Name of the case study	Ikpiarjuk- Technology and traditional knowledge to cope with the risk of climate change - Canada [Resilience]		
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	Climate change is challenging Inuit communities' livelihoods in Ikpiarjuk (Arctic Bay). Change in sea ice dynamics, thinner ice, later freeze-ups and earlier break-up, and winter conditions affect the capacity of hunting and all the cultural reproduction that these practices require. Access to land for hunting is more complex and dangerous, decreasing the space to develop skills and traditional knowledge. Furthermore, economic changes are also affecting the community's adaptive capacity. The increase in living expenses, lack of job opportunities, and youth disengagement in the hunt accentuated the effects of climate change. The community recognized that nowadays, people have less time to hunt due to wage labour, affecting the space to transmit knowledge and skills. Technology has been used as a tool to face environmental and socio-economic challenges, such as GPs, the internet, and social media. Access to the internet had strengthened sharing networks, extending beyond family members. However, technology has also influenced the behaviour of hunters, increasing risk attitudes and decreasing the use of traditional knowledge.		
Template completed by: *Main contributor	Carla Lanyon Juan Rocha	**Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Archer, L., J. D. Ford, T. Pearce, S. Kowal, W. A. Gough, and M. Allurut. 2017. Longitudinal assessment of climate vulnerability: a case study from the Canadian Arctic. *Sustainability Science* 12(1):15–29. (2) Ford JD, Smit B, Wandel J (2006) Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. Glob Environ Change Human Policy Dimens 16:145–160 **(*) Mainly all the information comes from (1). Otherwise, is explicit cited as (2)**	
Reviewed by (name and affiliation)			
Category (mark with X)	**Resilience/ Adaptability**	**Loss of resilience**	**Transformation**
	X		

Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**
	Nunavut, Canada	Ikpiarjuk	247,5 km²	2004-2015	Fishing and hunting	

Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other:** ***state here***
	X		X					

	Biophysical	**Social**
1. Basic description of coupled social-ecological system in focus **(**What are the key components and stake holders) If possible draw a systems diagram or conceptual map of the case – this can be a series of diagrams to capture different periods in the case and the drivers/ actors/ events that characterize the period.	**a) What types of ecosystem(s) and other major biophysical features are present?** Arctic bay, rivers, lakes, sea-ice, wind, coastlines. **b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics?** According to the different lake ice, open-ocean, and terrestrial environment surrounding Arctic Bay, the system's boundaries are defined.	**c) Who are the key groups of people in this case?** Ikpiarjuk is an Inuit coastal community. The settlement has 823 inhabitants. 96% of them are Inuit people. **d) What kinds of livelihoods are important in the system?** The community has a mixed economy between subsistence activities and wage labor. The subsistence activities are fishing, hunting, and harvesting local plants as a source of country food. **e) What institutions are key to this case? If possible define what scale it addresses.** Hamlet office Department for Emergency Management Inuit coastal community **f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?** The boundaries of the system defined by subsistence activities are reproduced along the Arctic Bay. T

2. Timeline Draw a timeline of *key* events/ developments to the case. Points to include: Make clear the period of time over which the change is being considered. Provide a brief description of event/ actors, and ecological impacts. Mark particularly significant events with *. Consider both biophysical and social dimensions. Additional points that can be considered: Is it possible to identify periods of change from one type of system to another, transformations? Identify disturbances or events that challenged, built, or reduced resilience or adaptive capacity in the system.	1950´s 1990´s: There have been dramatic changes in Inuit livelihoods due to the transition of a traditional subsistence Inuit lifestyle to a mixed economy. Associated with this transition has been a settlement of semi-nomadic groups in centralized, permanent villages, increasing importance of the federal government in people's lives, the development of formal economic sector activities, participation in, and dependence on external markets compulsory schooling for children. (2) 1960´s: The settlement has expanded. The economy has shifted from one based entirely on subsistence activities to a mixed economy where both the informal and formal economic sectors assume an essential role. (2) 1967: Lead, zinc, and silver mine construction 20 miles away in the community of Nanisivik. The mine was a relevant job source in the area and accelerated the transition to a mixed economy. 1970´s: Oil exploration reinforced the shift in livelihood from subsistence to a mixed economy. 1991: Sealskin was one of the income sources for hunters. The decline of skin markets in Europe forced hunters to find more income sources to support their hunting activities. For instance, the commercial exploitation of narwhal for the tusk ivory (2). 2006: The mine was shut down, affecting the employment rate of the area. 2010: Support program for hunters. The Department for Emergency Management created a program to improve hunting through the use of GPS. They provided short-term loans of 15 GPS to residents of Ikpiarjuk.

3. Disturbances What are the key disturbances in the system (present and past)	**a) Have there been major biophysical disturbances that are relevant for the case?** Sea ice dynamics have changed, having later freeze-ups, earlier break-ups, and thinner ice. Winter conditions also change, becoming stronger and in different directions. Due to the changes in the ecosystem, the health and availability of key species for the community decrease. For instance, caribou was lost in the area, other species have decreased, such as ptarmigan and bird population. The arrival of new species in the area as orca and polar bears, and fox.	**b) Have there been major social disturbances that are relevant for the case?** Floe- edge creates unstable ice conditions for narwhal hunters, increasing the risk and cost of hunting. The incrementation in the market value of narwhal tusks. The profits are used to invest in hunting equipment. Declining markets in Europe for seal skin force hunters to look for other sources of income, such as narwhal hunt. The closure of the Nanisivik mine led to a decrease in job opportunities impacting the income of hunters used to invest in equipment for hunting. Living costs have increased, especially for full-time hunters and young with few resources. The high prices are mostly related to purchasing safety equipment or replace lost equipment or damage due to weather conditions.
4. Drivers of change Clarify what impacts these drivers have on the SES and if these are direct or indirect	**a) What are the key biophysical drivers of change?** Since 1968 the area is experiencing a warm-up, increasing the length of the ice-free open-water period. From 2004 to 2014, there has been a 25% increase (18 days more) of ice-free open waters. Breakup dates are occurring progressively later in the year, and free ice water during the summer is expected. Changes in the wind (direction, strength, and frequency) cause unexpected sea-ice disintegration. This change has an impact on narwhal hunt during spring due to the floe-edge.	**b) What are the key social drivers of change?** Regulations, quotas, and licenses limit hunters' and fishers' ability to be more flexible and mobile (2). Technology introduction to navigating the unpredictable weather and share information, especially young hunters. The decrease in prices and access to loans free of charge from the Hamlet office makes it easier for hunters to buy a GPS. Easy access to the Internet. Hunters start using online weather or sea ice reports as crucial to their preparations

5. Sources of adaptive capacity: What factors allow(ed) the system to adapt to disturbances in the past and present? Give a brief assessment of recent or on-going changes (+/-/0 = increasing/ reducing/ not affecting adaptive capacity)	**a) Within the ecosystem?** (-) Decreasing the access to marine mammals and birds (-) Loss of caribou in the area (+/-) Increase the abundance of other species. The particular case of the polar bear has created conflicts among the community due to attacks near the town.	**b) Within society (e.g. people, social capital, management, institutions, infrastructure):** (+) Sharing networks have adapted to the new dynamics of the community, not only for sharing food. For instance, the inclusion of financial support to hunters. As a result, hunters can provide food to their families and the community. (+) Social media as a network. Use Facebook to share information, local food, and equipment. Social media allows extending the sharing network from family to the community (2) (+) Experiences have shifted the beliefs of the community. The community recognizes climate change effects and is aware the changes will continue. (+) Technology us GPS is more accessible to the community. Hamlet offices facilitate GPS to hunters, and the decrease in techno advice is affordable for some hunters. (+) Learning from the experience of travel in new climate conditions. Hunters prepare more, pack more supplies, check with elders before leaving. (-)Reduced participation of younger Inuit in harvesting places strain on sharing networks, exacerbated by limited access to traditional foods. (-) Reduced access to hunting areas in the late spring and fall months as a result of these changes, with negative

		implications for food and income security (-) Lack of consistent long-term meteorological data from the local weather station in the community. (-)Loss of Inuit Qaujimajatuqangit (traditional ecological knowledge). Skills, values, and knowledge are not fully transmitted to younger generations. Young Inuit spend less time in subsistence activities. Therefore there less space to share knowledge between generations. Young Inuit consider that TEK is not usefull with the unpredictable weather, relaying more in technology. However, TEK is going through an adaptation process.
The next two sections break down the information in Section I. While it is not necessary to fill these sections, if you have additional information pertinent to specific rows below feel free to enter the material.		
II.1-8 SES, resilience and adaptive capacity		
	Biophysical	**Social**
II.1. Where do we find changes and resilience in the face of change?	**a) Within nature** Changes in the health, abundance, and migration timing of various wildlife species utilized for subsistence harvesting. Communities have seen how the population of caribou disappear from the place, and a decrease of Ivory Gull, and an increase in orcas, polar bears, and foxes in the area. The wind has changed the direction, strength, and frequency—thinner ice year-round, with the most notable changes in ice thickness in the spring and fall.	**b) Within society** The main changes are the rising cost of living, the lack of employment opportunities with the closure of the Nanisivik mine, the increased financial cost of hunting due to climate change, and the weak transmission of traditional knowledge. On the other hand, their hunting practices have been modified due to climate change and the new mixed economy system. The introduction of technology such as GPS to navigate climate uncertainty, the climate conditions, the higher cost of hunting has shifted young interests, having a lack of youth participation in the sector losing TEK, land

		skill and the culture related to hunting.
II.2. What are the system's key components?	**a) Key Ecological components (e.g. lakes, coastal zones, caribou)** Key species locally harvested include narwhal, ringed seals, caribou, arctic char, ptarmigan, snow goose, beluga whale, and arctic fox. Sea-ice, coastal lines, lakes.	**b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.?** - Hunters and their families - Elder and young hunters - Hamlet office - Rescue Service - National government
II.3. What are the key linkages? E.g. ecosystem services, resource extraction. These linkages should exist. If there are not mutual links between social and ecological components the case is not a social-ecological system.	**a) From nature to society (e.g. ecosystem services)** -Primary production -Traditional and cultural livelihoods	**b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)** Hunting and fishing
II.4. What are key interactions?	**a) What are the key ecological interactions within the case?** The unpredictable changes in wind strength and direction cause sea ice to unexpectedly disintegrate in summer, disconnecting the floe-edge from the ice that is connected to the shore. This sea ice modification unstabilizes the ice condition for narwhal hunters. The change in sea ice dynamics and the increase of winds have affected the landscape of the ecosystem generating	**What collaborations, conflicts, or other key linkages exist between actors?** Money has become part of sharing networks. From this network's hunters have access to financial resources to invest in their hunting practices. However, elders perceive this change as detrimental to Inuit culture with potential negative long-term implications for sharin**g.**

	change in the wildlife of the area. New species arrived in the area, such as Orcas and polar bears, other species populations have increased such as foxes, and others decreased or completely disappeared, such as caribou. **b) What are the most important biophysical tele-connections to distant systems?**	Hamlet office collaborates with hunters and provides loans to hunters accessing technology. Some young hunters still ask and discuss with the elders their hunt travel, mixing technology with traditional knowledge. **c) Between local actors and distant actors?** There is an increase in rescue missions in the area due to climate conditions and the risk behavior of young hunters. The frequency of emergency situations could lead to conflict between the rescue group and the hunters in the future
II.5. Culture	**a) How is the relationship between society and nature viewed?** The sea ice surrounding Ikpiarjuk is the platform for the community's wildlife harvesting activities and their culture. Spending time on land allows Inuit to transfer traditional knowledge. In this perspective, the change in the ecosystem due to climate change has affected the reproduction of TEK. (1) (2) **b) What meanings are attributed to nature and to interactions with nature?** Nature is a central element in Inuit life. Sea-ice allows them to reproduce their culture by practicing traditional livelihoods. It also provides country food and is the scenario of network developments based on their social structure.(2)	**c) What are key cultural features of relevance for the case?** Hunting has social, cultural, and economic significance to Inuit in Arctic Bay, helping to maintain cultural identity and strengthen social relationships within the community. (2) Country food is a critical element in the culture of Inuit people. Seals are a food source all year round, and caribou was also a significant physical and cultural importance species. In addition, sharing networks have long contributed to food security in the context of environmental stress. **d) What are key cultural practices and beliefs related to nature?** Practices surrounding hunting that remain important today

	(1)	are teaching, learning, sharing hunting skills and knowledge, sharing traditional food within the extended family unit, processing animal skins to produce clothing, and spiritual beliefs are connecting the hunter and 'the land.' These traditions and practices have been transmitted through generations safeguarding their cultural identity, strengthen community networks, and preserving Inuit livelihoods (2)
II.6. Disturbance What are important types of stress & shock	**a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc).** Disappear of the caribou population affects food security and increases the expenses in the family.	**b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc.)** The increase in narwhal market value has transformed this species into a relevant source of income for hunters. However, the hunt of this species has been affected by the quota policy. Quotas on narwhal have influenced the hunter's hunting practices and principles, following "first come, first served". The local hamlet office has promoted the use of GPS for safe harvesting facilitating GPs. This program is top-rated among hunters. Access to the internet allows the use of social media as a communication tool for the community. Extending the networks beyond family..

		Open /Close of the Mine: Nanisivik mine contributed to the shift from a subsistence economy to a mixed economy. The close of the mine brought a wave of unemployment affecting hunting practices.
II.7. What are key slow variables Changes that occur over decadal or longer time scales	**a) What types of ecological processes (e.g. loss of permafrost, shifts in species composition) are driving important long-term changes in ecological structures and processes?** Weather is more unpredictable, enabling communities to use their local knowledge for hunting. Change in the movement patterns, abundance, and health of wildlife. For instance, communities have recognized a change over ten years in the caribou population near Ikpiarjuk. There is no longer access to this specie, and hunters have to go further or buy from others communities, which is very expensive. And the increase of other species such as polar bears and orcas. Change in sea-ice dynamic and the thickness makes it easy to break it, increasing the harvest risk. In addition, there is an increase in rescue missions due to the change in the weather and sea-ice conditions.	**b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours?** Change in hunters values and principles. Narwhal market value, the lack of job opportunities, and the quotas restrictions have changed hunters' behaviors. They are willing to take more risks and follow the narwhal, regardless of the risky conditions to maximize the hunt before the quota expires. Disattach of young generations in hunting and other practices related to hunting such us sharing network. Climate change, wage labor, and socio-economic difficulties of hunting have shrunk the option space (land-access, time availability, high cost of hunting) for youth to participate in hunting, risking the transmission of traditional knowledge. Change in TEK incorporating new techniques and knowledge that technology provides. However, the use of technology can modify risk behavior. For example, young Inuit trust in technology such as GPs, and weather prediction increasing the perception of safeness and decreasing their alert state (the research acknowledges that more research should be needed to verify this point). The case presents an adaptive learning process going on. In

		earlier research (2004) community did not recognize climate change as the main challenge. For them, the climate had always changed, and they had always adapted (2). After ten years, the community acknowledges climate change is a real threat and a driver that is transforming the system.
II.8. Relationships with ecological regime shifts	**a) Are ecological regime shifts driving further ecological change or pressure?** However, there are no recognized cases of the warming trend that may lead to a shift of the species around the Bay. **b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?** Climate change	**c) Can social stresses or major changes be attributed to ecological regime shifts?** The transmission of IQ between generations is further challenged by climate change impacts that reduce the opportunities for going on the land and challenge the confidence of younger individuals. **d) Are there specific social practices that might be contributing to ecological regime shifts** The shifts in hunter values and principles, especially related to those species with high market value, in this case, narwhal, could lead to overharvesting of the species.
II.8 Regime shifts	**If a regime shift exists and is important to this case describe it below.** Speculative.	
II.8.a. Detailed description of alternate regime shifts A case study can contain more than one type of regime shift	**Briefly describe the structure of each regime. What does each regime look like?** **What are differences in ecosystem structure and function? (e.g. permafrost loss, vegetation change)?** **How do the properties and behaviours of regimes differ?** **e.g. collapse of subsistence food sources, fundamental change in types of livelihoods, change in governance institutions, new actors with significant political power who transform decision making)**	
II.8.b. Feedback	**Ecological feedback mechanisms**	**Social feedback mechanisms**

mechanisms within the system that maintain each regime		
II.8.c. What key changes drive regime shifts? Describe how these changes alter the state of the system or feedback processes.	**a) Drivers of ecological regime shifts (either social or ecological).** **b) How do these changes alter biophysical feedback processes?**	**c) Drivers of social regime shifts (either social or ecological).** **d) How do these changes alter the social feedback processes?**
II.8.d. Ecosystem services substantially impacted by regime shift	**a) Changes in ecological processes that produce ecosystem services**	**b) Changes in demand for ecosystem services (market and non-market)** **c) Changes in the institutional context of ecosystem services e.g. changes in access and changes in how ecosystem services are valued as expressed by rules and regulations.**
II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly	**a) Impacts from regime shift on ecological components**	**b) Impacts from regime shift on social actors**
II.8.f. Potential cascading effects	**Describe, if any, the likelihood of potential ecological cascading effects to other SES**	**Describe, if any, the likelihood of potential social cascading effects to other SES**
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening?	**Ecological oriented interventions**	**Socially oriented interventions**

REFERENCES/ SOURCES CITED:	
(1)	Archer, L., J. D. Ford, T. Pearce, S. Kowal, W. A. Gough, and M. Allurut. 2017. Longitudinal assessment of climate vulnerability: a case study from the Canadian Arctic. *Sustainability Science* 12(1):15–29.
(2)	Ford JD, Smit B, Wandel J (2006) Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. Glob Environ Change Human Policy Dimens 16:145–160
(3)	
(4)	

GLOSSARY OF TERMS IN THE TEMPLATE

Actor	We use this term generally to look for individuals, groups, organisations, and so on that structure actions and/ or are stakeholders.
Adaptive capacity	Is the capacity of actors in the system to manage resilience in order to stay within a desired state during periods of change. This is related to the diversity in the system behind the provision of a function.
Disturbance	This refers to any disturbance to the system, regardless of scale, duration, intensity and frequency. See shock and stress.
Driver	Actor or process that directly or indirectly affects change in a social-ecological system. External means that the system in question (the scale being looked at) is unable to affect the driver in question – there is no feedback from the system to the driver.
Ecosystem services	The goods and services humans derive from ecosystems. These include: provisioning, regulating, cultural ecosystem services respectively.
Feedbacks	A change within a system that occurs in response to a driver, and that loops back to control the system. A feedback can help to maintain stability in a system (negative or balancing feedback), or it can speed up processes and change within the system (positive or enhancing feedback). Feedback processes play a very important role in determining system thresholds and in maintaining system resilience.
Institution	Here we refer to the humanly devised constraints that shape human interactions, such as rules, norms and laws. These can be formal or informal. Note that we are not referring here to institutions as organisations.
Regime shift	For complex systems, a substantial and enduring reorganization of the system, where the internal dynamics and the extent of feedbacks undergo change.
Resilience	This is a property, in this context of social-ecological systems. It relates to the capacity of a system to cope with disturbances and recover in such a way that they maintain their core function and identity. It also relates to the capacity to learn from and adapt to changing conditions, and when necessary, transform.
Shock	A sudden, unexpected disturbance. This kind of disturbance is often punctual, and has important impacts on large parts of the system.
Slow variable	When analysing complex system is often useful separating “fast” and “slow” variables. Fast variables often represent the primary concern of ecosystem users, for instance game or crop production. Slow variables shape the behaviour of fast ones but change slowly with respect to the overall dynamics of the system. Examples of slow variables might include permafrost thawing for a social-ecological system of Arctic hunters where the fast variable is game, or soil organic matter for an agricultural system where the fast variable is crop production.

Stress	This is a disturbance that has long persistence and often low intensity in impact.
Social-ecological system	This is an interwoven system of human societies and ecosystems. This concept emphasises that humans are part of nature and that these components function in interdependent ways. In the template identifying these interactions between the components aims to identify the processes and actors/ components that interact and particularly the feedbacks between the human-related components and the ecosystems/ biophysical components.
Stakeholder	See “actor”
Systems Diagram	This is using a diagram to illustrate the configuration of a system. This is done by defining its structure, function, and feedbacks. For a case there may be more than one diagram if the system changes in character (actors, processes, drivers, disturbances, feedbacks etc.) over time.
Timeline	The goal with the timeline is to capture important events – both punctual and over longer periods of time, identifying the causes of these events and the actors/ processes involved. This should be done chronologically and distinguishing events.