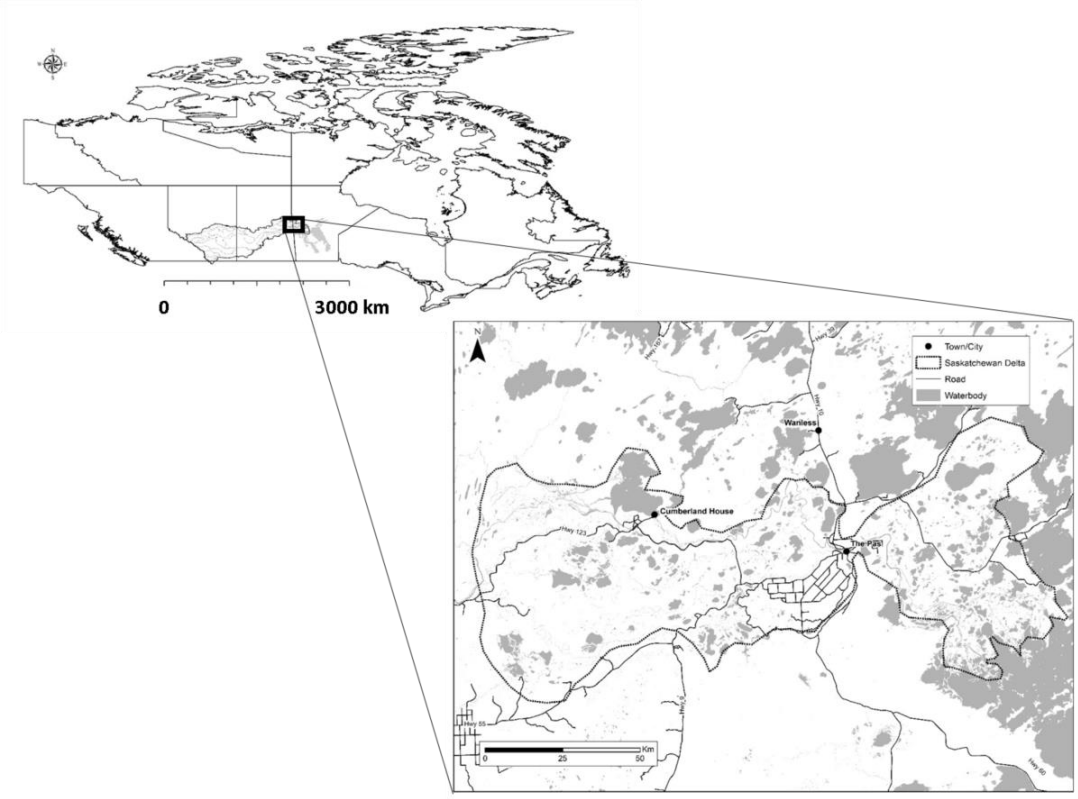

Figure 3.3: The Saskatchewan River Delta in central Canada

The delta is impacted by many upstream developments, which have altered its hydrology, physiography, health, and diversity (Partners for the Saskatchewan River Basin 2008). For example, three large dams impact the delta: the E. B. Campbell dam (formerly Squaw Rapids dam) (constructed in 1963), the Gardiner dam (constructed in1967), and the Nipawin Hydro dam (constructed in 1985). These upstream facilities have altered the natural functions of the delta. The E. B Campbell dam, for instance, operates as a peaking facility, meaning water is held and released as needed for power generation. This process results in unpredictable and extreme fluctuations of the delta's flow and flood regimes (Waldram 1989). The historical natural occurrence of spring and summer overbank flooding, which filled the lakes and river channels and maintained the delta's productive plant and wildlife communities and extensive shorelines, has decreased (Prairie Provinces Water Board 1976), leading to a general dryness of the delta, encroachment of willows, and decline in fish and fur-bearing animals (Committee on Saskatchewan River Delta Problems 1972). Variable flows, combined with the suppression of controlled burning, have also led to changes and loss of wildlife habitats (Wilson and Kowal

2004). Local observations indicate a multi-decadal decline and an altered distribution of wildlife populations, as well as a major change in the use of the delta, including difficulty in accessing fishing and hunting sites (Chapter 2).

3.4 Methods

This paper draws from narrative analysis of oral histories and semi-structured interviews with eight Elders and thirty-four active harvesters – fishers, hunters, trappers, and plant harvesters – all but one of whom were of Indigenous ancestry and all of whom had lived in Cumberland House for most of their lives. We chose study participants based on recommendations from community members. The strength of this approach lies in the selection of respectable local knowledge experts as interviewees (Davis and Wagner 2003). The rest were recruited through contacts established during fieldwork.

Data were collected in 2014 from February to September when the lead author lived and participated in the community and observed the local context. He spent almost two months in the community to establish a trusting relationship with community members before conducting the face-to-face interviews. Over several meetings with community members, the local people directed the research and agreed on a number of questions to be explored in the interviews to ensure that the study reflected local priorities and perspectives.

We asked the local people what they meant by well-being and how ecosystem services contribute to well-being. Hence, using an inductive approach we deliberately built our framework from the people's own interpretations. We asked questions about spiritual and cultural activities related to the delta, the importance of the delta to people, the reason why people fish, hunt, trap, or gather plants, how people feel when they are out in the bush, and how the loss of some important species or an inability to pursue traditional activities might affect individuals and the community as a whole. In the discussions, we were also interested in people's observations of change and impacts on traditional use of the delta. Conversations focused on individual stories and experiences of life on the land, such as growing up on the trap-line, as well as perceptions of the long-term changes in the socio-ecological system. Discussions continued until data saturation had been reached, defined as the point where no new evidence emerged. Interviewees requested that their real names be included in any documentation,

including journal articles. However, to comply with ethical standards of journal publishers, we use interviewees' initials instead.

All interviews were audiotaped, transcribed verbatim, and, together with the field notes, coded and analyzed by theme using NVivo 10, a qualitative analysis software program. A number of codes were descriptive and emerged from the field notes because they were issues that people talked about frequently during field conversations. A few codes were analytic; these came later in the coding process as they connect to the framework of the study. After preliminary analysis, the lead author returned to the community to present, discuss, and verify our results.

3.5 Results

3.5.1 Cultural valuations of the Saskatchewan River Delta

The people of Cumberland House articulated their experiences from the land as a *traditional way of life* (*pimachihowin*) that has been handed down through generations (see Table C.1 in Appendix C). In describing their way of life, people indicated they could not imagine how they could live and not pursue their traditional activities. Research participants' narratives on the meanings and experiences from the land revealed six main themes – 1) traditional way of life; 2) maintenance of Indigenous culture; 3) closeness to nature; 4) physical strength; 5) sense of peace; and 6) fun and games – as the socio-cultural values derived from the delta. One Elder recalled that his grandfather was still fishing at the age of 95, demonstrating how a traditional way of life was "in his nature." Numerous times, through community meetings, delta day symposia, informal conversations, and field interviews, we heard the people of Cumberland House refer to the delta as "our grocery store." They indicated that the community had been self-sufficient during the delta's most productive past years, as people could gather their own food to feed their family.

Residents desired that the delta's productivity be maintained for *cultural continuity* (see Table C.2 in Appendix C). In the opinion of the Elders, the skill of pursuing traditional activities needs to be passed on to the younger generations for them to appreciate their culture and to know what their ancestors did to survive. Moreover, residents spoke of eating wild food – muskrat (*Ondatra zibethicus*; *Wācask* in Cree), moose (*Alces alces*; *Mōswa* in Cree), and sturgeon (*Acipenser fulvescens*; *Naméw* in Cree) – and having cultural feasts to signify who they are

"around here in the delta." Traditionally, parents and grandparents fed children with traditional food so that they would grow up eating them. Residents also expressed their desire to maintain the culture of sharing food procured from the delta. Food sharing is highly valued not only because the people attach great value to eating bush food, but also because eating this food together sustains and strengthens the social bonds that exist in the community. There is, therefore, a strong desire among harvesters to always procure something to distribute, especially to family members and Elders who do not or cannot live off the land, as a means to fulfill a cultural obligation.

When asked how they feel when they are out in the bush, research participants relayed stories about *closeness to nature*, a spiritual connection to the delta, and interactions with animals and the Creator (see Table C.3 in Appendix C). Other residents spoke about connecting to the land, water, and wildlife, including a local spiritual group that told us that they occasionally go and pray by the main Saskatchewan River, demonstrating a connection to their Creator.

Residents ascribed their *health and well-being* to the practice of living off the land (see Table C.4 in Appendix C). The traditional practice of gathering country food required many physical activities, including canoeing, paddling, and walking. In the opinion of the Elders, life on the trap-line was healthy as they were active, moving around several miles to trap and gather food. Moreover, residents perceived country food to be healthier than store-bought food. They recounted that when all they ate on the trap-line was bush food, "the food didn't make them sick," attributing the common occurrence of diabetes partly to the eating of store-bought food. In addition to getting *physically strong* by moving around and eating 'healthy' food, harvesters also ascribed a sense of mental well-being to living off the delta in that "mentally you felt better to gather food yourself to feed your family" when you did not have to worry about where to get money to buy the next meal.

In our conversations, we heard many times that "it's peaceful out there" in the bush, indicating that residents derived a *sense of peace* from their experiences in the delta (see Table C.5 in Appendix C). As they narrated, the bush is not only calm and quiet but also "there is no swearing, no cursing, no bad words, and there is no stress." The bush has become a place to get away from the noise in the community and the pressure from family and friends.

Many past and present social activities in Cumberland House were and continue to be related to the land and water (see Table C.6 in Appendix C). Examples include dog sled racing, canoe racing, and fish derbies. Residents also reported that they have *fun* listening to animal calls, especially when they call a moose and it respond to their calls.

3.5.2 Impacts of cultural value change on Indigenous well-being

Research participants also discussed changes in socio-cultural values and the implications of these changes for their well-being (see Table C.7 in Appendix C). First, the lifestyle on the trap-line is no more, and every Elder and adult we talked to indicated that s/he has "missed everything on the trap-line." They all wished "things were back to where it was before," being able to go out on the trap-line, especially in the springtime to trap muskrat. People spoke of how they felt sad when they went out there and "couldn't even recognize the places where we used to live in the spring [because] everything is completely bush," attributing these changes to bans on fire and alterations in water regimes.

Residents used words like "depressing," "devastating," "mad," and "lonesome" to describe how they feel when they reminisce about the past – the old kind of life when everything was plentiful and the water was clean, and "now it's gone," "the water has changed," and "even the animals and the fish, they taste different." Elders and adults, in particular, expressed strong cravings for muskrat every spring. In an interview conducted in May 2014, the exact time people would have been trapping for muskrat, one male adult trapper indicated, "Everybody in the community right now all the Elders and the middle people like 30 years old and up eh like we are all craving for muskrat." We were told, in recent times, trappers now travel many kilometres to southern areas of the province "to look for muskrat just to eat." In the spring of 2013, following a heightened craving for muskrat, the Chief of Cumberland House Cree Nation paid some trappers to go search for muskrat for a community feast. The trappers caught about 200 muskrats, and, out of 150 Elders in the community, 107 showed up for this traditional feast. The Chief described the turn-out as huge, signifying the impact of muskrat cravings on people who do not get to eat it anymore.

In discussing how they would feel if they were not able to hunt, fish, trap, or pick berries anymore, participants mentioned that they would be "broken down," "get sick," "feel sad," and,

"be lonely" because "there'd be something missing in [them]." One woman explained an inability to pursue her traditional way of life as "tak[ing] away who people are," indicating a loss of identity.

Issues of a sedentary lifestyle and reliance on store-bought foods came up many times in conversation. In the residents' opinion, a sedentary lifestyle in the community has replaced the active lifestyle on the trap-line, and over-eating of store-bought foods has replaced the reliance on wild foods. People attributed poor health, such as high levels of diabetes, to inactivity and over-eating of store-bought foods, both of which have become a common occurrence in the community, possibly related to the decline in traditional activities and scarcity of wildlife. They not only indicated that wild food is healthier than store-bought food, but they also bemoaned the high cost of store foods, as well as their poor quality when they have been kept too long on the shelves.

Aside from poor health, other cultural impacts of over-reliance on store-bought foods are recognized in the community. For instance, residents lamented that many children do not eat the traditional food. For example, while acknowledging that muskrat is part of their traditional diet, people narrated that younger people do not eat muskrat because, for over thirty years, muskrat has been scarce and many children "didn't grow up with it." The Elders expressed concerns about such cultural loss, agonizing about the fate of their future identity as Cree (*Nehinuw*) or Indigenous peoples (*Ininiyuk*). Youth disconnection with traditional ways of life was spoken about by many of them, who indicated that those aged 20 years or more did not know how to hunt or fish or trap, a change from the pre-1960s when children often learned those activities by the age of 10 or less. Many of today's youth have never been out on the land, and residents expressed worries about the loss of traditional land-based knowledge. Decreased opportunities to live off the land have forced many adults to seek wage employment, making them less able to take their children out to teach them, thereby undermining the maintenance of their culture and traditional way of life.

The decline in the delta's provisioning services has reduced the culture of sharing, and, instead, has resulted in the buying and selling of traditional food. Harvesters expressed difficulties in sharing when they harvest less. Moreover, the decline in the delta's productivity suggests that harvesters now expend more effort and money, resulting in the high cost of harvesting. To offset part of their costs, especially "gas money," harvesters sell portions of their

harvests for cash, a practice decried by residents as non-Indigenous. Thus, the ecological and economic changes that make it difficult or impossible to harvest traditional food challenge the efforts of the people of Cumberland House to maintain their culture and way of life.

The delta's reduced productivity has made it difficult for harvesters to adhere to their own stewardship and management practices. For instance, in Cumberland House there has been a weakening in the cultural appropriateness of harvesting as a result of the scarcity of wildlife and lack of success in the hunt. As an example, the season for moose hunting is July "when the moose are fat," but hunters told us they sometimes "can't wait until July because we're craving for it." This indicates that the traditional ways of resource management and the ethics of resource use have been impacted by changes in the delta.

Changes in the delta have also impacted the fun and games that are related to it. For instance, residents spoke of how canoeing and paddling have become impossible during dry periods in the delta, and how low water also disturbs fish derbies. Moreover, in the opinion of residents, "the delta is quieter now" as the animals are not calling as much; hence, people do not regularly hear the animal calls when they go into the bush.

Regarding livelihood (*pimachihowin*), people spoke of how in the past they got everything off the land, but now they are less able to live off the land because "there is nothing out there." We heard many times that what harvesters expend on their activities "can't pay off what we got" because there is always little harvest. The traditional way of life is, therefore, "not feasible," as the delta is not providing as much for a decent living. While they preferred to live "the traditional way," many harvesters expressed that they have sadly "hung up" the traditional way of life and now pursue it as "a hobby" instead of as a livelihood. In the opinion of residents, "the community is not going to make a living out of the delta" as it did in the past. They feared that there would be heightened dependency of people on the welfare system and government assistance.

3.6 Discussion: A New Framework for Rethinking the MA Framework

3.6.1 Limitations of the MA framework

Our findings suggest many limitations of the MA framework. The separation of provisioning services from cultural services in the MA framework misses completely how

groups like Indigenous peoples understand provisioning. As mentioned earlier, Indigenous peoples ascribe cultural identity and meanings to provisioning services such as food. The wild foods procured from the land are valued as cultural diets, and Indigenous identity is tied to accessing and eating these resources. There is, therefore, an interconnection between provisioning and cultural services, as a loss of fishing or hunting opportunities, for instance, causes a loss of knowledge and cultural identity among Indigenous youth (Chan et al. 2012). Hence, separating food (and water) provisioning from cultural services is not appropriate in the context of Indigenous cultures.

Furthermore, the MA framework shows a weak linkage between provisioning services and good social relations. Yet, from the perspectives of Indigenous peoples, there is an inherently strong interconnection between provisioning services and social relations (Adelson 2000; Turner et al. 2012). Indigenous peoples rely on provisioning services both to provide nutritious food and to circulate food and to teach and enact social bonds (e.g., providing food for Elders, teaching land-based knowledge). For instance, among the Cree in Saskatchewan the word *weechihitowin* represents "the act of being helpful or supportive", and it is central to the well-being of people who depend on others to support them (Goulet and Goulet 2014). *Weechihitowin* then leads to *miyo-wicehtowin*, translated as "having or possessing good relations" (Cardinal and Hildebrandt 2000).

The MA framework also shows only a medium strength linkage between cultural services and health. Again, in the context of Indigenous community, we think that this deserves a careful evaluation as Indigenous peoples strongly attribute their health and well-being to the pursuit of traditional activities and cultural continuity. Wilson and Rosenberg (2002) have extensively explored the role of traditional activities in shaping First Nations peoples' health, and have argued for the incorporation of a set of measures of traditional activities within the determinants of a health framework. Similar to Wilson and Rosenberg (2002) and other studies on Indigenous peoples in Canada (e.g., Adelson 2000), our findings reveal that cultural continuity and attachments to traditional activities are necessary for good health or "good way of life" *(mino pimacihisowin),* as spending time on the land, participating in traditional activities, and acquiring food through hunting, fishing, and trapping enhances physical strength. These activities also contribute to Indigenous identity, which is recognized as basic to their well-being (Turner et al. 2008).

Lastly, a reciprocal connection between human well-being and ecosystems is absent in the MA framework, as the framework considers only one-way connections. Yet there are ways in which livelihood and access to resources is coupled with a responsibility to maintain those resources (e.g., Turner et al., 2000; Turner et al., 2013). In other words, there is evidence of reciprocal relations among food provisioning, social institutions and cultural identity, and individual and communal health and well-being. Examination of Indigenous perspectives can elucidate the connections and offer an opportunity for a more fundamental rethinking of the MA framework.

3.6.2 Re-drawing the MA framework

Our framework shows a list of constituents of well-being for understanding cultural ES as interpreted in an Indigenous context (Fig. 3.4). For the purpose of our illustration, and to ensure clarity, our framework omits supporting and regulating services, and merges provisioning and cultural services under one category: cultural-provisioning services. The framework includes a reciprocal interaction between Indigenous well-being and ecosystem services, illustrating that well-being, in turn, affects ecosystems and the services they provide.

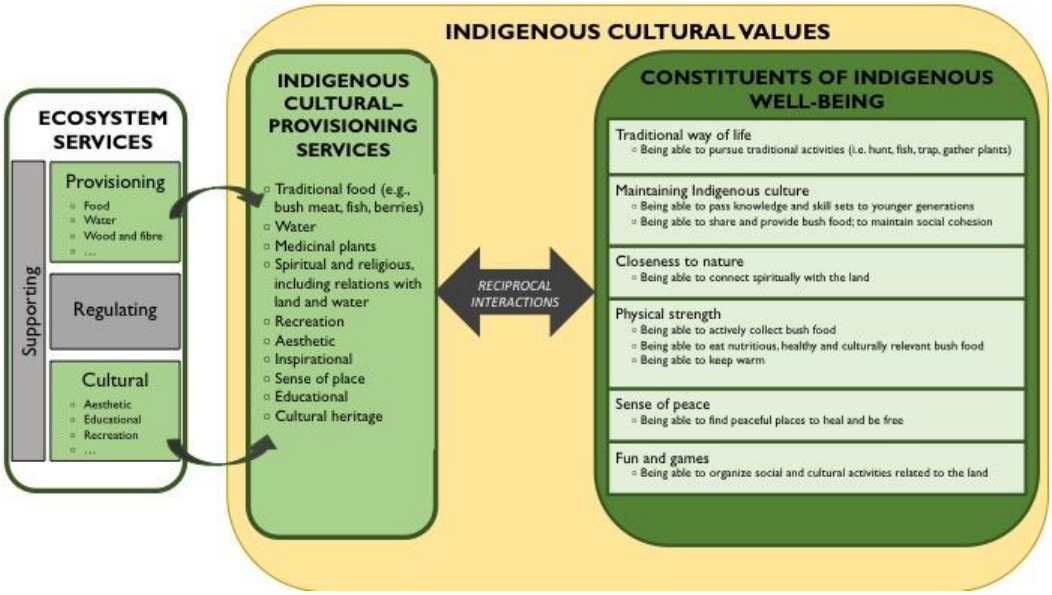

Figure 3.4: A Framework for Connecting Ecosystem Services to Indigenous Cultural Values

Our framework is structured such that when we consider how well-being is conceptualized in a specific context, the translation of ES into well-being becomes richer compared to the MA. Here, we see how ES contributes to the well-being of Indigenous peoples by depending on their senses of well-being. This recognition allows us to identify diverse and significant linkages between cultural ES and the various constituents of Cree well-being. For example, from Cree and other Indigenous perspectives, bush food, for instance, is not just a provisioning service but also a cultural service fundamental to their well-being.

Our effort at merging provisioning services and cultural services in an Indigenous context becomes clear and relevant when we think of how Indigenous peoples perceive locally-procured food and externally-sourced food. Whereas they are all provisioning services by the MA's standard, for Indigenous peoples, the meat, fish, and berries procured directly from their ancestral land are considered healthy relative to the unhealthy meat, fish, and berries imported to the local store. As Turner et al. (2008) document, Indigenous peoples have noted that when their diet changes from local, traditional food to processed, marketed food, the result is increased risk of health effects like diabetes and heart disease. Clearly, this shows that for Indigenous peoples, food is not only about the satisfaction of consumption, but also, and more importantly, about the cultural and social benefits of eating a particular kind of food – locally-procured food. Such benefits are not obtained from eating externally-sourced food, though these imported foods are also provisioning services from elsewhere.

We argue that our findings, and others such as Adelson (2000), show that cultural services contribute to most of the well-being constituents identified by Indigenous peoples. This makes credible our approach of integrating Indigenous well-being into cultural valuation, and also makes it appropriate to merge provisioning services and cultural services, as in Indigenous context all cultural services are mediated through provisioning services. Our argument supports Polishchuk and Rauschmayer's (2012) statement that how ES contribute to well-being depends on how well-being is defined or conceptualized. Thus, because Indigenous conceptualizations of well-being include more of the non-elementary aspects of well-being (Polishchuk and Rauschmayer 2012), we can distinguish a number of linkages between cultural services and various constituents of Indigenous well-being.

By focusing on ways in which Indigenous peoples express and realize environmental values, our framework goes beyond the categories of instrumental (anthropocentric) and intrinsic

values, identified in most ES studies (see Schröter et al. 2014), to demonstrate a third category of value: relational value (Chan et al. 2016). Our findings reveal that Indigenous peoples not only derive personal benefits from the ecosystem but also consider the meaning of their relations with nature and with others. For instance, the people of Cumberland House indicated that the use of the delta makes them who they are as people (cultural identity) and their connection with others (social cohesion); hence, they have the (moral) responsibility for keeping the delta healthy (care and stewardship), so as to be able to procure and share food or pass the knowledge and skills to younger generations (social responsibility) in reinforcing their cultural continuity (cf. Chan et al. 2016). It is in this intimate kin and stewardship relationships that their notions of well-being are rooted and expressed. By this we suggest that our approach extends the good social relations in the MA framework to include both relationships that are between people and nature, and relationships that are between people but involve nature (Chan et al. 2016).

3.7 Conclusion

This paper sought to revise the MA framework by integrating Indigenous conceptualizations of well-being into cultural valuation of ES to better account for Indigenous understandings of ES. Our argument has been that if we consider how specific groups perceive well-being and derive their cultural meanings from the land, we can: (1) reveal the diversity of ways in which ES contribute to the well-being of different groups; and (2) better understand the specific details behind how ES translate into personal and societal well-being, as suggested by critics of the MA framework. Based on in-depth research with an Indigenous community in Canada, we have re-defined a set of constituents of cultural ES to include in a new framework. In a more relevant way, the Indigenous constituents give deeper meaning and something to look for or measure when researching cultural ES, than say aesthetic or cultural heritages, which are too superficial.

Our framework has demonstrated reciprocal interactions between ES and human well-being. By viewing human-ecosystem relationships through the lens of reciprocity, we have shown that access to resources, attachments to traditional activities, and cultural continuity also affect ecosystems and the services they provide. Our examination of Indigenous senses of well-being has thus offered the opportunity for a more fundamental rethinking of the MA framework.

At the heart of our framework is the demonstration of relational value, which is absent in most ES frameworks. Focusing on Indigenous perspectives of well-being has shown that ES contributions go beyond personal benefits to include meanings of relations with nature and with others. Accordingly, we suggest that ES valuation should be broadened to also involve elements of relational value.

By introducing a framework specifically for valuing cultural services, our approach provides a better understanding of cultural services, which has received little attention in the ES literature. In particular, the approach captures categories of cultural services not recognized or measured in economic terms because they are, to use Turner et al.'s (2008) word, "invisible." Significantly, our findings reveal more cultural dimensions of human-ecosystem relationships compared to the MA, and thus contribute to the emerging knowledge that ecosystems provide a broad range of cultural services beyond those currently measured. We agree with Polishchuk and Rauschmayer (2012) that such cultural contributions of ES need to be considered and included in well-being assessments.

Importantly, our conceptual integration of Indigenous senses of well-being into valuation of cultural ES not only deepens understandings of the cultural dimensions of ES, but also is a step to developing a comprehensive framework that captures the full set of ES values necessary for improved decision making. Moreover, the framework is potentially useful in increasing awareness of sensitive cultural values, which can be helpful in informing policies around wildlife and resource management. For negotiating resource rights, for instance, the framework may help explain that providing substitute provisioning ES (e.g., hunted meat vs. provided meat) is inadequate. The framework is also helpful in moving beyond technical aspects of valuation. Finally, the paper is useful in partly serving as a post-project impact assessment, which is uncommon in Canada. Significantly, the findings contribute to the information on the long-term impacts of hydro-dams, including the E. B. Campbell dam, constructed at a time when environmental impact assessments were not required.

PREFACE TO CHAPTER 4 – ADAPTATION THROUGH BRICOLAGE: INDIGENOUS RESPONSES TO LONG-TERM SOCIAL-ECOLOGICAL CHANGE IN THE SASKATCHEWAN RIVER DELTA

The previous chapter assessed the impacts of change in the SRD on the well-being of the people of Cumberland House. A new framework was proposed to revise the MA assessment framework, leading to a set of well-being constituents specific to the context of Indigenous cultures. Results indicated that Cumberland House residents' experiences from the land are articulated as a traditional way of life, cultural continuity, closeness to nature, physical strength, sense of place, and fun. Changes, however, in the delta have affected these social-cultural values. The next chapter follows up on the changes and impacts in the delta, investigating the adaptive responses of the local people to securing the continuation of their livelihoods and well-being. This chapter explores a new platform to engage with the cultural dimensions of environmental change. The chapter develops and applies the concept of bricolage to demonstrate how local adaptations are constructed. The chapter reveals that Cumberland House residents improvise, hybridize, negotiate, and contest existing practices to create different kinds of arrangements for adapting to changes in the delta. The chapter, thus, presents residents as active social agents, capable of recognizing and acting upon circumstances that confront them.

CHAPTER 4 – ADAPTATION THROUGH BRICOLAGE: INDIGENOUS RESPONSES TO LONG-TERM SOCIAL-ECOLOGICAL CHANGE IN THE SASKATCHEWAN RIVER DELTA

Abstract: Social and ecological change in Canada's north challenges Indigenous communities to develop responses that secure the continuation of their livelihoods. Although there is significant evidence that effective response and adaptation opportunities exist in Indigenous communities, understanding of *how* such locally developed adaptations are constructed remains limited. This paper develops and applies the concept of bricolage to demonstrate how Indigenous societies build their adaptive capacity to address long-term social-ecological change. Our concept bridges institutional and productive forms of bricolage to explain how individuals and households make conscious decisions and adjustments to retain their livelihoods. Long-term engagement with residents of Cumberland House, Canada by conducting field observations, oral histories and semi-structured interviews, demonstrates that Indigenous peoples *improvise*, *hybridize*, *contest*, and *negotiate* existing practices to create different kinds of adaptive arrangements. We find, further, that whereas certain livelihood practices have changed, cultural norms such as respect and reciprocity have remained. Our findings strengthen the argument that Indigenous peoples possess the capacity to take a leadership role in adaptation decisions; hence, adaptation planners should include Indigenous peoples in adaptation decisions and learn from locally-developed responses to focus adaptation planning on the relevant needs of Indigenous communities.

4.1 Introduction

Social and ecological systems in the Canadian north continue to change rapidly as a result of increasing human development and climate change (Krupnik and Jolly 2002; Wonders 2003; IPCC 2007; Angell and Parkins 2011). These changes challenge the livelihoods of Indigenous peoples living in northern communities who still rely heavily on renewable resources. Importantly, Indigenous peoples have always had to accommodate and respond to changes in their environment (Berkes and Jolly 2001; Turner and Clifton 2009), and there is evidence that effective response and adaptation opportunities exist in Indigenous communities (Nickels et al. 2002; Kofinas et al. 2010). However, an understanding of how locally developed responses are

constructed remains limited. Knowing how Indigenous peoples respond and adapt to change can provide insights useful to guiding adaptation planning (Boissière et al. 2013).

There is no doubt that the pace and magnitude of recent changes have been accelerating (IPCC 2007; Turner and Clifton 2009; Berkes and Jolly 2001), heightening the challenges facing northern communities. In this context, scholarly representations of Indigenous peoples are mixed. Numerous studies (e.g., Furgal and Seguin 2006; IPCC 2007; Ford et al. 2010) suggest that Indigenous communities are severely vulnerable to the impacts of recent changes. Some of these studies do not consider the role of Indigenous peoples in adaptation at all, merely mentioning them as "helpless victims of changes beyond their control" (Salick and Ross 2009:137); hence, these studies advocate for government and adaptation planners to recommend a range of strategies. Yet evidence from other scholars (e.g., Nickels et al. 2002; Sayles and Mulrennan 2010; Turner and Spalding 2013) points to the inherently adaptive nature of Indigenous societies and cultures. For example, Nickels et al.'s (2002) study in three Inuvialuit communities found that some local adaptations appeared to have already been initiated in the region in response to reported environmental changes – "different types of environmental change have different and unique impacts, each requiring different types of responses" (Nickels et al. 2002:324). More recently, Turner and Spalding (2013) noted that recognizing and accommodating change has always been a part of the social-ecological systems of Indigenous communities. They suggested that Indigenous peoples believe they "might go back to the [past]" to draw on previous values and practices to secure their livelihoods (Turner and Spalding 2013:1). Along similar lines, Salick and Ross (2009) argued that since Indigenous peoples experience local changes firsthand, much of the information on the effects and potential responses exists with them (see also Nickels et al. 2002).

These perspectives that local Indigenous peoples demonstrate adaptive capacity support Adger et al.'s (2013: 116) suggestion that "better understanding of the cultural dimensions of adaptation to climate hazards and risks will better inform decision making and planning for climate change" and that scholars and planners must find "new platforms and new ways to engage with cultural dimensions of environmental change." Our research explores one new way to engage with the cultural dimensions of environmental change. We consider changing practices in a northern Indigenous community through the concept of bricolage, exploring how locally developed adaptation practices have been formed. Our analytical framework draws attention to

how an Indigenous society improvises traditional or Western practices, hybridizes elements of Indigenous and Western cultures, and legitimizes everyday practices in creating different kinds of arrangements for adapting to environmental change. We apply the bricolage concept to a community located in the Saskatchewan River Delta (SRD) in northern Canada. Since the 1960s, partly as a result of many upstream developments (e.g., hydro-dams and water withdrawal for irrigation) and climate variability, the community of Cumberland House has observed rapid and on-going changes in the SRD. These changes have had a wide variety of impacts, including altering patterns of water availability, changing transportation modes and patterns, overgrowth of vegetation, diminishing wildlife habitat, and decreasing harvesters' ability to access and share traditional food. Our research traces the construction of adaptations to these effects by the people of Cumberland House through a bricolage perspective.

We begin by describing the notion of bricolage, highlighting the varied usages of the concept and its key characteristics. We then connect bricolage to livelihood and elucidate the construction of livelihood through the bricolage lens. Next, we give an overview of the study site and the research methods employed, before presenting adaptation scenarios observed in the community of Cumberland House. Our discussion provides reflections on how adaptation occurs through the process of bricolage and concludes with the novelty of the bricolage perspective in shedding light on how adaptation strategies are developed in Indigenous peoples' practices of daily life.

4.2 The Concept of Bricolage

The term bricolage was first introduced by Claude Lévi-Strauss to refer to the process of "making do with whatever is at hand" (Lévi-Strauss 1966:17). Comparing mythical (the bricoleur) and scientific (the engineer) worldviews, Lévi-Strauss developed the notion of intellectual bricolage to explain how the bricoleur accomplishes a large number of diverse tasks by creatively drawing on heterogeneous repertoires at his/her disposal. Rather than an engineer, the bricoleur is a handyman, materially limited, but collecting and retaining whatever comes in handy and putting these items later to use (Lévi-Strauss 1966). Key to Lévi-Strauss' description of bricolage is the idea that, when confronted with a situation, the bricoleur's first practical step

is retrospective – turning back to an already existing set of materials and reconsidering what it contains to decide what to choose to solve the problem.

Since Lévi-Strauss, the concept of bricolage has been adapted to a range of fields and contexts, including resource management, entrepreneurship, and forest-based livelihoods. Table 4.1 provides examples of the varied usages of the bricolage concept. Here, we draw on the notion of institutional bricolage and productive bricolage to help analyze and explain how Indigenous adaptations in livelihood as a consequence of long-term hydro-ecological change are constructed. We adapt the work of Frances Cleaver (2012) to demonstrate how Indigenous peoples "make do" through three key processes – hybridization, legitimation, and improvisation of everyday practices (Cleaver 2012).

Table 4.1: Varied usages of bricolage in the literature

Term	Definition/Meaning/Use	Author/Source
Institutional bricolage	A process by which people consciously and unconsciously draw on existing social and cultural arrangements to patch or piece together institutions in response to changing situations.	Cleaver 2001; 2012
Entrepreneurial bricolage	A model for understanding how entrepreneurs create something out of nothing in resource-constrained environment; the pursuit of opportunity through close regard to the resources at hand.	Baker and Nelson 2005
Social bricolage	The innovative ways social enterprises acquire new resources from existing materials in the context of resource-scarce environments to create social value	Di Domenico et al. 2010
	A spontaneous collective action and social networking activity, involving combining and locally integrating chunks of everyday routine to rapidly respond to emergencies.	Johannisson and Olaison 2007
Productive bricolage	The way in which rural people construct a livelihood system that is a response to local constraints and opportunities and to broader patterns of income-generating possibilities.	Batterbury 2001
	The flexible and dynamic crafting together of various livelihood options and the associated impacts on the landscape.	Ros-Tonen 2012

A key construct of bricolage is the idea of *making do*, meaning using whatever resources are at hand for new purposes (Lévi-Strauss 1966). In elaborating institutional bricolage, Cleaver (2012) suggests that people *make do* by borrowing from existing institutions, styles of thinking, and sanctioned social roles and relationships to create institutions to suit new purposes (i.e., resource management in Cleaver's case). By the characteristics of *making do*, the exercise of agency is said to be an inevitable part of bricolage, as the bricoleur creatively makes choices and takes actions within the parameters of resource constraints. Thus, the bricoleur has the ability to act, and through innovative actions, is able to make transformations within the limits of social constraints (Cleaver 2012).

Associated with agency, therefore, is another key construct of bricolage – *improvisation* (Lévi-Strauss 1966). Proceeding with whatever material is at hand, the bricoleur remains innovative by improvising – turning anything into something else, or re-using resources for purposes different than those for which they were originally intended (Baker and Nelson 2005). Cleaver (2012) suggests that people improvise in many ways, including adapting well-worn and accepted practices to new conditions, as well as re-inventing arrangements and drawing on meanings and ideas from elsewhere.

In thinking of the process of making do with whatever is at hand, Cleaver (2012) and others (e.g., Rao et al. 2005) have explored bricolage as *hybridization* – blending new and old materials to make something different, or adopting elements of the modern and traditional and combining them in new ways to represent new meanings. Analyzing cases of institutional bricolage in rural Tanzania and Zimbabwe, Cleaver (2012) showed in detail how people piece together elements of old practices and accepted norms with new arrangements such that the resulting arrangements are neither completely new nor completely traditional.

Key to the idea of institutional bricolage is the *legitimation* of new arrangements formed. As something different pieced together from the old and new and, occasionally, by bending the rules, Cleaver (2012) posits that new arrangements are subjected to scrutiny before they can have any purchase and endure over time and space. To gain legitimacy, new arrangements must be familiar to the actors and fit socially, meaning they must be perceived as the "right way of doing things" (Cleaver 2012:55). This, as Cleaver (2012) suggests, involves negotiation and contestation of competing claims to tradition or modernity.

In sum, bricolage denotes people's creative and resourceful use of available resources, reconfiguring or building on them to construct new ones in meeting objectives or solving problems. In so doing, elements of the old and new, modern and traditional, formal and informal are drawn upon or blended together in a dynamic hybridity. The resulting arrangements or actions are legitimized by reference to tradition or modernity and socially accepted ways of doing things.

4.3 Connecting Bricolage and Livelihood

Concepts of livelihood and bricolage can inform one another. Livelihood, as defined by Chambers and Conway (1992:7), "comprises the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living." Key to this definition, and relevant to our discussion here, is the connection between assets and the options available to people to pursue livelihood activities. As Scoones (1998) and Ellis (2000) note, to create livelihoods, people draw on the capital endowments (e.g., claims, stores and material resources) that they have access to and control over. Within the bricolage construct, Lévi-Strauss (1966) draws similar connections between the repertoire of materials and the options available to the bricoleur. As he describes, acting within the bounds of circumstantial constraints, the bricoleur's rule of the game is to always draw on whatever resource is at hand to accomplish a given task.

The process of bricolage is evident in the construction of livelihoods. For instance, Scoones (1998) and Carney (1998) suggest that livelihoods also occur within a vulnerability context – critical trends, shocks, and seasonality. When faced with shock, households respond by turning to their accumulated assets (stores, resources, and claims) to resume new livelihood strategies. In Ellis' (2000) accounts, such new strategies often involve drawing down on savings (financial assets) and on reciprocal obligations (social assets), as well as selling movable (e.g., cattle) and fixed (e.g., land) assets. Similar to the bricoleur who collects and retains whatever comes in handy to be used in the future, individuals and households also build assets, both tangible and intangible, for the pursuit of future livelihoods. Ellis (2000:74) uses the term "asset strategy" to refer to households' investments in future livelihood.

As mentioned earlier, a key construct of bricolage is improvising, meaning the bricoleur is adept at using materials and tools for different purposes than those for which they were

conceived and procured (Lévi-Strauss 1966). This characteristic of improvisation is also frequently found in the construct of livelihood. For instance, in their livelihood analyses, Scoones (1998) and Ellis (2000) noted households' ability to convert one type of wealth into another, or to switch between assets and activities. Besides asset substitution, households may also transform existing assets through re-investments. For example, a household may transform degraded land into productive land with the investment of money, labour, and skill (Scoones 1998). Thus, we can see that households' actions are marked by continual adjustment.

Bricolage has been used to denote hybridity in that the bricoleur recombines different elements at hand for new purposes. Again, this construct is useful in explaining the creation of livelihoods. The literature on livelihoods clearly shows that rural households commonly survive through pursuing a combination of activities. Importantly, Ellis' (1998) definition of livelihood diversification includes the process whereby rural families construct a diverse portfolio of activities in order to survive. A household may combine agriculture, market trading, odd jobs, social provisions, and remittances in creating a living. Ellis (2000) categorizes such a mix of activities into farm, off-farm, and non-farm income sources. Aside from combining activities, households also mix different types of assets for the pursuit of a livelihood strategy. For example, a household may combine natural assets (e.g., land) with financial assets (e.g., credit) and social assets (e.g., networks associated with labour sharing) when intensifying its agricultural activity (Scoones 1998). The foregoing review shows that livelihoods are created and re-created through bricolage, even if scholars have not explicitly adopted this framework. We consider whether the bricolage framework can shed light on how adaptation strategies are developed in Indigenous peoples' practices of daily life in times of change.

4.4 Study Site

4.4.1 Cumberland House in the SRD

Our study focuses on Cumberland House in northern Saskatchewan, established in 1774 as a fur trading post by the Hudson's Bay Company (HBC) (Kew 1962; Bicentennial Committee of Cumberland House 1974). The community has a growing Indigenous population of Métis – people with mixed North American "Indian" and European ancestry – and status (Treaty No.5) "Indians" or First Nations, who are descendants of Swampy Cree people (Waldram 1989).

Traditionally, the people of Cumberland House have been hunters, fishers, trappers, and plant harvesters. Like many Indigenous communities in Canada, the local economy is mixed – reliant on wage income, welfare payments, and subsistence harvesting.

Cumberland House is situated in the SRD. Spanning a geographic area of approximately 10,000 km^2, the delta is in the central lowlands of Canada and straddles the border of the provinces of Saskatchewan and Manitoba (Fig. 4.1). A complex area of wetlands with active and abandoned channels, the delta contains diverse and abundant plant, fish, and wildlife species (Kew 1962; Bicentennial Committee of Cumberland House 1974), and provides an important livelihood and other benefits to the approximately 2000 Indigenous peoples who live there.

The delta is impacted by many upstream developments, which have altered its hydrology, physiography, health, and diversity (Partners for the Saskatchewan River Basin 2008). For example, three large dams impact the delta: the E. B. Campbell dam (formerly Squaw Rapids dam) (constructed in 1963), the Gardiner dam (constructed in 1967), and the Nipawin Hydro dam (constructed in 1985). The E. B Campbell dam operates as a peaking facility, meaning water is held and released as needed for power generation. This operation has altered the natural functions of the delta (Chapter 2).

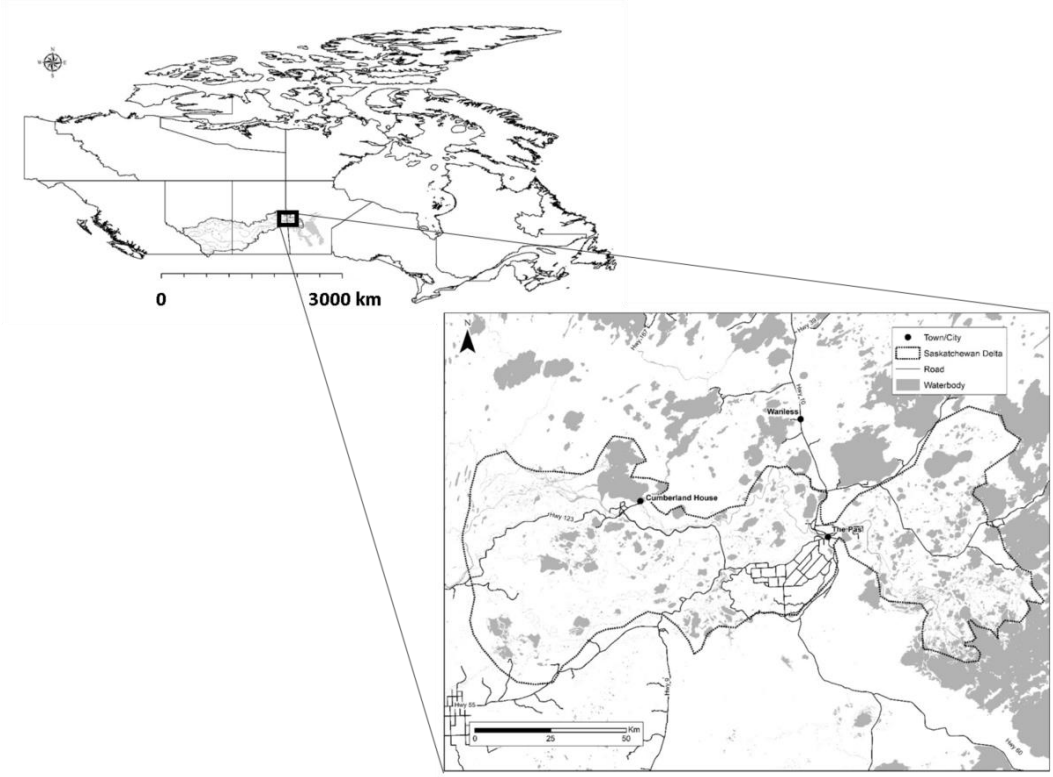

Figure 4.1: The Saskatchewan River Delta in central Canada

4.4.2 Hydro-social-ecological change in the SRD

The people of Cumberland House have reported devastating changes in the delta since the construction of the E. B. Campbell dam in 1963, including changes in water quality and quantity, fish and wildlife distribution, and vegetative growth. Residents have indicated that these observed changes have significantly impacted their land-based activities. A summary of the changes and their impacts is found in Table 4.2 (see Chapter 2).

Table 4.2: Key social-ecological changes in the SRD since dam construction and impacts on land-based activity

Change	Summary comment	Impact on land-based activity
Hydrological change	Water levels fluctuate on daily and hourly basis; very unpredictable	Difficulty in accessing harvesting sites
	Lakes and rivers are getting shallower, shrinking and drying out	Alteration of travel routes
	Less water in the lakes; freezes to the bottom	Exposed fishing nets, left high and dry
	Seasonal flows have changed; low in summer, high in winter	
	Less spring inundation	
	Floods are not natural; unable to replenish the delta	
	Water in the marsh is stagnant, not fresh, and stinks	
Wildlife change	Declining habitats; less hospitable and less accommodating	Less harvest
	No more muskrats	Destruction to local outfitting business
	Declining moose population; moving away from the delta	
	Geese and ducks leave early now	Spend more effort and days to get a kill
	Meat tastes different than before	
	Decline in waterfowl nesting in the western portion of the delta	Longer travel distance
		High cost of harvesting
Fish change	Less whitefish production in Cumberland Lake	Less income from fishing
	Destruction of fish spawning areas	Less fish harvest
	No more fishing in the Old Channel	Scary to eat fish due to mercury contamination
	Goldeye fishery has collapsed	
	Fish are contaminated with mercury	
	Fish tastes different now	
	Sturgeon has been declared species of special concern	
Vegetation change	Changes in berries seasons	Less berry harvest
	More vegetation growth on lake shorelines	Difficult summer travels and fishing
	Less growth of berry plants	
	Overgrowth of emergent aquatic vegetation	
	More dead willows and grass; no control burning in the past 20 years	
Transportation change	An all-weather road was completed in 1967	Wider exchange networks
	A bridge over the Saskatchewan River was completed in 1996	More opportunities for paid employment (e.g. taxi business)
	Many residents own cars now	Drive to other areas of the province to look for game

Source: Field notes, interviews, and archival records

4.5 Methods

This paper draws on field observations, oral histories, and semi-structured interviews with eight Elders and thirty-four active harvesters – fishers, hunters, trappers, and plant harvesters – all but one of whom were of Indigenous ancestry and all of whom had lived in Cumberland House for most of their lives. We chose study participants based on recommendations from community members. The strength of this approach lies in the selection

of respectable local knowledge holders as interviewees (Davis and Wagner 2003). The rest of the participants were recruited through contacts established during fieldwork.

Data were collected in 2014 from February to September, when the lead author lived and participated in the community and observed the local context. He spent almost two months in the community to establish a trusting relationship with community members before conducting the face-to-face interviews. Many residents opened their home to him during his stay in the community, and he visited them a number of times, partaking in their harvesting and other socio-cultural activities.

Conversations with research participants focused on their perceptions of life in the community, past and present, and the contrasts and contradictions they have experienced in the wake of development and change. Interviews with active harvesters also centered on how they have adapted their resource use and the factors that shape their capacity to adapt. Discussions continued until data saturation had been reached, defined as the point where no new evidence emerged (Morse 2015).

All interviews were audiotaped, transcribed verbatim, and, together with the field notes, coded and analyzed by theme using NVivo 10, a qualitative analysis software program. A number of codes were descriptive and emerged from the field notes because they were issues that people talked about frequently during field conversations. A few codes were analytic; these came later in the coding process as they connected to the framework of the study. After a preliminary analysis, the lead author returned to the community to present our results for verification.

4.6 Results

4.6.1 Adaptation scenarios observed in Cumberland House

Here, we present our results in the form of three scenarios of harvesting practices witnessed by the lead author while living in Cumberland House and participating in activities with the residents.

4.6.1.1 Scene one: We went for beavers, but we got a moose

In May 2014, while living in Cumberland House, the lead author joined two middle-aged hunters (who were also trappers) on a beaver-hunting trip. In the course of searching for beavers (*Castor canadensis*; *Amisk* in Cree), the hunters saw a moose (*Alces alces*; *Mōswa* in Cree) and killed it. Soon after the hunters had reached home, news of the successful moose hunt spread throughout the community. The following day it became a discussion topic between the lead author and an Elder whom he was visiting. The Elder explained that the trappers had hunted "out of season." By "out of season," the Elder was not referring to regulations imposed by the government on sports hunting; rather, he was speaking of the traditional seasonal cycle for moose hunting that starts in July, "when the moose are fat," and ends in February. The Elder condemned the practice of hunting out of season as not the culturally appropriate way of doing things, but recognized that when hunters go two or more years without moose, they become desperate for their cultural food. In such cases, the Elder explained, hunters could not be completely condemned. These sentiments expressed by the Elder were repeated in subsequent interviews with other Elders and hunters from the community. They reiterated that the seasonal cycle of hunting moose is mostly followed, but hunters sometimes "can't wait until July because [they're] craving for it," especially when culturally relevant foods hadn't been consumed for a long time.

Residents crave for moose meat because the moose population has dropped drastically in the delta region, making it difficult for moose hunters to be successful. Living memories suggest that up until the 1960s, the delta was very productive and contained abundant wildlife, including moose; hence, even hunts that lasted only a day were hugely successful. In recent years, however, partly due to the operation of the E. B. Campbell dam since 1963, wildlife habitats and production levels have declined. Reduction in species numbers has meant that hunters expend more effort, travel longer distances, and spend more than a day or two in search of game, sometimes returning home without success. Hunting has thus become costlier because much money is spent, especially on gasoline. Consequently, hunters now require financial support to sustain hunting. Household members with wage employment and those who receive social welfare payments provide money to support their food providers. Moreover, active harvesters are taking up seasonal and odd jobs to support their harvesting activities.

Discussions with Elders and hunters revealed that flexibility in harvesting patterns is part of Cree cultural adaptation. For instance, the lack of success in moose hunting has meant that deer, which is relatively plentiful in the delta, is sometimes hunted. Cumberland House residents traditionally did not care for deer, as they described themselves as moose eaters because they grew up mostly eating moose. Many described the taste of deer as bitter. With less success in the moose hunt recently, however, some hunters have started killing deer. But since they do not favour the taste of deer, they take their deer meat to a processor located a two-hour drive away to process them into sausages and hamburgers. In another example of cultural adaptation, trappers traditionally search for muskrats (*Ondatra zibethicus*; *Wācask* in Cree) in the springtime, but with no muskrat around, beaver has become the target species.

4.6.1.2 Scene two: Who should share in the moose meat: intra- and inter-community trade

The moose hunting experience was one topic that repeatedly surfaced in the lead author's conversations with research participants. On one of his subsequent visits with an Elder, for instance, the Elder asked him whether his hunting partners offered him a chunk of the moose meat. His answer, "no," generated a conversation around food sharing. As the Elder explained, the culture of food sharing – a means to maintain social networks, provide support, and reduce risks in difficult times – remains in Cumberland House, but the practice has evolved over time. In the past, sharing occurred among the immediate family and those with kinship ties, but, because of the complex networks of relationships that existed, it often went beyond to include other members of the community. Distribution beyond the immediate family often occurred in the form of barter trade – exchanging a chunk of meat for anything that a person brought, usually a tin of milk, sugar, baking powder, a quarter pound to a pound of lard, or a piece of cloth, among other items. In recent years, however, new forms of food sharing, involving providing food mostly for Elders and cash-based trade, are evident in the community.

The acceptance of cash in exchange for wild food, though frowned upon by Elders as a non-Indigenous practice, has become necessary because of the recent high cost of harvesting. Active harvesters who accept cash justified this practice as a means to defray costs. Some residents supported this claim, emphasizing that it was a way to assist harvesters in their search

of a kill. Yet others described the practice as selling wild food, which is alien to the Cree culture. Although different in form, food sharing remains a part of the intra-community relationship.

Aside from intra-community food sharing, traditional exchanges also extended beyond the local scale to involve other communities like Red Earth, Shoal Lake, Sturgeon Landing, Pelican Narrows, Denare Beach, as well as The Pas, Manitoba (Fig. 4.2). Inter-community trade has always been important as it ensured the provision of resources that were not found locally. Cumberland House journals, for instance, reveal that provisioning from more distant hunting grounds was a feature of trading post life in the early years of the HBC (Colpitts 2008). Seasonality and dramatically shifting wildlife population cycles meant that nearby meat resources often could not sustain local needs, and, therefore, required trading post employees to trade, and consume dried meat (especially buffalo) from ever more distant hunting grounds (Colpitts 2008). Today, caribou (*Rangifer tarandus*; *Atík* in Cree), trout (*Salvelinus namaycush*; *Namégõs* in Cree), and blueberries (*Vaccinium myrtilloides*) from distant communities are traded for moose, geese (*Branta canadensis*; *Niska* in Cree), walleye (pickerel) (*Esox americanus*; *Õgaw* in Cree), and raspberries (*Rubus idaeus*; *Âyôskana* in Cree) locally procured from the delta.

Elders revealed that connections to other communities were originally possible through water transportation and travels on winter highways. The completion of an all-weather road in 1967, and a bridge on the Saskatchewan River in 1996, shifted transportation overland and connected Cumberland House permanently to cities such as Carrot River, Nipawin, Prince Albert, Saskatoon, Regina, and the rest of the province (Fig. 4.2). These road improvements not only expanded the geographic extent of inter-community trade networks, but also involved accepting processed foods and other store-bought materials (e.g., beef, pork, chicken, and turkey) from city folks in exchange for locally-procured foods. The expanded inter-community networks that move food and other goods between communities are now a feature of the daily lives of Cumberland House residents.

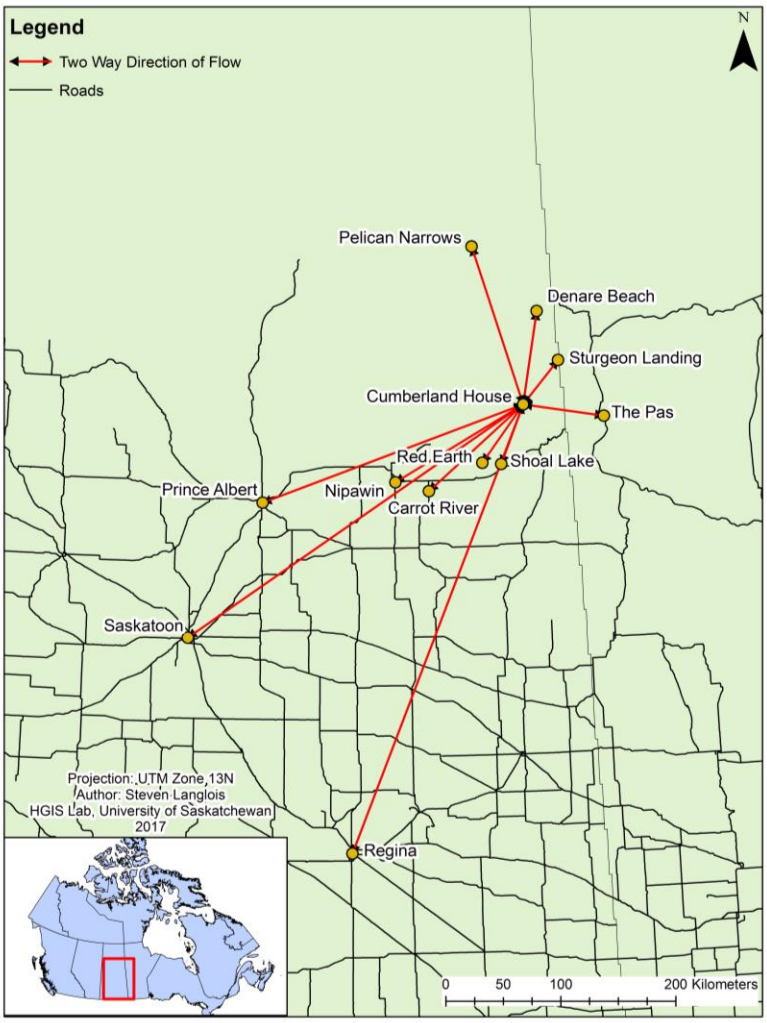

Figure 4.2: Food exchange networks between Cumberland House and other communities

4.6.1.3 Scene three: U-Picking berries in Nipawin, Saskatchewan

Declining wildlife production has also affected the procurement of other country foods. As the lead author discovered through discussions with women, berry production and growing seasons have become less predictable. Aside from experiencing delays in picking berries in some years, and harvesting fewer berries in other years, the women indicated that some species of berries they used to pick no longer grow around the community. Given the cultural and spiritual importance of berry picking, the women indicated that they "feel disappointed" when there are fewer or no berries to pick. When asked what they do in such circumstances, they explained, "That's when we go to the U-Pick in Nipawin." The U-Picks are cultivated berry farms open to

the public during the berry seasons for a fee. People pay between $8 and $10 to pick an ice cream pail (four litres) of strawberries, raspberries, saskatoons, and cherries at U-picks. Residents of Cumberland House convey elderly women to the U-Picks, where they can enjoy gathering berries and connecting with nature. The lead author was told that it does not take long for the elderly women to fill their pails at the U-Picks. The relative ease of transportation now makes berry picking at U-Picks a viable option.

In the discussions, participants also spoke about other examples where they substitute commercially available products for less available traditional foods. They indicated, for instance, that when there is no moose meat, they buy beef, steak, pork, or bologna as a replacement, and when there is no mallard (*Anas platyrhynchos*; *Ininisip* in Cree) and geese, they buy chicken or turkey. As well, they substitute canned tuna, sardines, and pink salmon for walleye (pickerel) and whitefish (*Coregonus clupeaformis*; *Atíkamég* in Cree).

4.7 Discussion: Reflections on How Adaptation Occurs Through Bricolage

Three key characteristics of bricolage are manifest in the above adaptation scenarios (Table 4.3). For example, the narratives reveal that local adaptations are formed in the "necessary improvisation of daily practice" (Cleaver 2012:46). In particular, the case of residents taking their deer meat to a processor to process them into sausages and hamburgers is a clear demonstration of an *improvisation* and a feature of bricoleurial mind set. As residents indicated, they did not favour the taste of deer meat and so processing it into sausages or hamburgers was an alternative way for them to eat deer. We suggest that this action well illustrates the "creative crafting" (Ingram et al. 2015:58) of anything into something useful – in this case the bitter taste of deer into something palatable.

Table 4.3: Bricolage characteristics and examples from local narratives

Bricolage characteristic	Definition	Example
Improvisation	Creative turn of anything into something useful; leakage of meaning and idea from one context to another; usage of material for different purpose than those for which it was originally intended.	Hunting "out of season" Berry picking at U-picks Turning deer meat into sausages and burgers
Hybridization	Dynamic blend of new and old materials to form something different; adoption and combination of elements of 'traditional', 'modern' and the 'formal' and 'informal' to represent new meanings.	Food sharing Mixed economy
Legitimation	Negotiation and contestation of competing claims to tradition/modernity; acceptability of adapted arrangements and practices as right ways of doing things.	Elders' vs. younger people's acceptance/response

Improvisation also characterizes the picking of berries at the U-Picks. As mentioned earlier, our research participants indicated that they prefer to pick wild berries from their cultural land, and only go to the U-Picks in a nearby city when there are few or no berries around the community. In this example, we see a clear demonstration of leakage of meaning from a traditional setting onto a more urban setting. In going to the U-Picks, Indigenous women, we argue, are moving their cultural experiences onto a different landscape, partly in anticipation of having a feeling of closeness to nature. This connection to nature that they describe when picking berries at the U-Picks illustrates well the bricolage characteristics of improvisation.

Furthermore, *improvisation* plays out in the example of hunting moose "out of season." Clearly, this practice illustrates that in changing situations hunters depart from their regular hunting cycle to shoot moose. Citing the lack of success in the hunt and length of time since they had eaten moose as the reasons for killing moose out of season, one can observe how hunters adjust the when and how of harvesting according to contemporary demands. Their indication that they do follow the seasonal cycle but are sometimes unable to wait clearly demonstrates a practice consistent with the past but occurring in contemporary contexts. Thus, in response to increasing livelihood demands, hunters' actions are marked by continual adjustments required for bricolage to occur.

The construct of *hybridization* also features well in the community narratives. Clearly, the narratives reveal that, similar to other Indigenous communities (see Kofinas et al. 2010), the people of Cumberland House are both actively engaged in subsistence and cash economies. Hence, there are opportunities for the attachment of Western elements to traditional norms necessary for bricolage to occur. Our clearest example is the practice of sharing. We suggest that the introduction of cash in the sphere of sharing relationships indicates the potential of the local people to harness elements of the market economy and to blend them with elements of tradition to form a new practice. Moreover, similar to Kofinas et al.'s (2010) observations in interior Alaska, our observations reveal that in the current context, sharing extends to involving local residents (with access to wild foods) and urban relatives (with greater access to wages and commercial goods). We suggest here again that this involvement of city folks who bring processed and other store-bought products in exchange for wild foods shows a dynamic mix of elements of subsistence and market economies.

The necessity of sustaining a mixed economy in Cumberland House also illustrates well the characteristics of *hybridization*. Because the costs are high, harvesting is supported by wage jobs and welfare payments, which provide cash to buy fuel and harvesting equipment. Hence, as our observations show, members that received incomes or payments contributed cash to support their household harvesters, whereas some active harvesters also took seasonal jobs to meet their harvesting expenses. The mixed economy also permitted new forms of sharing in which food-rich residents shared with cash-rich members of the community (see Berkes and Jolly 2001). We argue that in this hybrid form, elements of Indigenous practices existed side by side with Western cultures, as residents who were fully engaged in wage jobs and were unable to go out to harvest wild foods bought them from food providers. This observation in Cumberland House is consistent with Berkes and Jolly's (2001) findings in the Inuit community of Sachs Harbour and Kofinas et al.'s (2010) observations in the interior of Alaska. We agree with Kofinas et al. (2010) that the demands of contemporary livelihoods underscore why many households continue to depend on a fluid interdependence between harvesting wild foods and wage jobs – a clear mix of livelihood activities (Ellis 2000; Scoones 1998).

Legitimation of new arrangements or practices in the process of bricolage also plays out in our scenarios. There are clear demonstrations in the local narratives that certain practices are negotiated and contested. In an Indigenous community like Cumberland House, contestations

and negotiations usually concern responses between Elders and younger people. Often, Elders invoke the legitimacy of tradition and the right way of doing things (cf. Cleaver 2012) to guide practices, but younger people appeal to the reality of contemporary demands to negotiate older practices. For example, when Elders referred to the recent practice of accepting cash in exchange for wild meat as alien to Cree culture, they were actually invoking the legitimacy of tradition and implying a culturally desirable way of doing things as Cree. On their part, however, the younger harvesters asserted claims to the contemporary costs of harvesting and the demands of the market economy to negotiate the practice of sharing. We observed that both claims to tradition and contemporary demands tended to exist side by side in Cumberland House.

Furthermore, we observed that the practice of hunting moose out of season by younger hunters was made possible through negotiations, facilitated by the lack of success in the hunt and the cultural meaning of craving for a traditional diet. Importantly, the recognition by Elders that the hunters could not be completely blamed for killing moose out of season, when they had not consumed this culturally-relevant meat for a long time, meant that this practice seemed to have been well negotiated by the hunters. This, in effect, shows that the community of Cumberland House makes accommodations for changing practices in line with contemporary (livelihood) demands. In this case, the Elders legitimized the action of the hunters by asserting that they had not been successful in the hunt and were craving wild meat. This desire to eat a cultural diet was expressed largely in participants' narrations and was also used to reinforce the difficulty of sharing food when the harvest is poor.

How the characteristics of bricolage play out in the adaptation scenarios in Cumberland House reflects the pathways by which environmental and socio-cultural systems are interconnected (Fig. 4.3). As Adger et al. (2013) note, whereas people's actions affect the environment, changes in the environment, in turn, shape socio-cultural practices. Hence, for Indigenous communities living in fragile ecosystems like the delta, adapting to change has become an integrated part of their socio-ecological system (Turner and Clifton 2009; Turner and Spalding 2013). Our findings show that socio-cultural changes or responses do not just happen but rather can be understood as deliberate responses with institutional and productive assets at hand. The resulting adaptive practices through the process of bricolage indicate how the people of Cumberland House are responding to impacts of environmental change.

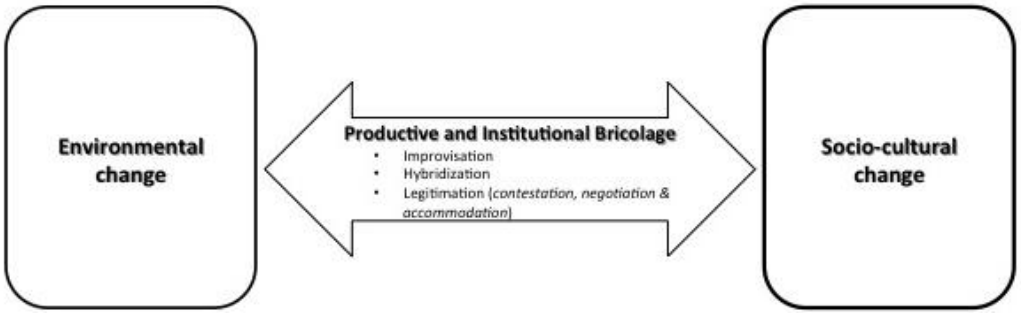

Figure 4.3: Interconnections between environmental and socio-cultural systems mediated through the process of bricolage

While the bricolage concept is very much associated with the construction of livelihoods, the literature has explored little about such connections. Here, we draw on the livelihood approach and suggest how the construction of livelihood can be observed through the bricolage lens. We find the bricolage concept useful for explaining many of the behaviours of individuals and households in creating and re-creating livelihoods. Regarding adaptation, we suggest that the bricolage concept is novel in revealing "a complex and underappreciated dynamic between human resistance and adaptation to environmental change" (Sayles and Mulrennan 2010:1). The concept is also novel in realizing how contemporary and longstanding institutional practices are brought together in creating different arrangements for adapting to change.

4.8 Conclusion

We set out to explore new platforms for understanding cultural dimensions of social-ecological change, adapting the concept of bricolage to analyze adaptation and livelihood responses. While social and environmental changes pose threats to cultural, institutional, and productive assets, responses are drawn from cultural assets at hand. More specifically, a bricolage perspective revealed how longstanding practices are negotiated, contested, improvised, or hybridized, to generate practices that account for contemporary realities such as road construction, ecological alteration, and the introduction of a market economy while retaining key traditional norms and values. For example, despite changing practices associated with food-sharing and hunting, the norms of respect and reciprocity – a value system based on

responsibility towards others, both human and non-human beings (Turner 2016) – continued to undergird all transactions. We have dispensed with the perception of Indigenous peoples as helpless victims of change by demonstrating *how* Indigenous peoples respond to changes in their social-ecological system.

A key contribution of this paper lies in unraveling how cultural connections to past practices are contested, negotiated, improvised, or hybridized with other practices within the context of contemporary changes and demands. In presenting Indigenous peoples as bricoleurs – both conscious and unconscious social agents – capable of recognizing and acting upon circumstances that confront them, we support the view that they demonstrate leadership in decisions about their future, particularly in the context of adaptations to environmental change. But as it is well known, the involvement of Indigenous communities in adaptation planning is rare, and the importance of their cultural values, norms, and past practices in shaping responses is not well recognized (Leonard et al. 2013; Salick and Ross 2009). We agree with others that if those values, norms, and cultural connections to past practices are ignored, it is likely that any externally initiated adaptation responses will fail because they are far from what matters to Indigenous communities (Adger et al. 2013; Turner et al. 2008). But if planners recognize Indigenous adaptive capacity and understand better how locally-effective adaptation responses are constructed, the involvement of Indigenous peoples in adaptation planning could become common practice. Application of the bricolage concept demonstrates a concrete way to document adaptations in the daily practices of Indigenous societies, offering governments and adaptation planners an important rationale for engaging Indigenous peoples and more effective ways of understanding their perspectives and agency when planning for adaptation.

CHAPTER 5 – CONCLUSIONS: UNDERSTANDING LONG-TERM SOCIAL-ECOLOGICAL CHANGE IN THE SASKATCHEWAN RIVER DELTA

5.1 Thesis Summary

Human-ecosystem interactions are more pronounced at the level where people derive their livelihoods and cultural meanings directly from the landscape. In the Canadian north, Indigenous peoples have over time depended directly on natural resources and have long interacted with their ecosystems (Usher 2000; Krupnik and Jolly 2002; Turner and Spalding 2013). They continue to experience environmental change first hand and to develop adaptive responses to these changes (Nickels et al. 2002; Salick and Ross 2009; Turner and Clifton 2009; Kofinas et al. 2010). They, therefore, possess long-term intimate knowledge of their environment and have a history of responding to environmental events (Berkes and Jolly 2001; Turner et al. 2000; Turner and Spalding 2013). Bringing their knowledge system into environmental decision-making and management can therefore both contribute to enhanced understanding of environmental change and impacts and guide more effective adaptation planning (Ignatowski and Rosales 2013; Turner and Spalding 2013; Boissière et al. 2013). Their cultural meanings and values derived from the landscape can also contribute to cultural valuation of ecosystem services (ES) (Chan et al. 2012).

However, it is widely documented that the contributions and involvement of IK and its holders in environmental management and decision-making have only recently been recognized and appreciated. For a long time, only Western science (WS) and scientists expanded our understanding of environmental change because IK was considered non-science (Wonders 2003; Agrawal 1995; Nadasdy 2003; Agrawal 2002). Today, however, IK is seen as scientifically useful and has been portrayed as science that can be used together with WS for enhanced understanding (Berkes 2012; Tsuji and Ho 2002; Usher 2000; Riedlinger and Berkes 2001). A major challenge now concerns how to use IK and WS together in a way that respects and maintains the integrity of both.

In a similar vein, Indigenous involvement in adaptation planning is limited (Salick and Ross 2009; Petheram et al. 2010; Leonard et al. 2013) because scholarly representations of Indigenous peoples are mixed, especially in the context of rapid environmental change. While some studies (e.g., Furgal and Seguin 2006; IPCC 2007; Ford et al. 2010) suggest that

Indigenous peoples are vulnerable to the impacts of recent changes, others (e.g., Nickels et al. 2002; Sayles and Mulrennan 2010; Turner and Spalding 2013) point to evidence of the inherently adaptive nature of Indigenous societies and cultures. In another strand of thinking, Indigenous cultural meanings, values and interpretations of the landscape have not been well integrated into ES valuations and frameworks (Turner et al. 2008; Chan et al. 2012). This is because much of ES valuation has focused on monetary contributions of ecosystems to human well-being. Hence, several questions have arisen that need to be empirically demonstrated: First, how can IK be used together with WS to better understand environmental change in a manner that the integrity of each is retained? Second, how have Indigenous peoples locally constructed adaptations to respond to environmental change? Third, how do Indigenous peoples interpret their cultural meanings from the landscape to reveal locally relevant sets of constituents of well-being necessary to include in ES frameworks?

The purpose of this research, therefore, was to investigate the long-term hydro-ecological change in the SRD, and examine the implications of those changes for the well-being and adaptation of the people of Cumberland House who reside there. This research brought together WS and the IK of the people of Cumberland House to better understand the long-term changes in the SRD. It also brought together cultural valuations and Indigenous concepts of well-being to understand how Cumberland House residents derive livelihood and cultural meanings from the SRD. Additionally, it drew on a bricolage perspective to understand how the people of Cumberland House construct adaptations that help them adjust to changes in the SRD. The objectives of the thesis were as follows: (1) to examine the long-term hydro-ecological change in the SRD by drawing on WS and IK systems; (2) to assess the cultural and spiritual values derived from the SRD, and explore how changes in the delta have affected the local interpretations of ecosystem services and well-being; and (3) to examine the adaptive strategies of the people of Cumberland House to the changing social-ecological system.

Chapter 2 detailed the long-term changes in the SRD. The operation of the E. B. Campbell dam in 1963 was used as a benchmark, and pre- and post-dam changes were investigated. For an enhanced understanding, the chapter used IK and WS together in a knowledge bridging exercise. The chapter demonstrated Miller et al.'s (2008) concept of epistemological pluralism in a research context through using Mi'kmaq Elder Albert Marshall's two-eyed seeing approach. It drew on and evaluated three knowledge sources – IK, instrumental

observations, and archival records – to search for synergies, contradictions, and knowledge gaps under three themes: hydrological change, fish and wildlife change, and vegetation change. The three data sources revealed areas of corroboration on topics such as alteration of seasonal flow, shrinking lakes and rivers, declining whitefish, sturgeon, and muskrat populations, and migration of moose to southern areas, among others. This high level of corroboration amongst the information sources was important because it increased confidence in the understanding of change in the SRD. However, there were instances where the knowledge systems differed. For instance, on topics such as water quality and northern pike production, there were inconsistencies in the information sources. In these cases, the findings revealed potential limitations in the accuracy of the knowledge sources, and therefore considered each as confirming the accuracy of the other and promoting further exploration. Information was also found only in one or two of the data source(s). A clear example was IK holders' comments about changes in the duration of berry-growing seasons; no such knowledge appeared in archival and instrumental records. This research, thus, would not have revealed this change had it depended on instrumental observations or archival records alone. In such instances, the chapter considered the knowledge source(s) as filling in the gaps that the other leaves behind. Such cases highlight the need for bringing multiple knowledge systems together for an enhanced understanding of long-term change. The two-eyed seeing approach demonstrated empirically how IK and WS can be brought together in a more respectful and appropriate way to overcome the issues of power that underpinned previous exercises of knowledge-integration.

Chapter 3 examined the socio-cultural impacts of the reported changes on the well-being of the people of Cumberland House. The chapter drew on Naomi Adelson's (2000) work on Cree conceptualization of health and well-being – translated as "being alive well" – to help understand the cultural meanings and values that the Swampy Cree of Cumberland House derive from the SRD. For the northern Cree, well-being has everything to do with life on the land and more broadly with "being Cree" (Adelson 2000). The chapter detailed six socio-cultural values – 1) traditional way of life; 2) maintenance of Indigenous culture; 3) closeness to nature; 4) physical strength; 5) sense of peace; and 6) fun and games – that residents of Cumberland House communities derive from the SRD. Changes, however, in the SRD have affected these socio-cultural values, thus impacting local well-being. The findings in this chapter gave rise to a set of well-being constituents specific to the cultural context of Cumberland House. Hence, this chapter

demonstrated a new approach to re-thinking the MA (2003) framework by clarifying how Cumberland House residents experience cultural ecosystem services. It provided a revised assessment framework with the local set of well-being constituents to advance understanding of Indigenous valuation of cultural ecosystem services.

Chapter 4 highlighted locally developed adaptive responses to the changes and impacts reported in Chapters 2 and 3. This chapter explored a new platform to engage with the cultural dimensions of environmental change. Drawing on the concept of bricolage, the chapter demonstrated that local residents improvise, hybridize, contest, and negotiate existing practices to create different kinds of adaptive arrangements. For example, the chapter indicated that residents adjust their hunting patterns (e.g., hunt out of season), pick berries at the U-picks, and process deer meat into sausages and hamburgers – practices that demonstrate bricolage characteristics of improvisation. Furthermore, the chapter found that residents' engagement in subsistence and income economies provides them the opportunities for the dynamic mix of elements of both economies that well illustrates characteristics of hybridization. The finding, for instance, that wage jobs and welfare payments support harvesting in the delta is indicative of a dynamic hybridity. The findings of this chapter, therefore, dispelled the perception of Indigenous peoples as "helpless victims of change" (Salick and Ross 2009:137) by demonstrating their agency in responding to changes in their environment. The chapter also revealed that, although practices change, key traditional norms and values such as respect and reciprocity remain.

In summary, by (a) highlighting long-term hydro-ecological change in the SRD, (b) illustrating the impacts of these changes on the socio-cultural values of Cumberland House residents, and (c) revealing the adaptive responses of local residents to changes in the delta, this thesis has specifically accounted for Cumberland House residents' interactions with the SRD and its services. It has shown, for instance, evidence of deeper meanings of change in the delta and how these meanings lead to cultural change and adaptation. Furthermore, it has revealed that residents possess certain knowledge of the delta that Western scientific techniques or instruments cannot observe or measure. To understand such knowledge involves long-term engagement and collaboration with the local residents. Moreover, the approaches and frameworks used in this thesis have demonstrated empirically (a) how IK can be used together with WS successfully while retaining the integrity of each, (b) how Indigenous peoples have locally constructed adaptations by drawing on their past, and (c) how Indigenous peoples have interpreted their

cultural meanings from the landscape to give rise to local sets of constituents of well-being to be included in ES frameworks.

5.2 Challenges

Although the objectives of this thesis were achieved, some challenges were encountered during the study. One of the challenges had to do with the archival research. In looking for historical information, it was difficult to know how much data was contained in the archives, and thus challenging to decide at what point to stop looking for information. I searched for archival information for about three months before leaving for Cumberland House for field research, and I continued to search for more historical information upon my return to the University of Saskatchewan. At some point I had to make a firm decision to stop looking for archival data and work with whatever information I had obtained. Although I had a lot of information to work with, I suspect I may have missed some relevant data in the archives.

Moreover, the local politics in Cumberland House, especially between the NVCH and CHCN (see below), posed some challenges in my engagement with the community. As mentioned earlier, as a municipal settlement (NVCH) and an "Indian" Reserve (CHCN), the two communities are politically distinct. The politics sometimes play out in the communities' engagement with outsiders, including government officials, policy and decision-makers, as well as researchers. To maintain the partnership that the large project team had with the two communities, and to avoid the impression that either of them was being sidelined in my engagement with them, I had to seek "positional spaces" (Mullings 1999:340) during my stay in Cumberland House. I was fortunate to stay at the teacherage – accommodations provided for teachers at the Charlebois Community School in Cumberland House – with a non-Indigenous person originally from Ukraine; hence, I was seen as not belonging to any faction. I was asked many times by residents from the two communities where I was staying. While I might be wrong that the reason behind this question was politically motivated, my answer that I was staying at the teacherage with the Ukrainian teacher was well received by those who asked.

Lastly, while I initially planned to interview four Elders, I ended up interviewing eight. The first four interviews were conducted in Cree, since these Elders were not comfortable speaking in English. I employed a Cree interpreter to assist me with the interviews, but how the

interpretation went was less than satisfactory. The interpreter summarized the Elders' responses, asked his own probing questions when he became interested in some stories he was hearing for the first time, and on many occasions personally responded to questions directed at the Elders since he believed the issue was common knowledge. Consequently, four English-speaking Elders were recruited to augment the findings from the four Cree-speaking Elders.

5.3 Contributions and Significance

The manuscripts in this thesis have contributed to both the theory and method for sustainability science research. Theoretically, this thesis has revised the Millennium Ecosystem Assessment (MA) framework by re-defining a set of well-being constituents specific to the context of Indigenous cultures to include in a new framework. The revised framework has contributed to advancing an understanding of cultural valuation of ES. Additionally, in this thesis I developed the concept of bricolage, originally used to explain institutional formation and forest-based livelihoods, to analyze the construction of adaptations. The novelty here is the way this thesis bridged institutional and productive forms of bricolage and applied it to explain how Indigenous societies build their adaptive capacity to address long-term social-ecological change.

Methodologically, this thesis has contributed to community-based research by demonstrating how non-Indigenous academics can appropriately engage and collaborate with Indigenous partners to build trust and work across cultural and knowledge divides. The research included community partners in the design of the study to ensure it reflected local priorities and perspectives. The research also used creative means of applying both IK and WS together to better understand and communicate changes in the delta. In particular, the two-eyed seeing approach used in this research offers one strategy that demonstrates how outsiders of Indigenous communities working at the interface of Indigenous and non-Indigenous knowledge can use both knowledge systems or combine a range of source material in a way that is rooted in a respectful and appropriate community-based methodology.

Specifically, by introducing a framework purposely for valuing cultural services, this thesis has contributed to non-monetary metrics for characterizing values of ES, which has received little attention in the ES literature. In particular, the framework used in this thesis captures the categories of cultural services that are not recognized or measured because they are,

to use Turner et al.'s (2008) word, "invisible"; hence, the thesis has contributed to the emerging knowledge that ecosystems provide a broad range of cultural services beyond those currently measured.

This thesis has also contributed to filling a thirty-year gap in information on the changing social-ecological system of the SRD. As mentioned earlier, the last time an ethnographic qualitative research was done to document socio-economic impacts of changes in the delta was in 1984 by James Waldram. Since Waldram (1989), no other research has been done to elicit perceptions and meanings of change in the delta even though much has happened in the thirty years since his research was published. This thesis has therefore provided community observations of change, impacts, and adaptations over the last three decades. Moreover, no study has been done on the spiritual and cultural values of the delta; therefore, another major contribution of this thesis is its investigation of the spiritual and cultural values that the people of Cumberland House derive from the delta.

In Canada, post-project impact assessments are uncommon. The few that exist are recent (e.g., Noble and Birk 2011; Noble and Storey 2005; Storey and Noble 2005). Hence, little is known about the long-term impacts of hydro-dams constructed when environmental impact assessments were not required. Since the E. B. Campbell dam is one of these early dams, this thesis has made a significant contribution to the sparse information on post-project impacts of dams by documenting long-term change and impacts resulting partly from the construction of the E. B. Campbell dam.

The findings in this thesis are significant in that they can inform policies and decisions regarding land use and development in areas inhabited by Indigenous peoples. For instance, this research has increased awareness of sensitive cultural values of ecosystems that can be helpful in informing policies around wildlife and resource management. The cultural ES framework in this thesis may help Indigenous peoples to negotiate resource rights by explaining, for example, that providing substitute provisioning ecosystem services (e.g., provided meat for hunted meat) is inadequate. The findings of this research have also provided important insights on adaptations in the daily practices of Indigenous societies, offering governments and planners an important rationale for engaging Indigenous peoples in adaptation planning.

5.4 Conclusions and Suggestions for Future Research

This thesis investigated the long-term hydro-ecological change in the Saskatchewan River Delta (SRD) and explored the implications of those changes for the well-being and adaptation of the people of Cumberland House in northern Saskatchewan. Using a metaphor of two-eyed seeing, this research (Chapter 2) drew from three different knowledge sources – IK, archival records, and instrumental observations – to derive a comprehensive understanding of the long-term change in the SRD. The two-eyed seeing approach was useful in drawing upon the strength of each of the knowledge systems to overcome the limitations in others. Hence, the thesis findings suggest that two-eyed seeing provides a more accurate description of long-term change than any single knowledge system or assessment could do alone. Moreover, when coupled with a commitment to community-based research, two-eyed seeing makes it possible for outsiders of Indigenous communities to use WS and IK in an appropriate way that demonstrates respect for both knowledge traditions.

By integrating Indigenous well-being into cultural valuation of ecosystem service, the findings in this thesis (Chapter 3) have better accounted for Indigenous peoples' interactions with the environment, especially the link between ecosystem change and Indigenous well-being. Importantly, this approach has demonstrated reciprocal interactions between Indigenous peoples and their ecosystems, revealing that ecosystem services not only contribute to well-being but also that well-being (e.g., access to resources, attachments to traditional activities, and cultural continuity), in turn, affects ecosystems and the services they provide. Moreover, by focusing on Indigenous perspectives of well-being, the thesis findings revealed that Indigenous peoples not only derive personal benefits from the ecosystem, but also consider the meaning of their relations with nature and with others. It is in the intimate kin and stewardship (respect and reciprocity) relationships that their notions of well-being are rooted and expressed. Changes, therefore, in the ecosystem influence their interpretations of ecosystem services. Accordingly, this thesis suggests that valuation of ecosystem services should be broadened to involve elements of relational value.

The bricolage perspective adapted in this thesis (Chapter 4) to analyze Indigenous adaptation and livelihood responses has shown a new platform for understanding cultural dimensions of social-ecological change. Significantly, the approach revealed how longstanding practices are negotiated, contested, improvised, or hybridized to generate other practices that account for contemporary realities of change. Both the older practices and the new practices co-

exist, so, for example, the market economy exists side by side with traditional practices such as hunting and fishing. In both, key traditional norms and values are retained. From these findings, this thesis suggests that Indigenous peoples are active social agents capable of recognizing and acting upon circumstances that confront them. This thesis, thus, supports the view that Indigenous peoples should guide decisions concerning their future, particularly in the context of adaptations to environmental change. They should, therefore, be directly involved in adaptation planning, so their values, norms, and cultural connections to past practices can be brought to bear on their current reality, and adaptations can focus on their communities' needs.

In conducting this study, I have suggested several areas for future research. First, the thesis findings speak to the need for frequent studies to be done on the SRD to offer up-to-date information on changes and impacts in the social-ecological system. Current data are important because, as this thesis revealed, limited ongoing monitoring or follow-up studies have created information gaps. As mentioned, since Waldram's (1989) socio-economic study in 1984, no similar study has been done, so there is no record of impacts and adaptations over the last three decades. This thesis fills this void and suggests that another wait for thirty years will again create a temporal gap in our understanding of the SRD.

Second, this thesis has demonstrated that bridging diverse knowledge systems to enhance understanding of social-ecological systems is empirically possible. I, thus, suggest that future research on complex systems should also bridge different knowledge systems for a more comprehensive description. Furthermore, in this thesis I used one approach – two-eyed seeing – for my bridging activity; future works could use different approaches for bridging knowledge systems. Such efforts would contribute more empirical examples on how bridging activities could be done successfully.

Third, in this thesis I applied frameworks that resulted in findings that are specific to the communities of Cumberland House in the SRD. For instance, though Cree concepts of health and well-being (*miyupimaatisiiun* or *mino pimacihisowin*) are broadly related to life on the land, my application of these concepts to Cumberland House gave rise to cultural and spiritual values specific to the context of SRD. Likewise, the application of the bricolage concept to Cumberland House highlighted adaptation responses specific to these communities. Therefore, there are opportunities to apply these frameworks offered in this thesis to other regulated inland deltas in Canada to examine the values that the surrounding delta communities derive from these deltas as

well as the local effective adaptation responses of those deltaic communities.

Lastly, as mentioned, many northern projects, including the E. B. Campbell dam, were constructed at a time when environmental impact assessments were not required. Given that post-project impact assessment in Canada is very recent (e.g., Noble and Storey 2005; Storey and Noble 2005; Noble and Birk 2011), little is known about many earlier projects. This thesis serves as post-project impact assessment/research for the E. B. Campbell dam, but more post-project impact assessment/research is needed to reveal the long-term impacts of earlier dams on northern environments and on Indigenous peoples who depend on the environment for their livelihoods. Such assessment should focus not only on environmental impacts but also on the socio-cultural implications of the long-term change.

To conclude, it is important to emphasize what might already be known in the literature: that doing research in Indigenous communities is challenging, expensive, time-consuming and requires commitment, the building of trust, and continuous deliberation. In particular, conscious effort and long-time collaboration and engagement with Indigenous partners are needed to use IK in ways that demonstrate respect for both IK and its holders. Such engagement is also required to balance local expectations and academic needs. Typically, these kinds of effort go beyond the capacity of a single individual or project. They require multiple strategies over multiple years. For students, this long-term commitment means learning the ethics of cross-cultural and community-based research, living and participating in research communities, gaining the trust of community partners, employing appropriate methods and processes of engagement, and finding creative ways to communicate research results. The efforts that I used and that are reported in this thesis are but one way of making this commitment.

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LIST OF APPENDICES

APPENDIX A: Hydro-ecological Changes in the Saskatchewan River Delta

Hydrological Changes

Table A.1: Scientific (archival and instrumental) records and community observations of hydrological changes in the Saskatchewan River Delta

Hydrological change	TEK from field interviews	Archival Records (Qualitative & Quantitative)	Instrumental Observations
Daily and hourly fluctuations and unpredictable water levels†	"*You might be in about a foot of water, by the end of the day if the water is going away from you, you might be in about 2inches of water. Or you might be in 3feets of water and if it is really windy, you might have about a foot of water only*." (**CC**)	Severe daily and hourly fluctuations in flows below Tobin Lake (e.g. daily fluctuations from September to February has changed from less than 500 ft^3/s 81 percent of the time and less than 1,000 ft^3/s 92 percent of the time in the pre-dam era to more than 500 ft^3/s 82 percent of the time and more than 4,000 ft^3/s 25 percent of the time in the post-dam era) (Committee on Saskatchewan River Delta Problems 1972); water level fluctuations in excess of one-half foot have become common in post-dam period (Waldram 1989); water level fluctuated nine feet in a span of twenty-four hours on August 28, 1984 (Waldram 1989).	Comparison of Water Survey of Canada gauges shows hydropeaking from 260 to 1140 m^3/s (Andrews 2015).
Lakes and rivers are getting shallower, shrinking and drying out†	*"We've lost a lot of water body, eh. Like, and now today it's just rivers going through those lakes eh. Like, and you can still see the outline of the lake, eh, because that's where the big trees are, eh, the big poplars, eh, like, and you can still see the outline of where the lakes used to be.*" (**GC**)	Smaller rivers and lakes are dying out because of low water (Waldram 1989); "Where there used to be a creek, today is nothing but bush. We used to go by canoes and today we can't. The lakes are just about dry in most areas" (Waldram 1989:18).	Reduction in average summer flooded area from 13% to 6% between 1913 and 2013 (Sagin et al. 2015).
No occurrence of ice jam; less deep ice breaks	*"We used to have some violent break ups from the ice eh. Boy, it was something to watch, you know. The whole community would run down the river and watch, you know. It was something to see every spring,*	No data	No data

	yeah, beautiful ice. Nice to watch, you know… We don't have those occurrences now. No. The ice slowly moves away. The water never goes overland now." (**DF**)		
Avulsion in 1870s	No data	River avulsion occurred in Saskatchewan River in the 1870s; over 500 km^2 of wetlands have been modified by the avulsion (Smith et al. 1989).	No data
Low water during dam construction†	"*Like when they built that dam, the water dropped about ten feet. Ten feet the water dropped because they had to back up all that water for power eh. The Saskatchewan River here, that you see there, it was so low you could walk across it. That's when they were backing up water for the dam in E.B. Campbell dam. And that was like that for – it was like that until freeze up*." (**NM**) "*People were walking across the Big Stone river the first time they shut it down. No water*." (**JC**)	Impoundment of Saskatchewan River to create Tobin Lake reservoir dropped water levels throughout the delta (Saskatchewan Archives Board R78-129 R-369).	No data
Less water in the delta; freezes to the bottom†	"*I know for a fact, eh, like, after they built that dam they short changed the delta sixteen percent of the water that used to come through here. And that sixteen percent, eh, has done a big impact*." (**GC**) "*In the wintertime when we try and fish out on the lake, there's hardly any water there. The ice just pretty much freezes right to the ground there…Like last winter the ice just froze right down to the bottom*." (**WC**)	Flood waters have been stored in Tobin Lake reservoir and have lowered the average water levels in the delta (Committee on Saskatchewan River Delta Problems 1972, Willard et al. 1978); most lakes are too shallow (Royer 1966, Brown and Werner 1969); reduced availability of water during low summer flows (Iverson 1977, Waldram 1989); no water in the Old Channel during the summer of 1984 (Waldram 1989).	No data
More silt has filled lake bottoms†	"*What's happening is, the lake is filling in with silt…*" (**RM**) "*The lake used to be a bowl, but now it is flat; the sediment has filled it*." (**RC**)	Silt deposits have filled in Cumberland Lake (Willard et al. 1978, Smith et al. 1998).	No data

Five fishing lakes are no more	"*Many lakes have dried up. Windy Lake…there's another Windy Lake within the system here, not the Windy Lake that we go in the wintertime. There's another Windy Lake here. And there's Sturgeon Fisheries Lake, Dumbbell Lake, Muskeg Lake, and Pine Bluff Lake. So all those lakes are gone now, eh. They're all gone now*." (**GC**)	No data	No data
Altered seasonal flow; low in summer, high in winter†	"*Our highest water was June and July. That's when we used to get floods in here…Now the way it is, they reversed that; the high water is in January, because they need the power. It's coolest and they need the power then, so that's when the high water is. It runs on top*." (**RM**)	Seasonal flows have changed from natural high summer, low winter to low summer, high winter levels (Godwin 1968, Committee on Saskatchewan River Delta Problems 1972, Iverson 1977, Waldram 1989); release of large quantities of water during winter months to generate power has resulted in higher than average winter water levels (Willard et al. 1978).	Reduced summer flows and elevated winter flows at gauge at The Pas in the post-dam era (Figure B.2).
Less spring inundation‡	"*I remember in the spring, there would be a spring break-up, and the water would go right over the banks…and flood the creeks, the channels…But that occurred annually, so they were prepared for it. But after the dam, that never happened. That is because the water's held back. There is hardly any water, and it didn't flood. It didn't go over the banks anymore and flood all the channels.*" (**LM**)	More frequent spring flooding in the past than present (Deloitte and Sells 1976, Waldram 1989); much of spring runoff used to fill Tobin reservoir for winter power generation (Committee on Saskatchewan River Delta Problems 1972, Waldram 1989); low water to flood the marshes (Iverson 1977, Prairie Province Water Board 1976).	Spring peak occurs on approximately day 120 (late April); it averaged ~1300 m3/s in the pre-dam era and is now ~1000 m3/s.
2005, 2011, and 2013 floods replenished the delta	"*But I don't know, for some reason, Razak, these past three floods that we've had, angling is going up. They've had a lot of success in catching sturgeon and walleye, like it's kind of exploded type of thing. But prior to 2005 you were lucky to bring home a walleye, and now people are bringing home their limits, six, seven, eight fish, oh yeah*." (**RD**)	No data	No data

No natural occurrence of flows and floods; recent floods are not natural†	"*There's no natural occurrence like water going overland. Back in… just recently, 2011, I think, you know, the water got high and they did get a little bit of water but it wasn't like the days when we got water going overland*." (**DF**)	Reduced occurrence of natural floods in spring and summer (Godwin et al. 1966, Prairie Province Water Board 1976, Willard et al. 1978); natural flood now only occurs during high water in the Saskatchewan River (Prairie Province Water Board 1976).	No data
Cumberland Lake is far now, no longer visible to the community†	"*Our lake is far out now. It's not even funny. You see, there's a lot of bush there now. There was no bush there at that time because it was just rocks. No bush. Like now you have to walk quite a ways because of the trees. I think our lake went down too – I would say*." (**HD**) *"The lake used to be close to the village, but now you can walk 3 miles before you meet the lake."* (**RC**)	The lake is no longer visible from the community (Waldram 1989).	No data
Cumberland Lake is shrinking, less deep†	*"Cumberland Lake was previously about 80 miles wide, stretching to the Pine Bluff area."* (**JC**) "*Cumberland Lake was 22 feet deep back then, eh. Like, and now today it's average about three feet deep*." (**GC**)	Cumberland Lake has reduced from average depth of 20 feet (6 meters) to average less than six feet (1.8 meters) (Committee on Saskatchewan River Delta Problems 1972, Willard et al. 1978); changes in mean monthly lake levels for the years 1953 to 1983 were in excess of one, and sometimes two, feet (Waldram 1989); reversal in the natural regime of the lake level – from a pattern of high summer low winter to a pattern of low summer high winter (Willard et al. 1978, Waldram 1989).	Before 2011, maximum daily water level in a given year was declining but high water years in 2011, 2013 and 2014 have reversed that trend (Figure A.1).
Depletion of oxygen†	"*When the lake freezes to the bottom, there is no oxygen in there*." (Field note)	Most of the lakes are subject to severe oxygen depletion during the winter (Royer 1966).	Of 26 lakes surveyed in winter 2014, half had dissolved oxygen <2 mg/L, with lowest concentrations in those lakes that were furthest from the river (MacKinnon et al. 2016).
Higher oxygen level in Cut Beaver, Waspisew and Redearth Lakes in winter	*No data*	Cut Beaver, Waspisew, and Redearth Lakes were found to be the only lakes which had sufficient oxygen during January (Royer 1966).	Of 8 lakes surveyed in winter 2014, Cut Beaver and Waspisew had highest oxygen (MacKinnon unpublished)

Exposed sandbars†	"*The first time I ever been out in this Cumberland, upriver here, it was just full of water…I could see a big open area. Now I just go there and I see islands all over the place. That's how much it changed*." (**JC**)	At average summer level of 871.5 feet, 111 islands are exposed on the [Cumberland] Lake; at 874 feet, 19 islands, and at 875 feet only 8 islands (Willard et al. 1978).	No data
Ice no longer floats†	"*When water is released by SaskPower in December, January and February, the water comes on top of the ice.*" (Field note)	The ice no longer "floats"; high water from the dam causes flooding of the delta ice surfaces (Willard et al. 1978).	No data
Sunlight gets to lake bottoms	"*You know, sunlight gets to the bottom; years ago sunlight didn't get to the bottom. And as a result you get more growth*." (**RM**)	No data	No data
Water in the marsh is stagnant, not fresh, and stinks†	*"There's a lot of stagnant water in the marshes, you know, in some places it doesn't smell very good because it's not running. They don't have a flow that they should*." (**DF**)	"Even where I trap in the Delta area, the water stinks because there is no movement of water. Before the dam, water was constantly moving…" (Waldram 1989:18).	Threshold for connection of wetlands to the Saskatchewan River is ~1000 m3/s (Sagin et al. 2015); this threshold was exceeded in every year between 1913 and 1962 (50 of 50 years) but was exceeded on only 38 of 46 years between 1968 and 2013.
Water is dirty, polluted, and unsafe for drinking†	"*Now we are scared to take even a mouthful of water when you're out there, you know, you don't know what's in the water*." (**DF**) "*But them years, it was good. It was really good in the'40s,'50s. Like I tell people it's brown now in the fall, eh? And when we were young, it was clear, light green. They really polluted, all the chemicals they emptied into the Saskatchewan River, they killed it*." (**EK**)	Water pollution from municipal and industrial sources (Committee on Saskatchewan River Delta Problems 1972); local expressions of concern with the turbidity of Cumberland Lake (The Lower Saskatchewan Basin Task Force 1979).	No data

† Topics where TEK, archival records, and instrumental observations corroborate or expand the information of the other

‡Topics where TEK, archival records, and instrumental observations differ/disagree with the other

Fish and Wildlife Changes

Table A.2: Scientific (archival and instrumental) records and community observations of fish and wildlife changes in the Saskatchewan River Delta

Fish and wildlife change	TEK from field interviews	Archival Records (Qualitative & Quantitative)	Instrumental Observations
No muskrats†	"*Two, three years already I haven't seen muskrat. There are muskrat houses but there's no water in them, just a house there…there's no water for them to live*." (**DS**) "*There're no muskrats now. Back in the day, they used to catch a lot of muskrats. They had no problem getting 100, 150 muskrats a day*." (**GC**)	Muskrat was scarce in 1947-48 (Saskatchewan Archives Board S-DNS1 I.A.368); muskrat harvest declined drastically during the 1969 and 1971 period (Committee on Saskatchewan River Delta Problems 1972); muskrat declined from a mean annual production of 18055 pelts in the pre-project period to 7512 in the post-project, a decrease of 58% (Waldram 1989).	Muskrat harvest in N28 and N90 blocks have declined to less than 100 per year (Figure B.3A).
Meat tastes different†	*"They're not very good-tasting rats, not like it used to be years ago*." (**RM**)	Ducks no longer taste as good as before (Waldram 1989).	No data
More dead fish are seen in the lakes during floods†	"*Like that 2005 flood when we went driving around me and bunch of my friends we seen floating fish all over, dead fish all over… I don't know what happened there like there was a lot of dead fish all over in the marsh*." (**DL**)	Fishermen often find dead fish on dry river beds after water has receded (Waldram 1989).	No data
More bears	*"I see a lot of bears all over the place. But mostly they know how to survive better than the moose or other animals because they can live in higher ground, the bear*." (**WC**)	No data	No data
Fish are contaminated with mercury†	"*Now our lake isn't even good to fish, we have so much pollution in our river system like mercury. They are saying our fish has mercury*." (**DL**)	Commercial fisheries were closed in 1969 and 1970s due to mercury contamination (Wobeser et al. 1970, Committee on Saskatchewan River Delta Problems 1972, Murray 1978, Department of Northern Saskatchewan (DNS) and Department of Tourism and Renewable Resources (DTRR) 1981).	Mercury concentrations in fish were high in the 1970s but have since been declining. They are now, on average, below the concentration considered safe to eat (Green et al. 2016).
Muskrats and beavers freeze to death†	"*And with the low waters, a lot of furbearers like muskrat and beaver, the lakes would freeze*	Muskrat and beavers forced out of homes and perish when water freezes to bottom	No data

	right to the bottom and there would be no water and they couldn't survive. I've seen that happen on some of those lakes back over here when the water was so low." (**GC**)	(Norris 1947, Waldram 1989).	
Muskrat production increased between 2005 and 2008 because of the 2005 flood†	"*We had an increase after 2005 till about 2007 and then our muskrats crashed in I guess you could call it the winter of 2007, 2008. We haven't had any since then. I'm still trying to understand why they didn't come back, because those two subsequent floods of 2011, 2013 should have brought them back, no they didn't. So, I don't know what happened*." (**LS**)	No data	Muskrat harvest increased from 40 in 2005 to 2935 in 2007 but then dropped to zero in 2010 (Figure B.3A).
Demise of goldeye fishery†	"*And one thing I notice too, when they fished, commercial fished, they used to go after a species called goldeye. And, oh, they used to get a lot of those. And now I don't even know. You know, nobody ever tries that*." (**DF**)	Goldeye fishery failed to recover after re-opening in 1979 following closure from mercury pollution (Department of Northern Saskatchewan (DNS) and Department of Tourism and Renewable Resources (DTRR) 1981).	>15000 pounds harvested in 1960s and >10000 pounds harvested in 1980s; decline to zero by 2005 (Figure B.4A).
More suckers; lots of pikes‡	"*There's always that northern pike where you can't get rid of that one. Lots of them jackfish*." (**GC**) *"There's getting to be more suckers when the water goes down that's when they lay eggs. And there're a lot of suckers in this lake and not enough 'money' fish. So the fishing is no good*." (**JC**)	Northern Pike were found throughout most of the delta; substantial numbers of pike congregated below Birch River dam and the Dragline channel (Royer 1966); suckers and pike have thrived in the deteriorating water conditions with the demise of the other fish species (Waldram 1989).	Pike harvest has also declined to near zero (Figure B.4B).
Low water expose nests and eggs	No data	Nests left exposed on barren shores when water levels declined, leaving eggs vulnerable to predators (Waldram 1989).	No data
Declining habitats, less hospitable and less accommodating†	"*The way it is right now, the water stagnates there and ferments and then turns into just like rotten eggs and muskrats can't survive in there*." (**RM**)	Habitat requirements of muskrat are not presently being met (Willard et al. 1978); presence of phragmites reduces pair use by dabblers (Dirschl et al. 1967); no	No data

	"*Our moose and deer and everything are moving on because there is no food out here for them*." (**DL**)	feeding grounds for waterfowls; their old feeding grounds are grown over with trees (Waldram 1989); lakes and streams are drying up, affecting moose food supply (Committee on Saskatchewan River Delta Problems 1972); moose habitat are less hospitable and less accommodating (Wilson and Kowal 2004).	
Declined whitefish production in Cumberland Lake†	"*Like that even whitefish we used to have lots of whitefish in Cumberland Lake and now we will be lucky to catch at least a tub of them out there in this lake eh, the water is so low and they don't…I don't know what happened to our fish*." (**DL**)	Whitefish were once taken in large quantities from Cumberland Lake, but since 1940s the catch has declined drastically (Royer 1966).	Peak of 20000 pounds of whitefish harvested in 1940s. Brief resurgence in 1980s but near zero since 2000 (Figure B.4C).
Declining moose population†	"*There's hardly moose now. There used to be lots of moose, even when you drive on the highway, you'll see about three, four moose a day when you travel there, and now… nothing now*." (CC)	Moose population has declined from average of $2/m^2$ ($5.17/km^2$) in the 1960's (Dirschl et al. 1967) to $0.08/m^2$ ($0.21/km^2$) in 2004 (Wilson and Kowal 2004).	No data
Decline in waterfowl nesting in the western portion of the delta	No data	130 ducks per square mile in 1960 to 50 ducks per square mile in 2007 (Slattery 2008).	No data
Sturgeon is endangered; production declined after 1973†	*"We are not allowed to commercial fish sturgeon. It is endangered species now. We are only allowed to catch one for food*." (Field note)	Low commercial sturgeon production after re-opening in 1973 following closure from mercury pollution (Committee on Saskatchewan River Delta Problems 1972, Department of Northern Saskatchewan (DNS) and Department of Tourism and Renewable Resources (DTRR) 1981).	Landings declined between 1985 and 1995 until the fishery was put in a moratorium in 1997 and officially closed in 2007 (Figure B.4D).
Abundant goldeye in 1950s and 1960s†	*"We used to catch goldeye here in the river, tons and tons of goldeye. Every fisherman used to get at least about 100 boxes, 150 boxes of goldeye. That's how plenty the goldeye was."* (**NM**)	Goldeye dominated the catches in gill-net sets in 1957 and 1958 (Reed 1962); more goldeye in 1960 (Kew 1962); 3,500 pounds of goldeye taken only in the night of August 30, 1966 (Royer 1966).	Goldeye dominated the fishery in 1950s and 1960s (Figure B.4A).
Fall spawning is disturbed	"*In the fall they're always filling up those reservoirs and of course they impacted the*	No data	No data

	downstream big time in the fall. And then nobody thought of what they were doing to the fall spawning, eh." (**GC**)		
Few lesser scaup†	"*There's one species of ducks that really went down in number…they started going down in the '70s. They're called scaup…they're right down in numbers.*" (**DF**)	Scaup population has declined across its range (Austin et al. 2006).	No data
Geese and ducks leave early now	"*You see, our geese stayed till November; most of the geese leave early now. Probably about October 15, October 12, they are gone. They will go. That's one big loss here*." (**CC**)	No data	No data
The delta (animals) is much quieter now	"*We're also noticing over the years…animals are much quieter now. So moose aren't calling as much…That we've noticed because before, you could sit out at night and you would hear the animals. Now, it seems to be quieter.*" (**RC**)	No data	No data
Waterfowl nest and rest in Tobin Lake reservoir	No data	Many waterfowl rest and nest in the Tobin Lake reservoir (Waldram 1989).	No data
Destruction of spawning areas†	"*My Elders and aunts have told me that the biggest spawning area for sturgeon, walleye was on the Tearing River here, but it kind of dries out, so I don't know if… At times it's dry, just a trickle of water goes by*." (**RD**) "*Goldeye used to spawn in the fall in the Old Channel. But now they are not spawning.*" (**GC**)	Destruction of sturgeon spawning grounds in Torch River and Squaw Rapids (Waldram 1989); limited and restricted area for sturgeon spawning (Department of Northern Saskatchewan (DNS) and Department of Tourism and Renewable Resources (DTRR) 1981); Tearing River, which was one of the best sturgeon fishing areas, now contains few fish (Waldram 1989); pickerel spawning grounds along the southern shore of Cumberland Lake have been seriously damaged (Waldram 1989).	No data
Disrupted fish migration; fish get trapped at the dam during floods†	*"When it floods, they have to open the spillway on the side. Like the dam's here and the spillway's over here and*	Fish are held back by the dam in Tobin Lake (Waldram 1989); fish are trapped and stranded at the dam's spillway	No data

	there's like a little lake here, small lake, that's where the fish will go. And then once the water recedes from the flood, then they'd hire us. They'd hire about four or five people, and they'd go salvage that fish." (**LM**)	basin during high water flows; 1,100 fish rescued at the dam on September 1, 2011 (Nipawin Journal 2011); some fish, especially sturgeon, are mutilated as they pass through the turbines at Squaw Rapids (Waldram 1989).	
Wildlife are drowned or stranded with water release; waterfowl nests and eggs are submerged under high water†	"*And I watched the moose and the animals when E. B Campbell release water in March. I watched the 8-12 moose and they were going upstream and they never reached. Because where they were going up they were in about 8ft of ice-cold water…They died of hypothermia*." (**CC**) "*Because you know when the water goes up they've got no place to go. Its food is all under water eh. Same thing when there's a – when they released the water early in the spring, they drown lots of eggs – duck eggs eh, goose eggs. All kinds of – all kinds of birds they're under water, they can't produce eh*." (**NM**)	Sudden increase in water flood out beaver and muskrat houses and food, waterfowl nests and eggs, and strand moose calves and other animals (Waldram 1989); upland bird habitat are lost with occurrence of flood (Willard et al. 1978).	No data
Whitefish in Cumberland Lake is no more grade "A"	"*People here go to Suggi Lake to commercial fish whitefish because the fish there is grade "A"; whitefish in Cumberland Lake is not grade "A*." (Field note)	No data	No data
Change in fish taste†	"*The taste of the fish has also changed. Sturgeon taste has changed for the past 15 years; it used to be that rich with nice taste but for the past 15 years it doesn't taste the same*." (Field note)	Residents feel that the fish no longer taste the same (Waldram 1989).	No data
Wolverines are coming into the delta	"*Even same thing with wolverines, eh, wolverines, they were further north, now we're starting to catch them here*." (**GC**)	No data	No data
Non-native birds are nesting	"*And there's other type of birds that we see here now that we*	No data	No data

	didn't have before, eh–One of them I know–what do you call it? There's [hawk] that looks like…looks like a seagull. I never used to see those before. And then there's a swordbird that I never used to see before that I see now." (**GC**)		
Most productive area was the Old Channel	*No data*	The bulk of 1958 fish harvest in the delta was taken from the Old Channel; commercial fishermen were making catches up to 600 pounds per night in August 1958 in the Old Channel (Reed 1962); most diversified fish faunas were found in the water bodies that had direct access to the Old Channel (Brown and Werner 1969, Committee on Saskatchewan River Delta Problems 1972).	No data
No more fishing in the Old Channel†	"*Back then they could fish on that Old Channel. That Old Channel, but that river dried up now*." (**DF**)	No data	Flows from EB Campbell of 850 m3/s correspond to only 65 m3/s entering the Old Channel (SWA 2003).
Hardly any coots	"*But one thing I find like there used to be so many of those coots, there used to be so many of them. Now there's hardly any of those around now. We used to collect eggs, eh. Last spring we went looking for some and we didn't find anything…about five, six years ago I started noticing [that coots were disappearing]*." (**GC**)	No data	No data
Moose are moving down south†	"*Like even all our moose, our deer, our elk, they are starting to go down south, even the muskrat themselves are going down south. It is getting very poor here. [They] go down south about around Tisdale area, Choiceland area, Wadena area, even Saskatoon they are starting to see moose, Regina they are starting to see moose in the street. There used to be no moose down there. Now they are migrating that way*." (**DL**)	Animals have left many of the traditional areas for areas with more stable water supplies (Waldram 1989).	In 2014, success rate of moose hunters in Wildlife Management Zones 60 and 61 were the third lowest (26%) and lowest (17%), respectively, of 45 WMZs across the province.

More moose harvest in the 1960s†	"*And in '69, in '69 I think it was. There was 1,800 moose that came out from our area out. They had a check station at Thunder Rapid there. Everybody that shot a moose as you were going out you had to report what you shot. And there was 1,800 moose that went out of our area, yeah, in one year. And I think that has a lot to do with the numbers declining…at that time there was a lot of hunters that used to come in into Cumberland and I think if I'm not mistaken I think the government allowed more than one moose at that time for one person*." (**DF**)	From 1956-66, sportsmen harvested an average of 460 moose per year and local residents harvested an average of 160 moose per year (Dirschl et al. 1967).	Estimated moose harvest in WMZs 60 and 61 was only 16 and 2 animals in 2014.
More fish in Tobin Lake, excellent for sport fishing†	"*When I go to P.A. I'm coming down a high hill there – I just hate coming down that hill on both sides – because I see those people taking off with big boats – Americans. Nipawin is making all the money. And they've got lots of water on that Tobin Lake, and we're dry here. They've got all our stuff over there, all our fish. The fish end up going that way*." (**LM**)	Excellent sport fishing occur at Tobin Lake (Waldram 1989). "I try to find time each June to go fishing at Tobin Lake, and I have to say the fishing is great," Premier Brad Wall said in a news release (Waterloo Region Record 2010).	No data
Commercial fisheries failed to recover after closure from mercury†	No data	Commercial fisheries in general failed to make substantial recovery after closure from mercury contamination (Damas and Smith 1980).	Three year gap was followed by initially good sturgeon harvest (~20 years) but goldeye and whitefish harvest was low after the moratorium (Figure B.4).
Colour of fish is different	"*The colour of the meat is not even right, you know, it's kind of a yellowish colour. It's no longer a nice white meat on the fish; it's not there anymore*." (**JF**)	No data	No data
Moose hunting was prohibited in the '40s	"*One time in the 40s there was hardly any moose, so they put a – they didn't let nobody shoot moose for ten years [in] Cumberland area, all over the place. That's when the moose population came up eh. It just kept on more and more*	No data	No data

	moose...twenty years, there was a lot of moose." (**NM**)		
Smaller deer antlers	"*But the thing I notice too is like when I was young, the deer, we trophy-hunt too for the antlers too sometimes, and back then you would see a lot of deer with bigger antlers than today, you'll see them average about this big – small. And back then average would be big, like this…way bigger*." (**GJ**)	No data	No data
Decline in walleye production since 1964†	*No data*	Since 1964, walleye production has followed an erratic decline (Committee on Saskatchewan River Delta Problems 1972).	Walleye production bounced back in the 1980s and 1990s (Figure B.4E) but declined since then.
Fish freeze and perish on ice surface in winter	No data	Fish are swept up onto the ice to die when high water is released in winter (Waldram 1989).	No data
Smaller fish size	"*Sturgeon fish no more weigh 100lbs and more; they are now small in size*." (Field notes) "*I used to catch 20lbs jackfish, but now I can't catch as big as those*." (**LM**)	No data	No data
More marten†	"*And another thing too…marten, eh, when we're trapping eh, marten there was nothing, was hardly anything, eh, just certain trap-line. Today there's loads of marten, every trap line you kill marten. [It] probably started about fifteen years ago, yeah…I never used to kill marten in my trap line, never, never…Now, today, like, I could go kill thirty, forty marten, and I never, never had them before there*." (**GC**)	No data	Marten were not trapped in N28 or N90 until approximately 1990; numbers have been steadily increasing (Figure B.3C).
Beavers are thriving†	"*The only animal that thrives – that's still trying to thrive is the beaver, the only one*." (**LM**)	No data	Decline in beaver numbers has not been as precipitous as muskrat (Figure B.3B).
The three floods [in 2005, 2011 and 2013] affected non-aquatic animals	"*Like for three years in a row we – there was a lot of big floods that killed lots of wildlife. Lots of wildlife – killed*	No data	No data

	lots of wildlife like moose, deer and bears and wolves, everything it killed. It's pretty hard on them eh. As the water goes up they don't have no food, like. Where my trap line is I – there's some pelts there that I miss like mice, weasels, squirrels, no more because they – the water got so high they starved to death. Because you know when the water goes up they've got no place to go. Its' food is all under water eh." (**NM**)		
Wildlife are slowly coming into the community	"*The wildlife are slowly coming in our community. Yeah, there'll be a bear walking behind here eating berries at night, when the berries come out, yes. Wolves coming closer to the community because of the water getting high they need to find dry land to survive*." (**CL**)	No data	No data
Deformed fish are being caught	"*I started seeing some fish with some lumps like they have lumps on the side, there are some fish they only have three fins, there are some of them will have missing fins, or some will have no back fins and stuff like that*." (**DL**)	No data	No data
Few swans and less geese	"*Geese are declining lots, too, because there used to be a lot of geese here, too. Now there're only maybe a few*." (**JC**) "*In the 60's, 70's when we looked out in the lake you could see–and towards the Oldman's, I would say–you could just see that white like snow on the lake and those were all swans– hundreds and hundreds of swans just sitting on the lake there. And it looked like snow. Now you don't see any thing. Nothing.*" (**HD**)	No data	No data
Less robins	"*Robins were plentiful…barely see any robins now*." (**HD**)	No data	No data

† Topics where TEK, archival records, and instrumental observations corroborate or expand the information of the other

‡Topics where TEK, archival records, and instrumental observations differ/disagree with the other

Vegetation Changes

Table A.3: Scientific (archival and instrumental) records and community observations of vegetation changes in the Saskatchewan River Delta

Vegetation change	TEK from field interviews	Archival Records (Qualitative & Quantitative)	Instrumental Observations
More vegetation growth on lake shorelines†	"*Our lake is getting smaller and smaller, because of the vegetation, it's just starting to grow on the edges of the lake there*." (**WC**)	There has been rapid shoreline growth resulting from low water in the lakes; new vegetation have gained hold of exposed lakes' bed (Waldram 1989); establishment of willow communities in the extensive shore and delta regions (Willard et al. 1978); the delta is in a state of succession from marsh to more terrestrial-like features (Wilson and Kowal 2004).	22% reduction in Cumberland Lake area between 1957 and 2002 (N. Smith reconstruction based on aerial photos).
No burning in the past 20 years†	"*What used to happen like thirty years ago is, these trappers took their own and they burnt the hell out their trap lines when they knew they needed a good burn…And we haven't done that in the last probably fifteen, twenty years it hasn't been done. So it does need to happen…there's no new growth there.*" (**AM**)	Wildfire suppression has permitted vegetation overgrowth (Wilson and Kowal 2004).	No data
Overgrowth of emergent aquatic vegetation†	"*30 years ago you could move in the river with motors, but now the vegetation is growing in the river…difficult to travel*." (**RC**)	Emergent aquatic vegetation has become so profuse in some delta lakes so as to make boat travel almost impossible; phragmites and bulrush has formed an almost solid stand of vegetation (Royer 1966).	No data
Changes in berries seasons	"*Like I remember one summer, Karen and I, we were picking Saskatoons in July instead of June. And then we were picking raspberries in August [instead of mid-July]. And even strawberries, one time, we were picking them late*." (**WM**)	No data	No data
Less gooseberries and	"*We used to pick the*	No data	No data

chokecherries	*gooseberries; there was lots back then, I think anyway. Now you only see them in little bunches every once in a while. In fact, we don't even pick them anymore*." (**KC**) "*It's the gooseberries that I don't see very much of now, and the choke cherries*." (**WM**)		
Blackberries are disappearing	"*I haven't found blackberries for many, many years now*." (**WM**)	No data	No data
Less chestnuts	"*We found a lot of chestnuts. But we don't anymore…I don't see very many of those trees around anymore*." (**RD**)	No data	No data
Tiger lilies are disappearing	"*Today now I can barely see any of the tiger lilies. There used to be plenty on the highway*." (**HD**)	No data	No data
More dead willows and grass	"*Another thing I noticed too is about eight years ago I'd say, I think yeah, about eight years ago, there is so much dead grass all over…there's layers and layers of dead grass and there's nothing growing*." (**GC**)	No data	No data

† Topics where TEK, archival records, and instrumental observations corroborate or expand the information of the other

APPENDIX B: Instrumental and Archival Hydrology, Fish, and Wildlife Data

Figure B.1: Maximum daily elevation (meters above sea level) of Cumberland Lake, the largest lake in the SRD, over the period 1953 to 2013

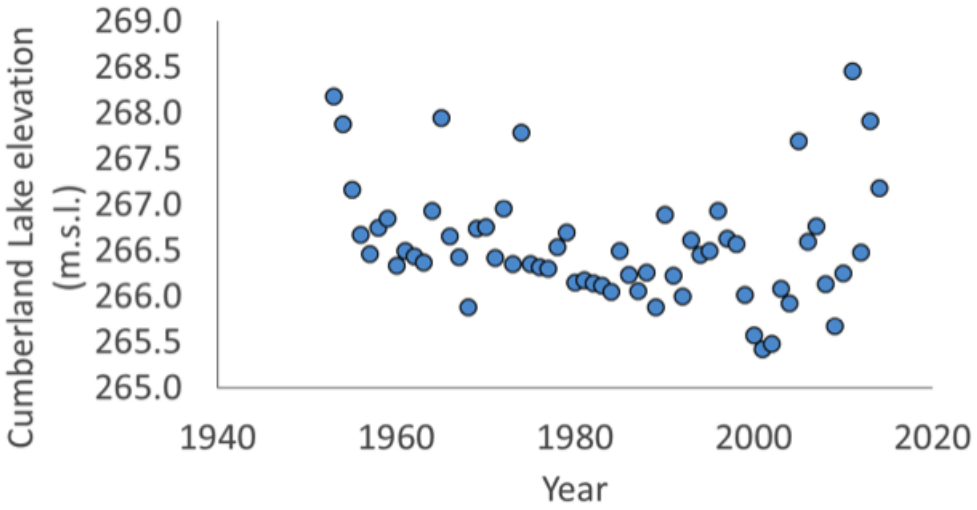


Figure B.2: Daily discharge for Saskatchewan River at The Pas (WSC gauge 05KJ001) over the period 1913-2014. Note elevated winter baseflow and reduced flood peaks since the 1960s

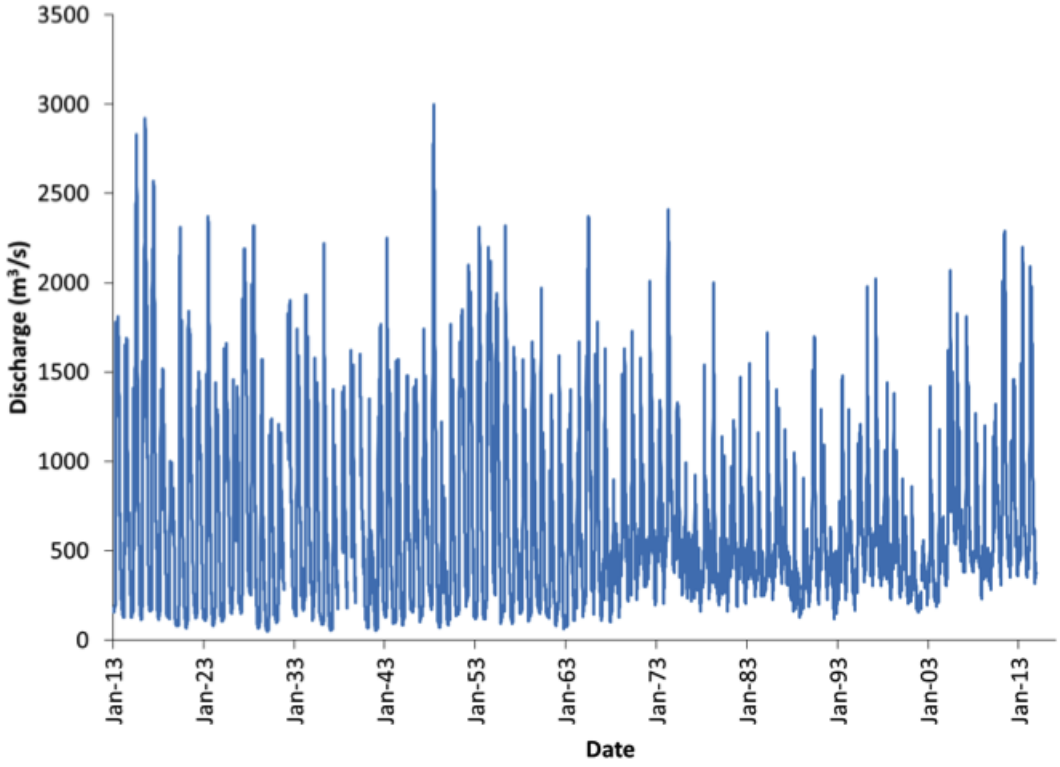


Figure B.3: Annual harvest of muskrats from two trapping blocks in the SRD

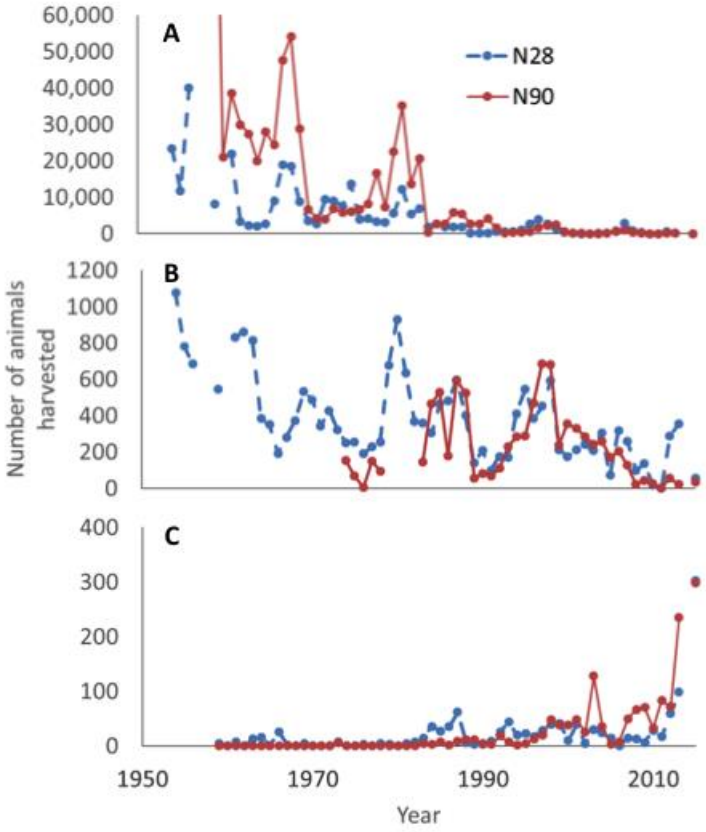
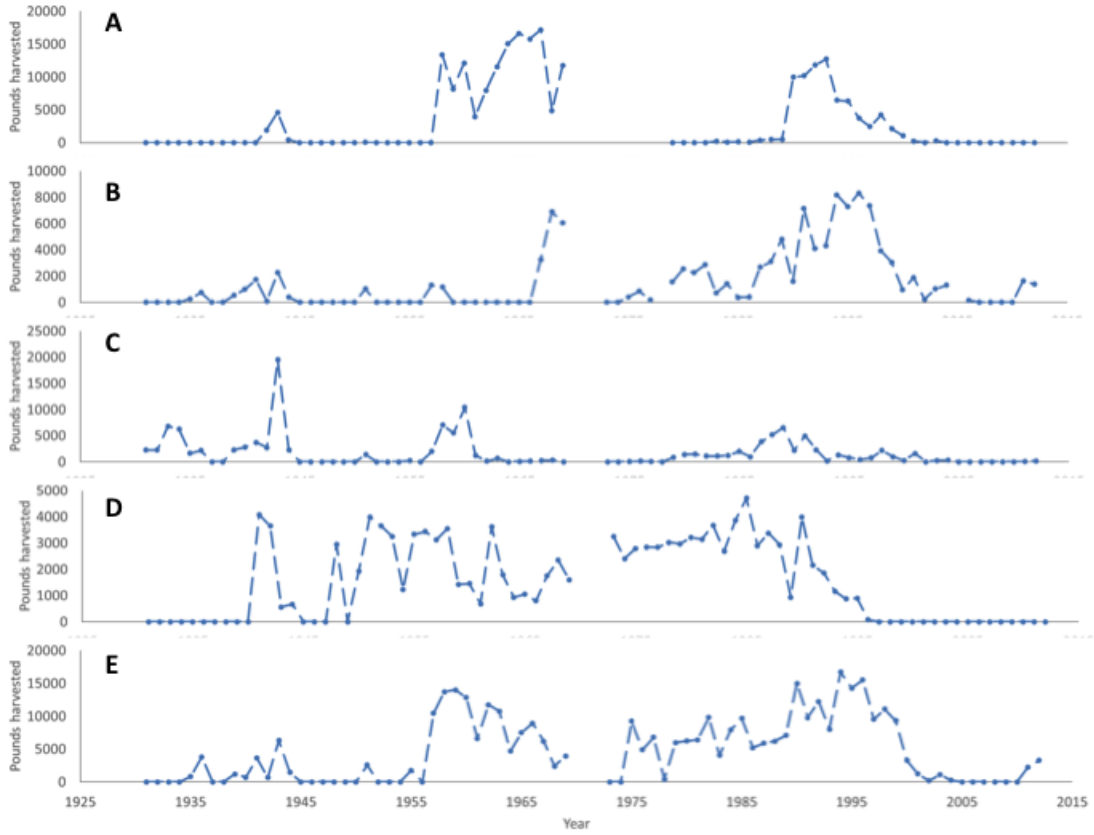


Figure B.4: Annual catch (pounds) of goldeye (A), northern pike (B), lake whitefish (C), lake sturgeon (D) and walleye (pickerel) (E) by Cumberland House fishermen



APPENDIX C: Narratives on Socio-cultural Values of the Saskatchewan River Delta

Table C.1: Narratives on traditional way of life

Summary statements	Narratives on traditional way of life
It is a lifestyle.	"That was my dad's lifestyle, my grandparent's lifestyle, and that's why it came to me, and I told myself this is going to be me." (**DL**)
We grew up doing this; it's part of who we are.	"It's just the way we grew up … people my age, eh, we grew up doing this … And we do it for the love of it, eh, like, it's not about the money, but it's a way of life, eh, it's part of us." (**GC**)
It was life on the trap-line.	"Life on the trap-line, oh, it was wonderful. To me, you know, that was the life, even though it was hard work." (**RM**)
The delta is our grocery store.	"They help with a lot of our grocery bill, that moose meat and the ducks and the fish." (**FM**)

Table C.2: Narratives on maintenance of Indigenous culture

Summary statements	Narratives on maintenance of Indigenous culture
It needs to be passed on to the children.	"I'd like to see it passed on. My own boys are doing it and I really want to see that traditional stuff continue on. And I'd like them to know our culture and where we come from, and all I can say about that is just not to completely lose it… No, I don't want it to be lost, no." (**RM**)
We feed children with wild food.	"We try to feed our kids with wild food … Children would eat wild food when they grow up with it." (**IM**)
Our culture is to share whatever we kill.	"The Elders, like if they request for stuff like I try go get them. Like one Elder asked me: "could you get me a rabbit, I need to eat a rabbit really bad." So what did I do? I went to get him a rabbit. And one asked me: "I need to eat a muskrat, can you get me a muskrat", and I got a muskrat. And the Elder that I go give it to I can't wait to see the smile, they will be so happy for it, yeah. And the rabbit too they will be so happy for that. So I was grateful to get those two little things." (**DL**)
We do it to keep our culture going.	"For us, I think we berry-pick just because we want to maintain that, you know, we want to maintain that." (**WM**)

Table C.3: Narratives on closeness to nature

Summary statements	Comments on closeness to nature
There is that connection with nature.	"When you get into that bush, it's like another world. It really is like you're stepping into another world. I feel like, I don't know, a spiritual connection there." (**RD**)
We get to interact with animals.	"We get to see moose, you know, when they're first born … You'll see ducks their eggs hatching … You watch muskrat right close by eating there." (**DF**)
You are close to your Creator.	"When you are out there on the land, you are all alone. You know that it's you and your creator. You always ask for help; you always talk to your creator." (**CC**)

Table C.4: Narratives on physical strength

Summary statements	Comments on physical strength
We were more active in the bush.	"Traditionally we were active … Like we had to go hunting for our food, you know, you had to move around." (**RM**)
Life on the trap-line is healthier.	"Out on the trap-line, shucks, I could go 10, 20 miles one day and come back just walking. My life on the trap-line is still better and it's healthier." (**JC**)
The old people were not sick and lived longer.	"Look at my mom. She never had diabetes. She never went to a hospital and she lived to be 100 years old. But she was on wild stuff – the real stuff that grows in a garden – most of her life, all her life because that's how she lived – my mom. She grew up to be healthy. She didn't have diabetes or stuff." (**HD**)
Wild food is healthier.	"We had plenty of food from the delta and it was clean … The food didn't make us sick. Nowadays you get if from the stores, and it's not healthy." (**LM**)

Table C.5: Narratives on sense of peace

Summary statements	Narratives on sense of peace
It is peaceful out there.	"Oh, it's so peaceful and you don't even think of anything else. All the worries just go away." (**GJ**)
You feel free in the bush.	"Whew… it's a healer. I mean it's a healer when you're out there. You feel free, yeah … It's awesome." (**AM**)
It's relaxing.	"To me berry-picking is relaxing. People think of it as work and sweat, but you know, like for me it's a time to myself, a time to reflect, lots of thinking." (**KC**)
You get away from all the stress at home.	"You don't hear the phone ringing. You don't hear vehicles…quiet, peace and quiet … I don't even phone my wife. I know as part of the reason that I go out there is getting away from my wife." (**GC**)

Table C.6: Narratives on fun and games

Summary statements	Comments on fun and games
We had sled dogs for racing.	"We'd try and drive dogs and go into races. And our teams used to do good because we were always working with them. There were three world champions from here." (**JC**)
Life was fun on the trap-line and in camps	"You know, as a kid when we used to go to these trap-lines there'd be a few families in the same camp. And, you know, me personally, I used to enjoy that." (**DF**)
It feels good to hear animals' callings.	"In September the elk would start calling I think around the 15th. Boy, they make beautiful noises. Their calls – they come up with different calls … It's beautiful standing on the road listening to those animals." (**LM**)
We have couple of fish derbies each year	"People come out here to enjoy themselves, watch the scenery, boat rides. They come from all over. Like that Senator Pierre Settee – that's a big one all the time. That's fish derby they have; that's what it's called. They have a truck and a car for first and second, and third for maybe three, four grand. Yeah, but you pay $150 a ticket but that's the chance you're taking too."(**DS**)

It's exciting to have your (first) kill.	"When I turned thirteen, I shot my first moose, yeah… Like I can't even explain it, so excited. When I first saw the moose I couldn't even put my bullet in the chamber, I was shaking too much; I was so excited. That'll be a day I'll never forget." (**GJ**)

Table C.7: Narratives on impacts of change on well-being

Summary statements	**Comments on impacts of change on well-being**
We feel sad when we reminisce about the past.	"You remember the times that your father was trapping there and now it's gone, and it's a very sad feeling." (**CC**)
We missed the life on trap-line.	"In a way I wish to have been on the trap-line still. I wish we still had that kind of life…I kind of wish sometimes. But no, it's not going to happen. Things have changed too much." (**HD**)
It is depressing when you can't go into the bush.	"I know a lot of older guys that can't trap anymore eh, and some of them get sick, you know, just lonely. They can't go out. Even me when I can't get out, I feel like I'm, I don't know, I feel very depressed or something because I have always been the person to be out there eh." (**GC**)
We are all craving for muskrat.	"Everybody in the community right now all the Elders and the middle people like 30 years old and up eh like we are all craving for muskrat." (**DL**)
It is a loss of identity.	"So if you take away hunting and fishing, it really becomes like that's who we are. So that's a big question because how do you take away who people are. And this is your land base. This is where people have -- you have this connection. And so you're saying what would happen if you take away somebody's home." (**RC**)
Our livelihood is disappearing.	"Like right now today you only go out there for, just like a hobby, you know, trapping. Very few trappers are left here in Cumberland. Not so many people trap there now for livelihood, it's mostly for hobby now." (**JF**)
It feels difficult now to share.	Even like this little one muskrat, it's even hard on me to give out that one muskrat, yeah. I want to eat muskrat really bad eh, but it has been asked by an Elder I have to go give to the Elder. It is pretty hard to go give it out. (**DL**)

APPENDIX D: Research Certificates and Instruments

Research Certificates

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB)

Certificate of Re-Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	Beh #
Timothy D. Jardine	School of Environment and Sustainability	13-42

INSTITUTION (S) WHERE RESEARCH WILL BE CARRIED OUT

Cumberland House
Saskatchewan

SUB-INVESTIGATOR(S)

Maureen G. Reed, Ken W. Belcher, David C Natcher, Douglas Clark, Renee Carriere

STUDENT RESEARCHER(S)

Razak Abu, Merle Massie, Merle Massie, Jay Sagin, Graham Strickert, Graham Strickert

FUNDER(S)

CANADA EXCELLENCE RESEARCH CHAIR

TITLE:

Assessing the Links Between Water, Animals and People in the Saskatchewan River Delta

RE-APPROVED ON	EXPIRY DATE
14-Feb-2014	13-Feb-2015

Full Board Meeting ☐

Delegated Review ☑

CERTIFICATION

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.usask.ca/research/ethics_review/

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB)

Certificate of Approval
Study Amendment

PRINCIPAL INVESTIGATOR	DEPARTMENT	Beh #
Timothy D. Jardine	School of Environment and Sustainability	13-42

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT
Cumberland House
Saskatchewan

SUB-INVESTIGATOR(S)
Maureen G. Reed, Ken W. Belcher, David C Natcher, Douglas Clark, Renee Carriere

STUDENT RESEARCHER(S)
Razak Abu, Merle Massie, Merle Massie, Jay Sagin, Graham Strickert, Graham Strickert

FUNDER(S)
CANADA EXCELLENCE RESEARCH CHAIR

TITLE
Assessing the Links Between Water, Animals and People in the Saskatchewan River Delta

APPROVAL OF	APPROVED ON	CURRENT EXPIRY DATE
Addition of House Hold Survey Participant Consent Form Survey	18-Feb-2014	13-Feb-2015

Full Board Meeting ☐

Delegated Review ☒

CERTIFICATION

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: *http://www.usask.ca/research/ethics_review/*

Participant Consent Form

Project Title: Knowledge, Use, and Change in the Saskatchewan River Delta: Assessing the changing livelihoods of Cumberland House Métis and Cree Nation

Researcher: Razak Abu, Graduate student, School of Environment and Sustainability
117 Science Place, University of Saskatchewan, Saskatoon, SK, S7N5C8
Phone number: 306-715-5951 or 306-966-7492
razak.abu@usask.ca

1st Supervisor: Dr. Maureen Reed, School of Environment and Sustainability &
Department of Geography
117 Science Place, University of Saskatchewan, Saskatoon, SK, S7N5C8
Phone number: 306-966-5630
m.reed@usask.ca

2nd Supervisor: Dr. Tim Jardine, School of Environment and Sustainability &
Toxicology Center
44 Campus Drive, University of Saskatchewan, Saskatoon, SK, S7N5B3
Phone number: 306-966-4158
tim.jardine@usask.ca

Purpose and objectives of the Research:

This project will attempt to explore the impacts of changing river flows in the Saskatchewan River Delta on the livelihoods and well-being of the people of Cumberland House. It aims to understand how changes in river flow influence wildlife and plant production in the delta, and how communities in the region harvest these resources. By exploring the impacts of changing river flow on the livelihoods of the people of Cumberland House, this study will show local resource use in the delta, which can help evaluate the ecological and societal consequences of future upstream water resource development.

Procedures:

This research will involve my participation in your traditional activities – fishing, hunting, trapping, plant gathering – where formal and informal observations, as well as unstructured and semi-structured interviews will be conducted. I am asking you to involve me when you go fishing, hunting, trapping, or plant gathering, and to spend time with me to complete an interview as I seek to learn and understand your resource-use in the delta.

With your approval, photos from participation and observation may be taken and included in the thesis. The interviews will also be audio-recorded, transcribed verbatim, and included in the thesis and other academic publications. However, after transcribing, you will have the opportunity to review your information, and whatever information you deem sensitive to be shared with the public will be deleted. If you are uncomfortable with having the interview taped, you can let me know and I will take notes instead. I am anticipating that other members of the

Hunters and Trappers Association and the Fishing Co-operatives will also be participating in this study, but your information will not be shared with them without your consent.

You are free to ask any questions regarding the procedures and goals of the study at any point during the research activities.

Potential Risks:

There are no anticipated risks associated with your participation in this study. Should you feel uncomfortable, you have the right to withdraw at any time in the research process.

Potential Benefits:

This project could benefit Cumberland House by helping to identify the effects of upstream water resource development on local use of the delta. This information may guide policies and sustainable management of the delta, as it will inform government and SaskPower about how the people of Cumberland House use the delta. It may also encourage the engagement of Indigenous peoples in decision-making regarding the delta. Other possible benefits of the study include passing on your knowledge to the next generation, and sharing your knowledge with U of S researchers who are working with CHCN and NVCH to better understand the Cumberland Marshes/Saskatchewan River Delta. These benefits require your ongoing participation in the project.

Confidentiality:

- All efforts will be made to ensure that your participation and information are kept confidential.
- Except you request so, your identity and name will not be linked with any information that you will provide, and they will not appear in any report or publication from this study.
- You are free to suggest a location that is comfortable and acceptable to you for interviews to be conducted.

Storage of data:

- All information will be stored in encrypted files on a password-protected computer owned by the researcher.
- Consent forms and other identifying materials will be stored in a locked cabinet separately from collected data.
- Data will be stored for a minimum of 5 years at the University of Saskatchewan.
- With your permission, other co-investigators from the University of Saskatchewan working on the same project may use data.
- When data is no longer needed, it will be destroyed beyond recovery. All files will be deleted from the computer.

Right to Withdraw:

Your participation in this research is voluntary, and you can choose to answer only those questions that you are comfortable with. You are also free to withdraw for any reason, at any time, without penalty of any sort. Should you wish to withdraw, all your information will also be destroyed. Your right to withdraw data from the study will apply until November 30th, 2014. After this date, it is possible that some form of research dissemination will have already occurred and it may not be possible to withdraw your data.

Follow up:

Data results will be presented first to you and other participants and then with the community's blessing may be used for presentations at conferences and in academic and policy publications. Papers written based on this project will be shared with you for your possible feedback and suggestions, prior to publication. Verbal presentations on the project are also available on request.

Questions or Concerns:

If you have any questions concerning the research project, please feel free to contact the researchers at the numbers provided. This research project has been approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board in February 2013. Any questions regarding your rights as a participant may be addressed to that committee through the Ethics Office (306-966-2084 or ethics.office@usask.ca). Out of town participants may call toll free (1-888-966-2975).

Consent to Participate:

I have read and understood the description provided; I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in the research project, understanding that I may withdraw my consent at any time. A copy of this Consent Form has been given to me for my records.

_____	_____	_____
Name of Participant	*Signature*	*Date*

_____	_____
Researcher's Signature	*Date*

☐ Do not include my name anywhere ☐ Include my real name in publications

☐ Do not take photos ☐ Take photos

My de-identified information collected in this study can be used for secondary research projects:
☐ No ☐ Yes

Transcript/photo release form

Title: "Knowledge, Use, and Change in the Saskatchewan River Delta: Assessing the changing livelihoods of Cumberland House Métis and Cree Nation"

I,_____, have reviewed the complete transcript of my personal interview in this study, and have been provided with the opportunity to add, alter, and delete information from the transcript as appropriate. I acknowledge that the transcript accurately reflects what I said in my personal interview with Razak Abu. I hereby authorize the release of this transcript to Razak Abu to be used in the manner described in the Consent Form. I have received a copy of this Data/Transcript Release Form for my own records.

As well, I have had an opportunity to review the photos and I authorize the use of them for:
Analysis _____ Dissemination_____

_____ _____
Name of Participant Date

_____ _____
Signature of Participant Signature of researcher

Basic questions

1. Please tell me your name (*if name is known, the spelling will be confirmed*).

2. Are you between: 15-24; 25-34; 35-44; 45-54; 55-64; or over 65years?

3. How long have you lived in CH?
   If not all your life,
   When did you come here?
   Where did you live before?

4. Do you trap?
   – hunt?
   – fish?

5. How many years have you been trapping?
   – hunting?
   – fishing?

6. How old were you when you first trapped?
   – hunted?
   – fished?

7. Who taught you how to trap?
   – hunt?
   – fish?

8. Where (in the Cumberland Delta) did you first trap?
   – hunt?
   – fish?

9. What changes in the delta have you heard from Elders or seen/experienced yourself?
   What were the cause(s) of such changes?
   How did those changes affect hunting, trapping, fishing?

Wildlife and Fish species *(questions in this section can be follow-up on questions in other sections)*

1. Are there any changes in the number or location of wildlife (muskrat, moose, beaver, etc.) or fish (walleye, sturgeon, northern pike, etc.) in the Cumberland Delta *(The species must be taken one by one)?*
    - What accounts for these changes – changing water levels, pollution from agricultural fields, over hunting/fishing, etc.?

Hunting

Introduction: now, I would want us to focus our conversation on hunting.

1. Why do you hunt?

2. How has hunting changed over the years – in the 40s, 50s, 60s, 70s, etc. depending on the age of the interviewee?
    - What kinds of changes – safety, location of hunt, number and type of species hunt, hunting seasons, hunting effort, use of technology/equipment, cost of hunting, etc.?
    - What accounts for these changes – changing water levels, changing species mix, government regulations, fur prices, changing technology, changing cultural practices, etc.?

3. How has changes in hunting affected your livelihood?

4. Do you hunt in the same places as you did when you started hunting? (Explain why or why not).

5. Tell me about the seasons and times you do hunting. At what times of the season do you hunt muskrat, moose, elk, deer, etc.? *(Turn to **table 1** below to record this information for different species)*

Trapping

Introduction: now, I would want us to focus our conversation on trapping

1. Why do you trap?

2. How has trapping changed over the years – in the 40s, 50s, 60s, 70s, etc. (depending on the age of the interviewee)?
    - What kinds of changes – safety, location of trap, number and type of species trap, trapping seasons, trapping effort, use of technology/equipment, cost of trapping, etc.
    - What accounts for these changes – changing water levels, changing species mix, government regulations, fur prices, changing technology, changing cultural practices, etc.?

3. How has changes in trapping affected your livelihood?

4. Do you trap in the same places as you did when you started trapping? (Explain why or why not).

5. Tell me about the seasons and times you trap. At what times of the season do you trap various species of animal? *(Turn to **table 2** below to record this information for different species)*

Fishing

Introduction: now, I would want us to focus our conversation on fishing

1. Why do you fish?

2. How has fishing changed over the years – in the 40s, 50s, 60s, 70s, etc. (depending on the age of the interviewee)?
   - What kinds of changes – safety, location of fish, number and type of species catch, fishing seasons, fishing effort, use of technology/equipment, cost of fishing, etc.?
   - What accounts for these changes – changing water levels, changing species mix, government regulations, changing technology, changing cultural practices, etc.?

3. How has changes in fishing affected your livelihood?

4. Do you fish in the same places as you did when you started fishing? (Explain why or why not).

5. Tell me about the seasons and times you do fishing. At what times of the season do you fish various species (sturgeon, whitefish, goldeye, etc.)? *(Turn to **table 3** below to record this information for different species)*

Adaptation

Short-term responses

1. When your catch changes in a season (say you get more or less than usual), what adjustments do you make?
   E.g., if more – do you share more, store more, etc.?
   If less – do you buy more from store, do without?

2. What kinds of changes have you made in your hunting/trapping/fishing practices since you started – changed location, changed prey species, changed timing, changed associated practices such as food sharing?

Long-term responses

1. Tell me about group hunting, trapping, or fishing. Do you go hunting/trapping/fishing in groups?
   If yes, how was it done in years ago, and how is it done now?
   What used to be the group size; what is the average size now?

2. Tell me about species switching?
   Can one species harvest (say muskrat, moose, etc.) compensate for another (say beaver, deer, elk, etc.)?

3. Tell me about flexibility in seasonal cycles?
   Do you adjust the timing of your seasonal calendar – like hunting some species late or earlier now than before?

4. Tell me about wild food sharing.
   How is the practice of food sharing now, compared to years ago?
   How important is it to share meat?

5. Tell me about intercommunity trade.
   Do people in CH export/give some species to other communities and receive other species in turn?
   Did it happen before?

6. Is there anything that you harvest and sell (within or outside CH)?

Socio-Cultural values

1. Tell me more about why hunting/trapping/fishing is important to you and your family.

2. How would you describe your relationship with the land/delta?
   Tell me about some values you derive from the land.

3. How would you feel if you could not hunt/trap/fish again?
   How might that impact the community as a whole?
   How might the loss of some important species (*name them*) affect the community as a whole?

Concluding question

Is there anything else that you would like to tell me?

Table 1: Hunting seasons for different species in the SRD

Species	Months of the year											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Moose												
Deer												
Elk												
Bear												
BIRDS												
Bufflehead												
Canvasback												
Shoveler												
Galdwall												
Mallard												
Pintail												
Black Tern												
Lesser Scaup												
Swan												
Teal												
Snow Goose												
Canada Goose												
Ruddy Duck												
Rough Grouse												

Table 2: Trapping seasons for different species in the SRD

Species	Months of the year											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Muskrat												
Beaver												
Rabbit												
Coyote												
Fisher												
Lynx												
Marten												
Mink												
Otter												
Squirrel												
Weasel												
Fox												
Wolf												

Table 3: Fishing seasons for different species in the SRD

Species	Months of the year											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Goldeye												
Sturgeon												
Whitefish												
Sucker												
Walleye												
Northern Pike												
Yellow Perch												
Sauger												

Guide for Plant Harvesters

Basic questions

1. Please, tell me your name (if name is known, the spelling will be confirmed).

2. Are you between: 15-24; 25-34; 35-44; 45-54; 55-64; or over 65years?

3. How long have you lived in CH?
If not all your life,
When did you come here?
Where did you live before?

4. How many years have you been gathering plants?

5. Why do you gather plants?

6. How has plant gathering changed over the years – in the 40s, 50s, 60s, 70s, etc. depending on the age of the interviewee?
   - What kinds of changes – location of harvest, species abundance and distribution, types of species gather, gathering effort (distance covered, times spent, etc.?
   - What accounts for these changes – changing water levels, habitat destruction, changing cultural practices, etc.?

7. Do you gather plants in the same place as you did when you started gathering plants? (Explain why or why not)

8. Tell me about the seasons and times you gather plants. At what times of the season do you gather berries, and other plants? *(Turn to **table 1** below to record this information for different species)*

9. Which species are harvested for medicine?

Consumption

1. Apart from using berries and other plants as food, tell me about other uses of the plants that you harvest.
Tell me about the medicinal/nutritional value of these plant species.

Adaptation

Short-term responses

1. When your harvest changes in a season (say you get more or less than usual), what adjustments do you make?
   E.g., if more – do you share more, sell more, store more, etc.?
   If less – do you buy more from store, do without?

2. What kinds of changes have you made in your plant gathering practices since you started – changed location, changed species, changed timing, changed associated practices such as plant sharing, etc.?

Long-term adaptation

1. Do you go to gather plants in groups?
   How was group harvesting done before, and how is it done now?
   What used to be the group size; what is the average size now?

2. Tell me about berries and medicine sharing.
   How was the practice done before, and how it is done now?
   Do you share (give/receive) berries and other plants within and outside the community?
   If yes, whom do you share with, and how important it is to share berries and medicine?

Socio-cultural values

1. Tell me more about why plant gathering is important to you and your family?

2. How would you describe your relationship with the land?
   Tell me more about some values you derive from the land.
   How do you feel when you are out on the land picking berries or gathering other plants?

3. How would you feel if you could not get plants to gather again?
   How might that impact the community as a whole?

Concluding question

Is there anything else that you would like to tell me?

Table 1: Plant harvesting seasons in the SRD

	Months of the year											
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Choke cherries												
Stinging nettle												
Saskatoon berries												
Fiddle heads												
High bush Cranberries												
Labrador Tea												
Birch Bark												
Strawberries												
Raspberries												
Maple Syrup												
Mushrooms												
Wégas												
Sweet Flag												
Wild Rice												
Chaga												

Guide for Elders' Oral History

Basic questions

1. Tell me where you were born, the year in which you were born, and the different places where you have lived. (How long have you stayed in Cumberland House)?

2. Who were your parents and grandparents, and where were they from?
   How did they come to be in Cumberland House?
   What did they do for a living?
   Is there anything that they told you about their days that you could tell me?

3. How was the community of Cumberland House like (in the 30s, 40s, 50s, 60s, … etc.) when you were a young person growing up?
   How was life in the community? How did people make a living in those days?
   How did you make a living as a young man/woman?

4. What were some of the good things about life in the old days (in the 30s, 40s, 50s, … etc.?

Traditional livelihood

1. Tell me about living from the natural resources (the delta) in those days when you were young, and now (before/after the dam).
   Did you grow up on the trap line or hunting camp? If yes, how was life on the trap line?
   From where did you obtain your drinking water? How? How did you know it was safe to drink? Was drinking water treated in any way?

2. How would you compare the traditional life of the people when you were young to now?
   How did you guys see trapping, hunting, and fishing activities in the old days, and how are these activities now?
   How has trapping, hunting, and fishing change over the years?
   When was licensing (permit) in the traditional activities introduced? How did the licensing system work? What were its effects on hunting, trapping, and fishing?

3. What wildlife and fish species were traditional delicacies in those days when you were young? Have that change now?
   What were the cultural important species?
4. Tell me about the practice of wildfood sharing. How was the practice in the old days, and the practice now?

5. How would you compare wildfood and store-bought food?

6. Apart from using plants/trees for food and medicine, what other purposes/benefits did you derive from plants/trees?

Tell me about logging. Was it done a lot in Cumberland House?

The Delta: its importance and changes

1. What stories did your parents or grandparents tell you about the delta?

2. Growing up, what changes in the delta did you see or experience?
   What were the causes of such changes?
   How did such changes affect traditional livelihood (wildlife, fish, and plant species)?

3. What do you have to say about the E.B. Campbell (Squaw Rapids) dam and its effect on the delta?
   a. How was it decided that the dam would be built? Was your community consulted? Were you or your community included in the decision-making process? Is your community included in the decision-making processes today?
   b. How has the dam and its affects impacted your Indigenous water rights?

4. How is the delta important to you, your family, and the community?
   What spiritual, recreational, and cultural values did you get from the delta?
   Would you say the importance of the delta is changing for the community?

5. What were the traditional ways of protecting or preserving the wildlife, plants, and the waters in the delta? (How did the old timers look after the land? How is it done now?)

Other questions

1. In sort of a general way, what differences are there between the earlier days and now? What changes have been in Cumberland House?

2. Tell me about some cultural activities in Cumberland House in the old days and now. Tell me about cultural activities related to water in the old days and now. Eg. Were certain waters a place for social gatherings? Did the water bodies serve as "social hubs"?

3. What will you say about the youth in your days, and the youth now? Are there any differences (in terms of attitude, respect for culture, regard for traditional activities, etc.) between the youth in the old days, and the youth now?
   How is water sacred to you? How did you learn to respect water when you were younger? Has this changed from the old days and now?

4. Is there something important you want to tell me about living here that you have not had a chance to say?

5. Do you have any questions for me or about my research?