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# Digital technologies and ILK in the Arctic: in search of epistemological pluralism

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## ABSTRACT

The digital revolution is profoundly challenging to Indigenous societies in their relationships with non-humans. To guide research that involves Indigenous communities and digital technology, we analysed the impacts of such technologies on Indigenous knowledge systems from the perspective of environmental ethics and anthropology. Using the example of Sámi reindeer husbandry in Sweden, we found that digital technologies, rather than relying on sensitive ways of understanding and experiencing nature, potentially reinforce a Western worldview of reindeer husbandry, instead of valuing a Sámi ontology. Therefore, they have the potential to compete with Indigenous ways of interacting with humans and non-humans. Our analysis also underlines that research with Indigenous people using digital technology in participatory research projects may contribute to this competition rather than empower the Indigenous knowledge system. Based on these findings, we distinguish two ethical directions – co-construction and strong epistemological pluralism – that can be followed to address concerns about the effects of the development of digital technologies on the diversity of knowledge systems in the Arctic, and elsewhere.

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## 1. Introduction

Indigenous and local societies are regularly brought to the fore because of the inextricable link between biological and cultural diversities, and to emphasize the role of Indigenous and local knowledge (ILK) in sustaining nature's benefits to people (IPBES, 2019). While there is evidence that cultural diversity is currently as threatened as biological diversity (Sutherland, 2003; Gorenflo et al., 2012), addressing this issue calls for a broader integration of ILK into science (Rosa et al., 2017) and, at the same time, for a maintaining of a pluralistic perspective of the relationship between human and non-human (Hill, 2020; Pascual et al., 2021). We believe that the introduction of digital technologies in Indigenous contexts, often jointly developed with research programmes, illustrates this antagonism and raises some important

challenges to be tackled rapidly, considering the current pace of technological changes in different knowledge systems, including ILK and science.

In this essay, we concentrate on the Arctic regions, where Indigenous communities have adopted a wide range of digital devices and services over the last 25 years in spite of obvious connectivity gaps: portable global positioning system (GPS) receivers, geographic information systems (GIS), mobile and later smartphones, were all adopted early on (Aporta and Higgs, 2005; Stammer, 2009). Social media platforms are extensively used (Castleton, 2018; Cocq and Dubois, 2020) and now drones are becoming one of the standard tools. More generally, the Internet and digital apps contribute to the strengthening of Indigenous identities outside of the Indigenous communities, to the fostering of pan-Indigenous identities, and to increasing communication about environmental battles on their lands (Niezen, 2009;

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Schillo and Turin, 2020). While they have different histories of introduction and usage across circumpolar regions, all these technologies share the potential to influence not only social relationships but the various ways individuals interact with nature and the knowledge generated through human – non-human interactions.

On a global scale, digital advances offer many promises (Sachs et al., 2019) but also generate serious criticism of their environmental and social impacts (Williams, 2011). However, in science, they are also a source of great optimism because they promise more data, faster processing or improved communication (Arts et al., 2015). In nature conservation, particularly in environmental monitoring where the interest and the need for multiple knowledge systems and participatory approaches to science are continuously increasing (Raymond et al., 2010; Tengö et al., 2014), the advent of digital, often mobile, devices has also the potential to reinforce this trend toward environmental sciences being more participatory and inclusive (Newman et al., 2012; Brammer et al., 2016; Andrachuk et al., 2019). This is particularly true in Indigenous, often remote, territories where such technology gives the opportunity to capture information previously inaccessible to scientists and even, sometimes, to Indigenous communities (Gearheard et al., 2011; Heath, 2020). The use of digital technologies has also a political dimension for ILK holders who can see a way to legitimize their knowledge and management for greater recognition and empowerment.

The central question behind this work goes beyond the somewhat limited scope of this article and is, ultimately, a classical question when it comes to the introduction of a new technology: does it improve or depreciate the pre-existing knowledge, and empower or weaken the knowledge holders to face their social and environmental problems? For knowledge systems that strongly rely on the continuous and innumerable interactions with the rapidly changing natural environment, understanding the consequences and eventually what is lost or threatened by digital technologies is thus necessary. Equally important is, perhaps, the need to examine the promises they convey and the justifications they endorse, especially when science and researchers are also involved in the development of digital platforms which can gather together scientists and ILK holders. To guide research that involves Indigenous communities and digital technologies, we analysed the various forms

taken by the digital revolution in Indigenous people's interactions with nature. We also investigated the potential for transformations that result from the introduction and adoption of digital technologies in Arctic communities, using Sámi reindeer husbandry in northern Sweden and the range of digital devices that have become part of standard tools of reindeer herders as the main examples. We then focus on the role of the researcher in these changes and provide a framework for a digital ethic for research in an Indigenous context.

## **2. An interdisciplinary approach to digital technologies**

### *2.1. An empirical emergence*

The adoption of a new technology in traditional livelihoods in Arctic regions immediately resonates with the famous “snowmobile revolution” case study (Müller-Willer and Pelto, 1971). It is, perhaps, not surprising then that there already exists previous literature describing and analysing the adoption of different digital technologies by communities in the region (Aporta and Higgs, 2005; Stammer, 2009; Kuoljok, 2019a). All these studies analysed the tensions between adoption of, and resistance towards, a particular technology. Building on these earlier studies, this work is also based on the observations carried out by one of the authors since 2007 of the successive introductions of digital technologies in Sámi reindeer husbandry in northern Sweden. These include, chronologically: GPS receivers introduced in the late 1990s, participatory GIS, smartphones and GPS collars in the 2000s, and finally drones in the 2010s. Working on the effects of commercial forestry on reindeer husbandry in a faculty of forest sciences, Roturier has studied contemporary Sámi pastoralism, their uses of different forest habitats, the consequences of forest management on reindeer and pastures, and the associated knowledge, practices and representations (Roturier, 2009). He worked with reindeer herders from different reindeer husbandry communities in the municipality of Jokkmokk, joined Sámi reindeer herders in their herding and political activities, and observed the variety of uses of digital technologies by reindeer herders. It would be unproductive to describe the use of these technologies in all aspects of Sámi life; however in Sámi reindeer husbandry they are used in routine tasks such as guiding herds across complicated terrains, or towards a corral entrance in treacherous

weather conditions with the help of a portable GPS unit or drones, checking herd movements of reindeer equipped with GPS collars on a GPS tracking webpage, watching reindeer crossing unstable ice using drones. These technologies, therefore, improve herders' safety, or are simply used to organize logistics with other members of the community via mobile phones out in the mountain tundra or in the conifer forest. Digital technologies can also take a more political dimension when they provide the means for Sámi herders to record their knowledge and observations that they make out in the field. Smartphones with cameras enable herders to bear witness visually to observations made out in the environment, which are always listened to incredulously by outsider observers for whom the value of proof is primarily based on images or written traditions (Figure 1).

In conducting research in the faculty of forest sciences, Roturier also had the opportunity to see the flourishing of research projects involving digital technologies in the forest industry, wildlife management, and in collaborative research projects between scientists and reindeer herders to help Sami communities to adapt to the changes and cope with the challenges they face. These include climate change or various forms of land encroachment such as traffic, tourism, predator conservation, mining or commercial forestry. At this point, he also spent a good deal of his time in the field with one herder who was in charge of consultation with the forest industry and particularly involved in the implementation of a participatory GIS, and carried out collective interviews with two families (Roué et al., In Press). While acknowledging the interest in digital technologies for reindeer husbandry, he was also drawn by the extreme simplification of the knowledge produced and displayed through digital technologies. However, it was useful to the herders, perfectly comprehensible and easy to integrate by researchers and engineers, and at least far better than the very detailed results of an ethnographic investigation, and with much less effort out in the field. Was this simplification a good thing for research and for reindeer husbandry? Was it a simplification only for scientists where herders could simply decide the fragments of knowledge they wanted to share and display? Would these projects confirm and legitimize their knowledge, and what would happen if not? Obviously, these questions were addressed to researchers as much as to ILK holders.

## 2.2. *Towards a digital ethic in Indigenous contexts*

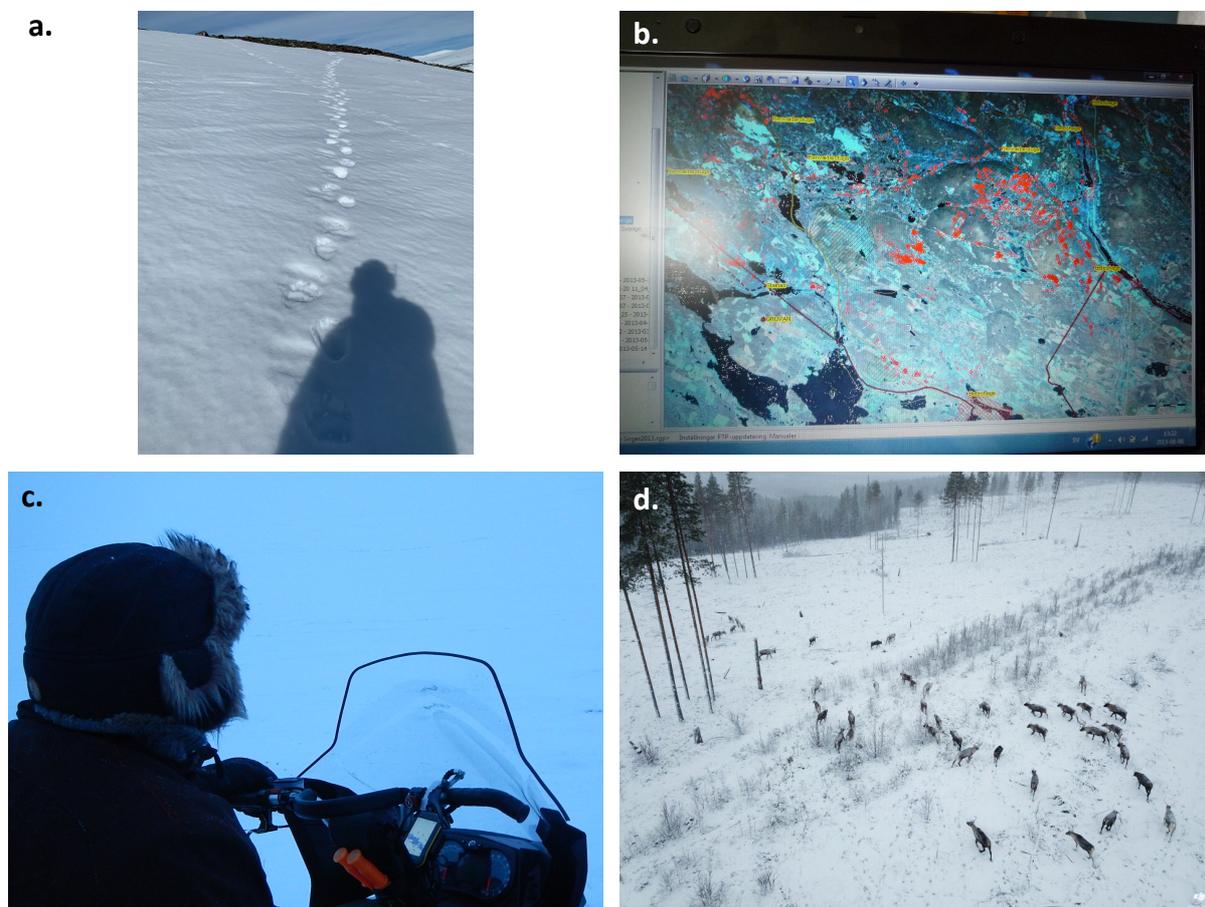
The issues raised by the diffusion of digital technologies in the Arctic context are closely related to shared central concerns of anthropology and contemporary environmental philosophy (Zimmermann, 2005). Beyond the dualisms that characterize Western thinking about the relationship between humans and nature (Descola, 2013), environmental philosophy is working towards the emergence of theoretical frameworks in which non-human beings are not reduced to passive recipients of human intentionality, but rather seen as active agents of social life within the diversity of communities that inhabit the Earth. As one of the authors of this paper has explored, this de-anthropocentrization of thought radically changes the thinking about the quality of everyday relationships between humans, animals, plants and other living things, and their environment (Beau, 2015).

These reflections take place as two of the many narratives that structure the field of environmental thinking are becoming more prominent. The first describes Westerners suffering from a loss of contact with nature and seeking to reconnect with it. Associated with this narrative is the call to practice other "ways of knowing, being and doing" (Martin and Miraboopa, 2003) inspired by Indigenous communities, which is strongly advocated by some environmentalists, sometimes at the cost of a certain idealization. The second narrative asserts that the solutions to this crisis lie in technological innovations, particularly in the digital sector (Morozov, 2013), which would allow for the development of smarter ways of managing the Earth. Ethical and political questions about the promise of digital technologies in the Arctic context are thus posed at the intersection of these two narratives. They underline the need for a more cautious approach to the diversity of epistemologies and ontologies in the environmental sciences.

However, being researchers in the dominant Western world, undertaking an ethical reflection on the development of digital technologies in Indigenous contexts and the following transformations is risky for at least two important reasons. The first is that the ethical study of digital technologies can quickly take the overlying prescriptive form of judgements about right or wrong, and lock the reflection into an opposition between technophobic and technophilic paradigms. The second lies in the ambition of developing such a reflection based on ethnographic material from

Indigenous people. While cultural anthropology has recently begun to pay more attention to ethics (Heintz, 2009), methodological relativism remains a fundamental principle of the discipline. Indeed, anthropologists are rightly reluctant to introduce any form of normativity into their work. As a field

discipline, the rule of anthropology is to describe, possibly theorize, but certainly not to judge the practices and collectives studied. Why then engage in such work?



**Fig. 1.** Examples of applications of digital technologies applications in Sámi reindeer husbandry. (a) Photos and videos taken with smartphones can easily contribute to acknowledging observations made by Indigenous Sámi herders in remote places: here, bear tracks crossing reindeer tracks used as proof of a hunting bear during calving can be sent to the wildlife services. (b) GPS points of reindeer equipped with GPS collars during winter, with a satellite image showing various forest habitats in background. (c) All herders travel with a portable GPS fixed to the front of their snowmobile. (d) Drones can be used to round up reindeer herds over unstable ice or difficult terrain. Herders can order their dog to bark at the right moment to augment the effect of the drone, or even upload and play a recording of a dog barking (or imitated with their voice) from the drone. (Photos: a. M. Kuhmunen, b. and c. S. Roturier, d. L.-E. Nutti).

Like other highly transformative technologies, such as heat engines, digital technologies have become part of virtually all cultures and knowledge systems on Earth, including ours. While it would clearly be irrelevant to commit ourselves to judging individuals or communities that succeed in adopting these technologies, we hypothesize that, for ILK systems, relying on livelihoods that developed through intimate relationships between human and non-humans, the ongoing

transformations raise more intense and specific ethical questions. In his book *Ecology, Community and Lifestyle*, the Norwegian philosopher Arne Naess analysed, in light of his ecosophy, the challenges of the transformation of lifestyles imposed by technological change within various human communities. Centred on the question of the relationship between humans and their milieu, his hypothesis is that where technology is usually considered as a set of mediations between humans

and their environment, certain technologies tend to build a sphere that becomes autonomous and displaces, to their benefit, the human attention that was given to the living and to the environment. There would be, in this sense, a transfer by which “the engagement in nature is reduced in favour of engagement in the technology” (Naess, 1989, p. 103). For the philosopher, the consequences of such a displacement on the level of the relationships between the humans and their environment are potentially devastating: “The degree of inattentiveness or apathy increases and thus our awareness of the changes in nature caused by the technique decreases” (Naess, 1989, p. 103). Therefore, rather than embodying a tool for the realization of goals pursued within a community, these attention-grabbing technologies erode the attachments to the milieu that justified the existence of these goals, sometimes to the point of making them disappear.

We believe that digital technologies that enable humans to interact with their environment pose such a risk to some Indigenous communities, even when they are introduced through collaborative research projects between Indigenous communities and research teams, or by members of the communities themselves. Following the ideology of progress, they hold the promise of positive social transformation, be it human emancipation or technical solutions to the environmental crisis. This promise holds in every geographical and ecological context, from megacities to rural areas at any latitudes, but the blind spots of the digital revolution might, therefore, be of greater concern and more disruptive for Indigenous knowledge systems, such as Sámi reindeer husbandry, that depend on a close relationship with their environment (Abram, 1997). Beyond the promises, we intend to highlight the main challenges of this diffusion in a particular Indigenous context, Sámi reindeer husbandry, and raise the ethical questions associated with it. Mobilizing then the emerging literature on the subject, especially among Indigenous researchers, we consider what ethics can and cannot do to address the risks of weakening epistemological and ontological diversity with digital technologies.

### **3. Digital technologies and sami knowledge**

#### *3.1. Gives you time for something else*

An advertisement for a manufacturer selling GPS collars to be fixed around the necks of reindeer shows a reindeer (ironically without a

collar) trotting in the tundra and a short text saying: “gives you time for something else”. GPS tracking of reindeer has become very popular among herders over the last 10 years, and the message refers to the time saved in exploring the vast landscape to search for the animals. It is extremely clear to reindeer herders that they can use this technology to assist them in the fundamental work of finding the reindeer for roundups, which requires them to know where their reindeer are. The form of reindeer husbandry practiced in Sápmi has evolved considerably throughout history. In northern Sweden, for about a century, it took the form of extensive herding, structured by migrations between different seasonal grazing lands, from the boreal forest in the lower lands to alpine tundra. During the year, the herders alternate between periods of loose and tight control, punctuated by at least four roundups for important operations such as calf-marking, slaughtering, herd separation, or migration. While not watching the herd daily all year round, the herders have to constantly know where their animals (sometimes thousands) are. As Ferret (2007) remarked in her ethnography of horse herding by Yakuts in Siberia, herders are sometimes more animal searchers than shepherds, and so it is for the reindeer herders as well. The very art of herding in this vast environment is thus to interpret, anticipate, encourage and eventually coerce the animals’ displacements according to pasture quality, herder strategy and animal need or will. Observing and understanding animal movements is the core skill in reindeer herding. Potentially, GPS collars complement this knowledge by externalizing part of the process of observation. This being said, one can think that what is lost in “saving time for something else” is potentially a knowledge of nature through a physical, sensitive engagement.

Knowledge about the environment is based on a strong empirical component, with knowledge acquisition mainly driven through the experience of nature and management practices (Ingold, 2000). It is acquired by moving around, exploring the world and being alert to the slightest changes, bringing all the senses to play, not just sight. Touching, hearing, smelling, sometimes tasting are all equally employed by herders to understand the environment, including a body sense as a product of all these perceptions (Ingold and Kurttila, 2000). Learning involves a sensorimotor engagement to understand and interpret all the perceptions from the wide range of phenomena at play in nature, including weather changes, vegetation growth, topography, animal behaviour etc. In Sámi reindeer

husbandry (Cogos et al. 2017), as for other Indigenous people (Henshaw, 2006; Davidson-Hunt and Berkes, 2003), this intimate relationship with the land is developed through the following of an itinerary, revealing a series of landmarks and through traveling again and again in an area. If motor vehicles have reduced travelling times and by doing so, the learning time (Helander-Renvall, 2007), GPS collars may simply prevent travelling altogether, saving the time indeed, and the fuel costs, but at the expense of in-the-field knowledge acquisition.

Learning is also mediated by animals. For Sámi herders, knowing and searching for the animals is learning to think as a reindeer. It is sharing the nomadic landscape (Stépanoff et al. 2017). It is an essential key to understanding their own interactions with the environment. Reindeer convey as much important information about reindeer as they do about their environment, such as grazing and snow conditions, temperatures, the presence of insects or wind. Animals open a perceptive space that exceeds the organic perceptive space of the herder. The question is, thus, to understand the extent to which technological devices such as GPS collars, drones, camera traps, or satellite images, which all enable observation of the environment at distance, enrich, deplete or replace Indigenous peoples' experience and knowledge of the environment. Used as perceptual prosthetics, digital devices represent a new perceptive space that is different from the one without digital devices. Drones in reindeer husbandry are another good example: by using them to observe reindeer at a distance, herders have access to a remote perceptive space normally inaccessible. However, with respect to the senses involved in knowledge acquisition, there is little doubt that drones, as with other digital devices, enhance the ability to see, but "switch off" the other senses, reducing their importance in the general perception and, in return, modifying the way herders act upon, and interact with, the environment and the animals. If digital devices are designed to carry information to humans, they also convey information to non-humans: so, the actions of the herder to control reindeer, for example using a drone, do not result in an *interaction* between reindeer and herder but rather between reindeer and drone. This is potentially also a major symbolic disruption of the man-reindeer relationships in the Arctic. All Indigenous societies that have depended on reindeer or caribou for their livelihoods for centuries have established a long-term contract of reciprocity, symbolic though, between both parties,

through domestication (Ingold, 1974) or hunting (Nadasdy, 2008). Digital devices, by giving access to the perceptive space of reindeer, exclude the herder from the reindeer perceptive space, and potentially dissolve the pre-established contract between human and reindeer.

### 3.2. Knowledge surrogates?

Being a complex assemblage of practices, know-how or technologies, Indigenous knowledge is never carved in stone and is continually updated (Nakashima and Roué, 2002; Sara, 2009). Sámi herders and other Indigenous people immediately recognized the potential of digital technologies for completing and enriching their knowledge acquired from the field, and there is no question that these developments can provide many kinds of solutions to sometimes vital issues, in many ways, for Indigenous people in the Arctic. However, it would be naïve to over-emphasize the potential they represent and to minimize the risk of substituting knowledge for information.

Digital technologies rarely generate new knowledge for Indigenous people. In reality, the information generated by digital technologies mostly complements or validates observations previously made by community members in the field, and is of low value without in-depth knowledge and experience of the terrain. For instance, in reindeer husbandry, the use of GPS collars on reindeer to track their movements must be related to grazing conditions and herders' decisions throughout the season, in order to be interpreted and truly generate knowledge as was shown in the first doctoral thesis investigating the topic (Kuoljok, 2020). By contrast, for outsiders, this information is easily regarded as "new knowledge" by providing what appears to be unequivocal evidence, often supported by images. That is why reindeer equipped with GPS collars are now becoming the standard when studying reindeers' reactions to disturbance from land encroachment (Hermann et al., 2014; Skarin et al., 2015). Having some reindeer fitted with GPS in the herd is strategic now, not because GPS tracks of reindeer are better than herders' thorough knowledge based on observations from the field, but because it is believed, although it narrows the disturbance to a single geographic dimension. It is particularly attractive because it gives credence to arguments, under a scientific veneer, arguments that have sometimes been made orally for decades. However, the evidence of numbers, data or images, such as GPS positions or tracks, involves risks of

simplification when it concerns complex processes, such as animal behaviour, and Sámi herders, like non-Sámi, can be as easily impressed as fooled.

Digital technologies can also supersede Indigenous knowledge and, in particular Indigenous categories, used to name their environment. The case of a participatory GIS project to map reindeer pasturelands and land uses is particularly illustrative. A prototype was designed in the 2000s by two pioneering reindeer husbandry communities jointly with the Swedish Forest Agency, the regulator of the forestry sector that competes for the same land. The mapping inspired from GIS models used in forest management and nature conservation thus imposed a framework to represent the pastures, and a nomenclature which ultimately imposed a hierarchy between “key-”, “core-” and “seasonal pastures” (Sandström et al., 2003). Although grounded in herders’ knowledge of the terrain, and achieved in a participatory fashion, this mapping simplified and conflicted with Sámi knowledge and traditional categories used to describe the quality of winter pastures in an almost constantly changing environment (Roué et al., In Press). A couple of years later, the Swedish state funded the extension of the mapping and made it mandatory for all communities, who all considered this to be a step forward in improved protection of their land. It thus became the new standard for extractive industries when dealing with reindeer husbandry, leaving no chance for Indigenous categories, and thus their worldview of the pasture, to influence commercial forestry and other extractive industries.

The generation who introduced digital technologies in husbandry are fully aware of the importance of knowledge from the field to sort out, interpret and integrate digital information captured in remote places. Particularly skilled herders are undoubtedly able to navigate between different sources of knowledge (Kuoljok, 2019b). However, this will inevitably constitute a challenge for subsequent generations of herders, or for herders who do not have the opportunity to learn in the field. This will also be a challenge for non-herders or outsiders, such as land managers, representative of different extractive industries or researchers, who constantly communicate with reindeer herders. While digital technologies compute, simplify and translate Indigenous knowledge into

colonizers’ languages and rationalities (Andersson and Keskitalo, 2017), the risk is clearly that they will be lured by the promises of being omniscient over the environment, without the ground layer of knowledge to interpret it.

#### 4. Ethical concerns for researchers

##### 4.1. *Researcher’s involvement in programmes based on digital technologies*

A technological innovation can only be evaluated in the light of its social reception, which depends on a cultural, political and economic context, but also on the capacity of individuals and collectives to develop local tactics for reappropriating this technique (Kranzberg, 1986). In this way, users can mobilize their pre-existing know-how in order to configure the use of a new technology actively. The use of drones by Sami herders during reindeer roundup is illustrative in this respect: used as dogs to drive the herd, drones are not replacing dogs or herders in these circumstances, but helicopters<sup>1</sup>. As a consequence, the use of drones requires more time and more people in the Sámi community to actively participate in roundups. However, the actors’ capacity for reappropriation should not obscure the potential for transformation inherent in a new technology and the power relationships, prior and linked to its introduction. Concerning digital technologies in their diversity, the analysis of our empirical material suggests that their transformative potential is as important as the tactics of reappropriation. They do not rely on sensitive ways of understanding nature, they potentially threaten knowledge transmission and, instead of valuing a Sámi ontology, reinforce a Western worldview of reindeer husbandry. Instead, they increase the capacity of information processing by externalizing it in digital devices and, potentially, in the hand of scientists. Therefore, they are more likely to contribute to building a rival knowledge system within reindeer husbandry, and outside.

In this regard, the role played by science over the last three decades within research programmes involving local and Indigenous people through digital platforms needs to be questioned in the Arctic and elsewhere. Many collaborative or participatory projects led by research centres or universities have contributed to the dissemination

<sup>1</sup> The use of helicopters in reindeer husbandry expanded in the 1990s, especially for finding and gathering animals in the tundra, requiring only one herder beside the pilot and very few people on the ground. The use of

helicopter has remained a debated question in Sámi communities, in particular because of the costs.

and adaptation of digital technologies to Indigenous environments and livelihoods. Considered as neutral platforms, these projects are frequently highlighted as innovative methods of dialogue or hybridization between ILK and science, wherein different types of knowledge can mix and mutually enrich each other (Brammer et al., 2016). In doing so, scientists pursue the hope of dissolving the power/knowledge relationships (Foucault, 1977) intensified by digital technologies in an Indigenous context but, in the end, it is questionable whether they are not, rather, conveying and disseminating the promises of their promoters, as well as submitting to them.

Indeed, the seemingly pluralistic vision that supports these programmes is based on the epistemic assumption that ILK might be translated using digital tools. Yet, as many Indigenous scholars have pointed out, such an epistemic claim is highly controversial (Smith, 1999). One of the main problems with this claim is that it seems to ignore the gap that digital technologies have created between knowledge acquired through our sensory embedment in a particular place, and knowledge that results from our digital commitments (Abram, 1997; 2018). Therefore, while promising to broaden the sharing of local knowledge globally, and Indigenous empowerment locally, collaborative or participatory programmes based on digital technology to link science and ILK may well contribute to the impoverishment of the diversity of “terrestrial attunements” (Abram 2018) embodied by ILK.

#### *4.2. In search of an ethical posture*

The risk of seeing humanity settle into a monoculture, as Claude Levi-Strauss (1955) put it, is a long-standing concern for anthropologists and more generally for researchers who study societies threatened by the process of biocultural homogenization (Rozzi et al., 2018). Levi-Strauss called it the problem of the ethnographer caught between the ambition to adopt a critical attitude towards his contemporary world and the detachment that would be required by scientific rigor (Levi-Strauss, 1955). For the French anthropologist, this tension could be solved by the gap introduced between the position of neutral observer, which is that of the ethnographer on his field of study, and that of the critical analyst of the customs of his own society. In this sense, Levi-Strauss wrote: “the society we belong to is the only society we are in a position to transform without any risk of destroying it, since the changes, being

introduced by us, are coming from within the society itself” (Levi-Strauss 1955). The analysis of the consequences of the deployment of digital tools within Indigenous communities leads to a more complex picture in which researchers are engaged in programmes such as digital mapping that undeniably contribute to the transformation of certain Indigenous practices. In other words, both researchers and ILK holders are involved in the same global trend that invite them to use digital technologies to understand the world.

The so-called digital revolution is not uniformly embraced by either ILK holders or researchers, and each digital technology, taken separately, has the potential to both alienate or to trigger a process where Indigenous people actively design and appropriate such technologies for their self-determined wishes. However, as a whole, digital technologies rely on a potentially disruptive epistemology for ILK systems that needs to be documented. From this point of view, as Robert A. Rundstrom’s seminal article indicates the concern for researchers is no longer simply to witness the destruction of the diversity of cultures and knowledge systems, but possibly to participate in it (Rundstrom, 1995). In the same vein, Aporta and Higgs (2005) renewed the call to reconsider the role played by digital technologies in the Arctic context ten years later. Ultimately, the proliferation of digital tools no longer allows us to neglect a problem that is always present, but insufficiently examined by researchers: how to ensure that their methodology and their way of producing knowledge about the societies they study do not, in fact, embody an additional form of cultural domination.

### **5. Two frameworks for digital ethics: Co-construction and strong pluralism**

#### *5.1. Ethics of co-construction and its limits*

The questions raised by the deployment of digital technologies in Indigenous contexts invite researchers to develop a greater reflexivity about their practices. This invitation was taken up by a number of them, who interpreted it as a problem requiring an ethical resolution (Kouril et al., 2016). Insofar as the use of certain technologies appeared to be problematic, it was a matter of defining rules of good practice for these uses. Thus, literature was written on how to design participatory research programmes that respect Indigenous knowledge. From this point of view, two methodological principles have been put forward: that of “co-

construction” on the one hand, and that of “giving back to” the Indigenous communities (Kuokkanen, 2008) on the other.

The principle of co-construction aims to go beyond a vertical model of knowledge production about Indigenous practices and geographies based on an external knowledge system, to establish a more horizontal model of knowledge produced with local communities. Following Apgar and colleagues, we can define co-construction “as a process through which different forms of knowledge that stem from different research disciplines (and their epistemologies) and non-researcher ways of understanding are brought to bear on real-life challenges linked to environmental sustainability” (Apgar et al., 2016). The main idea is that the implementation of a participatory methodology would make it possible to move away from the confrontation between two knowledge systems and, instead, promote a form of cross-fertilization. It is, in particular, this intention that has guided the development of Participatory GIS since the end of the 1990s (Abbot et al., 1998). From this point of view, the answer to the cognitive injustice inherent in the use of digital technologies (Pettersen, 2011) would be the development of a practical ethic, defining a set of rules or a guide to good practice “intended to provide non-exhaustive guidelines for making appropriate ethical choices for those practicing or wanting to practice PGIS” (Rambaldi et al., 2006).

The second principle put forward follows a retributive logic that consists of ensuring that something is given back in return for the involvement of local communities in a research programme. It is a matter of considering the usefulness of the knowledge produced for local communities as a necessary condition for the legitimacy of the research developed. This principle is therefore opposed to the instrumentalization of Indigenous knowledge for purposes that do not concern them (Kuokkanen, 2008).

From an epistemological point of view, this ethical framing leads to a rethinking of the place and role of researchers who study knowledge systems that are not their own. Taking into account the effects of their use of digital technologies, researchers must now face what appears to be the impossibility of considering themselves as neutral observers. In this respect, the procedural ethics of co-construction aims to define a normative framework in which researchers assume the transformative character of their practices, as long as the targeted goals are the expression of the

interests and values of Indigenous communities. However, while it may seem attractive at first glance, this initial proposal for digital ethics is ultimately only a partial response to the problems identified above. By placing too much hope in the design of research methodologies, it misses the deeper issue raised by digital technologies, namely the possibility of heterogeneous knowledge systems coexisting in a fully interconnected world. What if the real ethical question for researchers was not to define a procedural framework for blending ontologies, but to find a way to defend epistemological and ontological pluralism, and to assume that some knowledge might escape them?

### *5.2. The case for strong epistemological and ontological pluralism*

Faced with serious problems that call into question the legitimacy and meaning of their activities, researchers have often turned to ethics hoping to find answers and guidelines to reform some of their practices and restore their confidence in the directions they are taking. These approaches have led to the creation of ethical codes in different fields of application (medical ethics, animal experimentation, etc.). The establishment of a code of ethics for the use of digital technologies in an Indigenous context would be part of this approach and would, undoubtedly, be relevant. However, limiting ourselves to this single response would be to adopt an overly restrictive approach to ethical reflection and the potential for transforming practices that it holds. Beyond the problem/solution approach, ethics can appear as an obstacle in the researchers’ path and destabilize the implicit certainties on the axiological neutrality of their posture, on the supposed objectivity of their research or on their independence from power relationships (Cocq, 2021). Rather than considering ethics as a hole to be covered as quickly as possible with a sort of ethical band-aid, the concern raised by the use of digital technologies can be seen as a call to adopt a posture of sustained vigilance over time, which consists of being attentive to the epistemological presuppositions and practical implications of research activities. This ethical attitude consists of escaping a “climate of ethical and political quietism in science” (Plumwood, 1998), and is defined, in the first place, by the attention to the silent voices and to the knowledge made invisible by the dominant rationalist and dualist traditions of knowledge.

The valorization of these voices and this knowledge is at the centre of the Indigenous

research approach that aims to decolonize research methodologies (Smith, 1999). From this point of view, the ethical and epistemological questioning leads to the political issue of self-determination. It thus appears within this “Indigenous paradigm” (Kuokkanen, 2000) that intellectual self-determination is a crucial component of self-determination. It is also in this sense that the Sami scholar Vigdis Stordahl argued that knowledge building is an important part of nation building (Stordahl, 2008).

From this perspective, as Apgar and colleagues (2016) pointed out, the response of the ethics of co-construction remains insufficient, as it is essentially limited to a formal recognition of ILK, “with little analysis of how this recognition affect broader community processes of self-determination”. Thus, according to the authors, it is necessary to go beyond co-construction precisely for ethical reasons, because “being blind to politics and power is not sufficient and is unethical” (Apgar et al. 2016, 68). In order to grasp these issues, the reflection cannot be limited to the question of the integration of Indigenous knowledge in research protocols, but must go back to the root of the knowledge production process. The quest for epistemic justice requires a prior deconstruction of the dominant categories and conceptual reading grids, otherwise the biases of analysis that are expressed in the very terms of the debate will remain in place. This is the case when we question the ways of reconciling modernity and tradition in an Indigenous context, or of associating scientific and non-scientific thoughts through digital technologies. As the Sami researcher Jelena Porsanger argued, the necessary precondition for the analysis is to understand that the opposition between modernity and tradition does not even make sense for the Sami, and that it is a matter of escaping this “world of dichotomies” (Porsanger, 2011, 246). In the same sense, in light of the work on the epistemology of situated knowledge (Haraway, 1995), Bjørg Pettersen highlighted the way in which digital technologies, as long as they remain framed in a “co-construction model”, tend to prolong the quest for the “view from nowhere” (Harding, 1995), or the “all-seeing eye” (Öhman, 2017), rather than contributing to the intellectual self-determination of local communities. As Pettersen has suggested, an internal contradiction lies in the ambition to move towards open and pluralistic “knowledge societies” along a single path (Agrawal, 2002) and she adds: “it is impossible to reach one single common understanding of what the world actually looks

like, and we thus have a need for multiple ontologies” (Pettersen 2011, 176). From this point of view, ethical attention to the diversity of knowledge does not lead to an ideal of convergence between knowledge, but rather to a respectful posture of the plurality of knowledge systems, including the diversity of “standards of legitimate knowledge” (Porsanger, 2011). Positioning this strong commitment to epistemological pluralism allows us to dispel the ambiguity inherent in co-construction programmes and to consider the design of truly self-determined indigenous digital tools. In this regard, many initiatives outside the “co-construction model” intend to make space for indigenous future imagery (Winter and Boudreau, 2018), though questions remain about their ability to value indigenous ontologies.

At this stage, it appears that the responses to the concern about the effects of the development of digital technologies on the diversity of knowledge systems can ultimately follow two significantly different ethical directions. The first is that of the co-construction and hybridization of knowledge. The second aims at defending a strong conception of epistemological and ontological pluralism. These two directions imply distinct positions for researchers. In the first case, the researcher appears as a possible intermediary between knowledge systems. In the second case, they aspire to situate themselves within a knowledge system in order to contribute to the understanding of the concepts and methods that define it. We define these two models as “ideal-types”, in the sense that they do not claim to exhaust the diversity of research programmes carried out in Indigenous contexts, which are often situated between these two poles. By making this distinction, however, we hope to contribute to the clarification and explanation of the normative orientations that guide researchers concerned with the defence of knowledge diversity in the choices they make regarding the use of digital technologies. From this point of view, digital ethics can be a guide to orient oneself on a field where epistemological issues – what is the quality of the knowledge produced by digital tools? – and political issues – for whom is this knowledge useful? – are more and more closely intertwined.

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## Author contributions

SR collected the data in the field and provided the initial idea for this paper. SR and RB contributed equally to the writing.

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## References

- Abbot, J., Chambers, R., Dunn, C., Harris, T., Merode, E.D., Porter, G., Townsend, J., Weiner, D., 1998. Participatory GIS: opportunity or oxymoron? *PLA Notes* 33.
- Abram, D., 1997. *The Spell of the Sensuous: Perception and Language in a More-Than-Human World*, Vintage Books, New York.
- Abram, D., 2018. Magic and the machine. *Emergence Magazine* 3. <https://emergencemagazine.org/essay/magic-and-the-machine/>
- Agrawal, A., 2002. Indigenous knowledge and the policies of classification. *Int. Soc. Sci. J.* 173, 287–297.
- Andersson, E., Keskitalo, E. C. H., 2017. Technology use in Swedish reindeer husbandry through a social lens. *Polar Geogr.* 40(1), 19–34.
- Andrachuk, M., Marschke, M., Hings, C., Armitage, D., 2019. Smartphone technologies supporting community-based environmental monitoring and implementation: A systematic scoping review. *Biol. Cons.* 237, 430–442.
- Apgar, M.J., Mustonen, T., Lovera, S., Lovera, M., 2016. Moving Beyond Co-Construction of Knowledge to Enable Self-Determination. *Institute of Development Studies* 47, 55–72.
- Aporta, C., Higgs, E., 2005. Satellite culture: Global positioning systems, Inuit wayfinding, and the need for a new account of technology. *Curr. Anthropol.* 46(5), 729–753.
- Arts, K., van der Wal, R., Adams, W. M., 2015. Digital technology and the conservation of nature. *Ambio* 44(Suppl. 4), S661–S673.
- Beau, R., 2015. From Wilderness to Ordinary Nature. *Environmental Ethics* 37, 425–443.
- Berkes, F., 2012. *Sacred Ecology*, third ed. Taylor & Francis, New York.
- Brammer, J. R., Brunet, N. D., Burton, A. C., Cuerrier, A., Danielsen, F., Dewan, K., Herrmann, T. M., Jackson, M. V., Kenett, R., Larocque, G., Mulrennan, M., Pratihast, A. K., Saint-Arnaud, M., Scott, C., Humphries, M. M., 2016. The role of digital data entry in participatory environmental monitoring. *Conserv. Biol.* 30(6), 1277–1287.
- Castleton, A., 2018. Technology and Inuit identity: Facebook use by Inuit youth. *AlterNative* 14(3), 228–236.
- Cocq, C., 2021. Revisiting the digital humanities through the lens of Indigenous studies—or how to question the cultural blindness of our technologies and practices. *J. Assoc. Inf. Sci. Technol.* 1–12.
- Cocq, C., Dubois, T. A., 2020. *Sámi Media and Indigenous Agency in the Arctic North*, University of Washington Press, Seattle.
- Cogos, S., Roué, M., Roturier, S. 2017. Sami Place Names and Maps: Transmitting Knowledge of a Cultural Landscape in Contemporary Contexts. *Arct. Antarct. Alp. Res.* 49(1), 43–51.
- Davidson-Hunt, I., Berkes, F. 2003. Learning as You Journey: Anishinaabe Perception of Social-ecological Environments and Adaptive Learning. *Ecol. Soc.* 8(1), 5.
- Descola, P., 2013. *Beyond Nature and Culture*. The University of Chicago Press, Chicago.
- du Plessis, G., 2020. Killing reindeer: a spatial analysis of Nordic states and nomadic forms of life in the Arctic. *Int. Political Sociol.* 14(4), 347–365.
- Ferret, C. 2007. Les Iakoutes, des chercheurs de chevaux. *Ethnozootechnie* 80, 51–62.
- Foucault, M., 1977. *Discipline and punish: the birth of the prison*. Pantheon Books, New York.
- Gearheard, S., Aporta, C., Aipellee, G., O’Keefe, K. 2011. The Igliniit project: Inuit hunters document life on the trail to map and monitor arctic change. *Can. Geogr.* 55(1), 42–55.
- Gorenflo, L. J., Romaine, S., Mittermeier, R. A., Walker-Painemilla, K., 2012. Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. *Proc. Natl. Acad. Sci.* 109, 8032–8037.

- Haraway, D., 1995. The Science Question in Feminism and the Privilege of Partial Perspective', in: *Technology and the Politics of Knowledge*. Bloomington, pp. 175–194.
- Harding, S., 1995. "Strong objectivity": A response to the new objectivity question. *Synthese* 104, 331–349.
- Heath, J., 2020. SIKU: Mixing high-tech with ancient know-how. *The UNESCO Courier*, 20–22. <https://doi.org/10.18356/fla4b2d4-en>
- Henshaw, A. 2006. Pausing along the Journey: Learning Landscapes, Environmental Change, and Toponymy Amongst the Sikusilarmiut. *Arct. Anthropol.* 43(1), 52–66.
- Heintz, M., 2009. *The anthropology of moralities*, Berghahn Books, New York and Oxford.
- Helander-Renvall, E., 2007. Logical adaptation to modern technology: snowmobile revolution in Sápmi, in Heininen, L., Laine, K. (Eds.), *The Borderless North*. Publication of the Fourth Northern Research Forum. University of Oulu and NRF, Oulu, pp. 27–33.
- Herrmann, T. M., Sandström, P., Granqvist, K., D'Astous, N., Vannar, J., Asselin, H., Saganash, N., Mameamskum, J., Guanish, G., Loon, J.-B., Cuciurean, R., 2014. Effects of mining on reindeer/caribou populations and indigenous livelihoods: community-based monitoring by Sámi reindeer herders in Sweden and First Nations in Canada. *Polar J.* 4(1), 28–51.
- Hill, R., 2020. Working with indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. *Curr. Opin. Environ. Sustain.* 43, 8–20.
- Ingold, T., 1974. On reindeer and men. *Man* 9(4), 523–538.
- Ingold, T., 2000 *The Perception of the environment: Essays on livelihood, dwelling and skill*, Routledge, London and New York.
- Ingold, T., Kurttila, T., 2000. Perceiving the environment in Finnish Lapland. *Body & Society* 6(3-4), 183–196.
- IPBES, 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. <https://doi.org/10.5281/zenodo.3553579>
- Kouril, D., Furgal, C., Whillans, T., 2016. Trends and key elements in community-based monitoring: A systematic review of the literature with an emphasis on Arctic and Subarctic regions. *Environ. Rev.* 24, 151–163.
- Kranzberg, M., 1986. Technology and history: "Kranzberg's laws". *Technol. Cult.* 27(3), 544–560.
- Kuokkanen, R., 2000. Towards an "indigenous paradigm" from a Sámi perspective. *Can. J. Native Stud.* 20(2), 411–436.
- Kuokkanen, R., 2008. From research as colonialism to reclaiming autonomy: Toward a research ethics framework in Sápmi, in: *Ethics in Sámi and Indigenous Research (Report from a Seminar in Kárášjohka, Norway, November 23-24, 2006)*. Sami Institute, pp. 48–63.
- Kuoljok, K., 2019a. Reading the reindeer. New ways of looking at the reindeer and the landscape in contemporary husbandry. *Ethnologia Scandinavica* 49, 22–39.
- Kuoljok, K., 2019b. Without land we are lost: Traditional knowledge, digital technology and power relations. *AlterNative* 15(4), 349–358.
- Kuoljok, K. 2020. Digital Information and Traditional Knowledge. The Implementation of GPS Collars as a Tool in Reindeer Husbandry. Doctoral Thesis. *Etnologiska Skrifter*, Umeå Universitet 68.
- Levi-Strauss, C., 1955. *Tristes Tropiques*, Plon, Paris.
- Martin, K., Miraboopa, B., 2003. Ways of knowing, being and doing: A theoretical framework and methods for indigenous and indigenist re-search. *J. Aust. Stud.* 27, 203–214.
- Morozov, E., 2013. *To Save Everything, Click Here: the Folly of Technological Solutionism* PublicAffairs, New York.
- Müller-Wille, L., Pelto, P. J., 1971. Technological change and its impact in Arctic regions: Lapps introduce snowmobiles into reindeer herding. *Polarforschung* 41(1/2), 142–148.
- Nadasdy, P., 2008. The gift in the animal: The ontology of hunting and human-animal sociality. *Am. Ethnol.* 34(1), 25–43.
- Naess, A., 1989. *Ecology, Community and Lifestyle*, Cambridge University Press, Cambridge.
- Nakashima, D., Roué, M., 2002. Indigenous knowledge, peoples and sustainable practices. *Encyclopedia of Global Environmental Change* 5, 314–324.
- Newman, G., Wiggins, A., Crall, A., Graham, E., Newman, S., Crowston, K., 2012. The future of citizen science: emerging technologies and shifting paradigms. *Front. Ecol. Environ.* 10, 298–304.
- Niezen, R., 2009. The rediscovered self: Indigenous identity and cultural justice,

- McGill-Queen's University Press, Montreal and Kingston.
- Öhman, M.-B., 2017. Places and peoples: Sámi feminist technoscience and supradisciplinary research methods, in: O'Brien, J., M., Andersen, C., (Eds.) *Sources and Methods in Indigenous Studies*. Routledge, New York.
- Pascual, U., Adams, W. M., Díaz, S., Lele, S., Mace, G. M., Turnhout, E., 2021. Biodiversity and the challenge of pluralism. *Nat. Sustain.*
- Pettersen, B., 2011. Mind the digital gap: Questions and possible solutions for design of databases and information systems for Sami traditional knowledge. *Working with traditional knowledge: Communities, institutions, information systems, law and ethics* 163.
- Plumwood, V., 1998. Knowledge in an ethical framework of care. *Australas. J. Environ. Manag.* 5, 27–38.
- Porsanger, J., 2011. The Problematisation of the Dichotomy of Modernity and Tradition in Indigenous and Sami contexts, in Porsanger, J., Guttorm, G. (Eds.), *Working with traditional knowledge: Communities, institutions, information systems, law and ethics*, Sámi University College.
- Rambaldi, G., Chambers, R., McCall, M., Fox, J., 2006. Practical ethics for PGIS practitioners, facilitators, technology intermediaries and researchers. *Participatory learning and action* 54, 106–113.
- Raymond, C. M., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G. M., Evely, A. C. 2010. Integrating local and scientific knowledge for environmental management. *J. Environ. Manage.* 91, 1766–1777.
- Roturier, S., 2009. *Managing Reindeer Lichen during Forest Regeneration Procedures: Linking Sami Herders' Knowledge and Forestry*. Doctoral thesis. Swedish University of Agricultural Sciences & French National Museum of Natural History, *Acta Universitatis Agriculturae Sueciae* 84.
- Roué, M., Nutti, L.-E., Utsi, N.-J., Roturier, S., In Press. Mapping land use with Sámi reindeer herders: co-production in an era of climate change, in: Roué, M., Nakashima, D., Krupnik, I. (Eds.), *Resilience Through Knowledge Co-Production: Indigenous Knowledge, Science and Global Environmental Change*, Cambridge University Press and UNESCO, Cambridge and Paris.
- Rosa, I. M. D., Pereira, H. M., Ferrier, S., Alkemade, R., Acosta, L. A., Akcakaya, H. R., den Belder, E., Fazal, A. M., et al. 2017. Multiscale scenarios for nature futures. *Nat. Ecol. Evol.* 1, 1416–1419.
- Rozzi, R., May, R.H., Chapin III, F.S., Massardo, F., Gavin, M.C., Klaver, I.J., Pauchard, A., Nuñez, M. A., Simberloff, D. (Eds.), 2018. *From Biocultural Homogenization to Biocultural Conservation, Ecology and Ethics*. Springer International Publishing, Cham.
- Rundstrom, R. A., 1995. GIS, Indigenous Peoples, and Epistemological Diversity. *Cartogr. Geogr. Inf. Syst.* 22, 45–57.
- Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., Rockström, J., 2019. Six transformations to achieve the Sustainable Development Goals. *Nat. Sustain.* 2, 805–814.
- Sandström, P., Granqvist Pahlén, T., Edenius, L., Tømmervik, H., Hagner, O., Hemberg, L., Olsson, H., Baer, K., Stenlund, T., Göran Brandt, L., Egberth, M., 2003. Conflict resolution by participatory management: Remote sensing and GIS as tools for communicating land-use needs for reindeer herding in northern Sweden. *Ambio* 32(8), 557–567.
- Sara, M. N., 2009. Siida and Traditional Sámi Reindeer Herding Knowledge. *The North. Rev.* 30, 152–178.
- Schillo, J., Turin, M., 2020. Applications and innovations in typeface design for north American Indigenous languages. *Book 2.0* 10(1), 71–98.
- Skarin, A., Nellemann, C., Rönnegård, L., Sandström, P., Lundqvist, H., 2015. Wind farm construction impacts reindeer migration and movement corridors. *Landscape Ecol.* 30, 1527–1540.
- Smith, L.T., 1999. *Decolonizing methodologies: research and indigenous peoples*. Zed Books, London.
- Stammler, F., 2009. Mobile phone revolution in the tundra? Technological change among Russian reindeer nomads. *Folklore* 41, 47–78.
- Stépanoff, C., Marchina, C., Fossier, C., Bureau, N., 2017. Animal autonomy and intermittent coexistences. *North Asian modes of herding. Curr. Anthropol.* 58(1), 57–81.
- Stordahl, V., 2008. *Nation Building Through Knowledge Building. The Discourse of Sami Higher Education and Research in Norway.*, in: *Indigenous Peoples: Self-Determination, Knowledge, Indigeneity*. Eburon Academic Publishers, Eburon Delft, pp. 240–265.

- Sutherland, W. J., 2003. Parallel extinction risk and global distribution of language and species. *Nature* 423, 276–279.
- Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., Spierenburg, M. 2014. Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach. *Ambio* 43, 579–591.
- Williams, E., 2011. Environmental effects of information and communications technologies. *Nature* 479, 47–78.
- Winter, J., Boudreau, J. 2018. Supporting Self-Determined Indigenous Innovations: Rethinking the Digital Divide in Canada. *Technology Innovation Management Review* 8(2), 38–48.
- Zimmermann, M.E. (Ed.), 2005. *Environmental philosophy: from animal rights to radical ecology*, 4. ed. ed. Pearson/Prentice Hall, Upper Saddle River, NJ.