Name of the case study	Qaanaaq district – Migratory fishers and hunters to re-located communities – Greenland [Loss of resilience]
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	This case nicely shows a regime shift on the social system induced by the drivers of a potential regime shift on the natural system. Communities in northern Greenland have adapted to a harsh cold environment and lived there for at least 2000 years [2]. Their livelihoods strongly rely on hunting and fishing, both activities dependent on the ability to travel on ice [1]. Social capital in such communities also highly depends on mobility, as families often travel between towns to help each others and recreate their cultural practices. As the melting of ice arrives earlier each summer, mobility has been strongly affected, fishing and hunting is becoming more risky and reaching the fishing/hunting grounds harder. With less mobility there is also weaker social bonds in between communities, key to face the challenges of long cold winters. As consequence many Greenlanders are moving down to the cities and young people does not find incentives to continue with traditional livelihoods and local practices. "When the topological reality shifts, so does the emplacement of people – even when they remain in the same geographical location" Kirsten Hastrup (1:246)
Template completed by:	Juan-Carlos Rocha, Stockholm Resilience Centre **Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Hastrup, K. 2009. Arctic hunters: climate variability and social flexibility. Chapter 12 *in* K. Harsrup, editor. *The question of resilience, social responses to climate change*. The Royal Danish Academy of Science and Letters, Copenhagen, Denmark.
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)**
	Greenland	Communities in Qaanaaq district	Icescape – marine	1900-present	Fishing, hunting	Reduced mobility due to forced resettlement and changes in ice

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					X	

		centralization						

	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? Greenland is dominated by perpetual ice and close to the coast in summer there is tundra. b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? Boundaries are defined by the community settlement and the icescapes and marine areas where they hunt and fish.	c) Who are the key groups of people in this case? Examples of such communities include: Thule, Siorapluk, and others belonging to the Qaanaaq district. d) What kinds of livelihoods are important in the system? Their main livelihoods are hunting and fishing. e) What institutions are key to this case? If possible, define what scale it addresses. Hunting/fishing quotas f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?

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.	First inhabitants migrate from northern Canada and establish in the area 2000BC. Late 19th century: Inuits (or Eskimos) were first studied by American anthropologist Franz Boas, who reported that their mode of life depended completely on mobility following the migration routes of animals for hunting them to secure food (1). Robert Peary arrived in late 19th century and started first settlements by establishing trade points. 1910: Danish polar explorer, Knud Rasmussen, established a trading station and named it Thule (250 people), his explicit ambition was to help the Polar Eskimos make the transition from an isolated hunting community to a modern society (1). 1929: Due to increase of Thule's population, Knud Rasmussen established a second settlement further north in Siorapaluk. "At the time of its establishment, Siorapaluk offered easier access to trading for people from further north; today there are no people further north, but walrus and polar bear are still to be hunted up there…" Today Siorapaluk has ~50-60 people whose livelihood is hunting (1). 1930: Approved population regulation in Thule by Hunter's council proposed by Knud Rasmussen. Each individual hunter may stay only 3 years at a time. 1953: Relocation of Thule due to establishment of American airbase.

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? Early ice melting	b) Have there been major social disturbances that are relevant for the case? Establishment of trade center, military base and airport.
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? Temperature and ice melting/thinning affect mobility in local communities. It makes it harder to access hunting grounds and makes it more unsecure while bringing the catch to shore. Ice breaking disturbs populations because of noise driving them further off shore. Warming might also change migratory routes or abundance of target species.	b) What are the key social drivers of change? Centralization: whether through colonialism or democracy, northern communities are abandoning migration patterns and are gradually becoming more settled. It has created concerns about overexploitation of resources leading to re-distribution of population in the past. Today, however, there are policies in place to centralize services, such as health and education, which consequently further incentives of abandonment of migration practices. Globalization: Migration to urban centers to look for new economic opportunities.
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? (-) Mobility is a key source of adaptive capacity for marine mammals and other species. They can follow migration patterns of their prey. However, as ice melting and thinning of ice caps affect more and more the Arctic, mobility of terrestrial mammals such polar bears is reduced.	b) Within society (e.g. people, social capital, management, institutions, infrastructure): (0) Social capital: collective action and social cohesion has been fundamental to deal with disturbances in the past. (-) Traditional knowledge and language: geography is encoded in language but it's losing meaning as the icescapes change. (-) Mobility between dwellings: seasonal migration patterns following the migration routes of marine mammals.
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 Change: early melting of ice, more calving and less fresh water availability due to infiltration.	b) Within society Resilience: mobility, social capital, sharing game.
II.2. What are the system's key components?	a) Key Ecological components (e.g. lakes, coastal zones, caribou) Marine sea ice and access from land, migratory whale species, narwhal, polar beers, caribou.	b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organized – by geography, livelihood, family, etc.? Local hunter groups; northern Greenland communities (Thule, Siorapluk, Cape York, Etah); Thule military base; scientific expeditions; tourists; non-local hunters (tourist or further south hunters); government agencies (e.g. biological conservation agencies, municipalities); and 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) Provision of wildlife for hunting	b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution) Locally: Hunting, tourism. Globally: Green house gases that increase global warming.
II.4. What are key	a) What are the key ecological interactions within the case?	c) What collaborations, conflicts, or other key linkages exist

interactions?	Ice melting is the most important ecological process in this case. Although it's not reported explicitly, warming might increase primary productivity in the long term, but how species will adapt to warmer conditions is unknown. b) What are the most important biophysical tele-connections to distant systems? Greenhouse gas emissions, deforestation and other impacts on carbon cycle that potentially affect global warming and/or albedo feedback.	between actors? Conflicts have been reported with hunters from southern communities that do not hunt according to traditional practices and sometimes waste the game (1). d) Between local actors and distant actors? Touristic hunting, tourism in general and marine transport can have adverse effects on hunting due to the effect of noise on the target populations. There have also been reported conflicts to a lesser extent between conservationist groups and local hunters. Their knowledge sometimes clashes about the state of stock targets (1).
II.5. Culture	a) How is the relationship between society and nature viewed? For hunting in particular, the hunter establishes a courting relationship with the prey. b) What meanings are attributed to nature and to interactions with nature? For whale and narwhal hunters, the harpoon becomes an important recipient of the prey's soul, therefore it has to be adorned enough as to attract and honor the sacrifice of the prey when it surrenders to the hunter. This feature is common to other hunter communities in the Arctic (1), and harpoon's design stability has been correlated with climatic stress that could have induced decreased hunter's success (1).	c) What are key cultural features of relevance for the case? Thule culture has developed during the last 2000 years to adapt to the harsh conditions of the Arctic and almost perpetual ice. Their knowledge on how to deal with long winters, their migratory patterns, their language and the coding of the Greenlandic geography, and strong social cohesion are all adaptations to such harsh conditions. d) What are key cultural practices and beliefs related to nature? Hunting and the ritual of the hunt are key beliefs related to the Arctic ecosystem.
II.6. Disturbance What are important types of stress & shock	a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc.) Early melting of the ice difficult mobility for the hunters. Speed in the melting of glaciers also facilitates the vertical	b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc.) The establishment of towns and forced re-settlement are major

	divergence of arctic rivers reducing the flow of fresh water to coastal communities.	shocks for hunter communities in that it limits the migratory practices they rely upon. Current policies support centralization of administrative units setting incentives for mobilization towards urban centers within Greenland, and perhaps the abandonment of traditional hunting practices. Maritime transportation for tourism, or other kinds of industry, seems to have an impact on marine mammals, making it harder for hunters to reach their prey.
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? Temporal patterns of ice melting and divergence of fresh water flows from glaciers to the sea are affecting the adaptability of arctic communities. Increasing global warming can dangerously weaken the albedo feedback changing the reflectance of solar energy to the atmosphere and increasingly in turn the speed of climate change in a non-linear fashion.	b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviors? Language is a key adaptation to understanding and storing knowledge about the Greenlandic geography. As the geography changes faster than the language, adaptive capacity and memory is being lost [1]. Another important change is lack of interest of younger generations for engaging on traditional activities such as hunting as a livelihood. National politics are encouraging centralization of services and sometimes privileging scientific knowledge over local knowledge when making decisions about fishing quotas and conservation goals for marine resources (1).
II.8. Relationships with ecological regime shifts	a) Are ecological regime shifts driving further ecological change or pressure? It is not explicitly reported on the literature, but the collapse of Greenland ice sheet has been proposed as a potential tipping point for Earth climate dynamics. Although is not likely to occur short term, it will have devastating consequences for Arctic communities with expected sea level rise of up to 7 meters (2). b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)? The strength of the albedo feedback is key determinant of Arctic climatic dynamics and speed of warming. Another ecological	c) Can social stresses or major changes be attributed to ecological regime shifts? Not at this point. The main social stress is attributed to slow changes in the melting patterns of ice. But one cannot say yet that it induces a new ecological regime. d) Are there specific social practices that might be contributing to ecological regime shifts Not at the local scale, based on the few references reviewed. But at the global scale, global warming is at least partially caused by emission of green house gases, which in turn are affected by agriculture activities, fossil fuel economy, and deforestation

	dynamic relevant for the case study is the projected change in species abundance given warming of the ocean but also change of ocean currents and salinity. We know Arctic communities are likely to undergo several structural changes, we cannot predict in which directions they will reorganize.	amongst the major sources.
II.8 Regime shifts	**If a regime shift exists and is important to this case describe it below.** Please indicate whether the regime dynamics are well-established, contested, or 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)? Although the case study does not necessarily relate with the regime shifts to the Greenland Ice Sheet, symptoms of the regime shift are reducing the adaptive capacity of hunting communities across Greenland. The regime shift is characterized from permanent ice sheet regime to occasional ice sheet. Although the shift is expected to happen on a >300yr time scale, it will have devastating consequences in terms of sea level rise (2-7metres above present levels). Yet, the first symptoms of warming express themselves with early melting of snow, thinning of marine ice and percolation of freshwater have already shown consequences for northern Greenlandic communities in terms of mobility and freshwater provision. How do the properties and behaviors 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) The regime shift will have impacts on sea level rise, but even without the shift, it has already impacts on mobility on ice, hunting activities and provision of freshwater.	
II.8.b. Feedback mechanisms within the system that maintain each regime	Ecological feedback mechanisms Albedo feedback and melt-water ice sliding mechanism (3, 4).	Social feedback mechanisms Mobility and language as a form of social memory (1).

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). Greenhouse gas emissions b) How do these changes alter biophysical feedback processes? Global warming increases early melting of ice, alters albedo feedback and changes solar energy reflectance, reinforcing more energy absorption, and hence warming.	c) Drivers of social regime shifts (either social or ecological). Re-location and settlement of local communities, globalization and loss of TEK. Conservation policies clash with hunting interest and tourism activities produce noise that perturbs wild fauna. d) How do these changes alter the social feedback processes? Loss of memory and limited mobility reduces the adaptive capacity of communities.
II.8.d. Ecosystem services substantially impacted by regime shift	a) Changes in ecological processes that produce ecosystem services Early melting: mobility is affected, accessibility to hunting grounds and geographical references are lost [1]. Warming might also cause redistribution of biological resources and changes in communities' compositions.	b) Changes in demand for ecosystem services (market and non-market) Tourism although minor sector is increasing (1]). 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. Different conservation values between national policies and local management.
II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly	a) Impacts from regime shift on ecological components If the collapse of the Greenland Ice Sheet happens, the ecological components would be completely transformed by 2-7 meters sea level rise, change in salinity, ocean currents and presumably ecological communities.	b) Impacts from regime shift on social actors Unknown.
II.8.f. Potential cascading effects	Describe, if any, the likelihood of potential ecological cascading effects to other SES Sea level rise, climate change.	Describe, if any, the likelihood of potential social cascading effects to other SES Unknown.
II.8.g. Where do actors	Ecological oriented interventions	Socially oriented interventions

intervene to alter regime shift dynamics and who can do the intervening?	Reduction of greenhouse gas emissions (international)	Unknown.

REFERENCES/ SOURCES CITED:

(1)	Hastrup, K. 2009. Arctic hunters: climate variability and social flexibility. Chapter 12 *in* K. Harsrup, editor. *The question of resilience, social responses to climate change*. The Royal Danish Academy of Science and Letters, Copenhagen, Denmark.
(2)	Sørensen, M. 2010. Inuit landscape use and responses to climate change in the Wollaston Forland—Clavering Ø region, Northeast Greenland. *Geografisk Tidsskrift-Danish Journal of Geography* 110:155–174.
(3)	Murray, T., K. Scharrer, T. D. James, S. R. Dye, E. Hanna, A. D. Booth, N. Selmes, A. Luckman, A. L. C. Hughes, S. Cook, P. Huybrechts. 2010 Ocean regulation hypothesis for glacier dynamics in southeast Greenland and implications for ice sheet mass changes. *Journal of Geophysical Research* 115: F03026.
(4)	Parizek B. R., and R. B. Alley. 2004. Implications of increased Greenland surface melt under global-warming scenarios: Ice-sheet simulations. *Quaternary Science Reviews* 23: 1013–1027.

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.