Policy in the Peaks: Cybercartography and Traditional Ecological Practices to Diversify Pasture Policy-Making in Naryn Province, Kyrgyzstan

by

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Abstract

Kyrgyzstan's pasture management policies have been challenged by the limited capacity of its nascent, village-level committees and pasture user groups. The collapse of supporting Soviet-era institutions that collected up-to-date information means policies have little connection with actual practice on the ground. As a result, rural Kyrgyz livelihoods have stagnated in Naryn province.

A cybercartographic approach with user-generated data is implemented to visualize traditional practices on an online atlas. Participants identify pasture management, ecological monitoring, and medicinal plants as key categories of practices to be mapped. Both the produced atlas and the process of making the atlas are examined for their impact on pasture stakeholders' roles in pasture management.

Spatial and interview results show spatially different representations of pastures by various groups and a dialogue-building effect of visualizing practices on an atlas. Demonstrating spatial and thematic linkages between groups offers new partnerships and deeper possible engagement of pasture users in managing pastures. These results are discussed in the context of informing a future pasture governance tool.

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1 Introduction

In the wake of the Soviet Union's collapse in 1991, Kyrgyzstan has emerged as a democratic outlier in Central Asia. Reform in natural resource policy has progressed under six presidents, including the first instance of a peaceful transition of power between elected officials in 2017 (Gizitdinov 2017). While policy changes in lucrative sectors such as mining draw relatively quick action from the government, governance over the traditional sector of pasture use has stagnated. In mountainous Naryn province shown in Figure 1, agriculture and livestock herding accounted for 46.33% of all official employment in 2016, yet pasture policy remains centralized with the last instance of significant pasture reform occurring in 2009 (Statistics of the Kyrgyz Republic 2016; Crewett 2015).

Figure 1 - An overview of Naryn province within Kyrgyzstan, the project's province of study. Political boundary data for the map from Diva-GIS (www.diva-gis.org).

A national shift of management responsibilities to local-level committees and various user groups has proven to be largely ineffective due to a lack of local capacity, transparency, and supporting institutions that provide up-to-date information (Shigaeva et al. 2016). Actual pasture policy is a token acknowledgement of the official rules accompanied by the discretion and varying capability of the pasture committees, resulting in a patchwork of different pasture practices. At the root of this non-cohesive system is a lack of consultation with local stakeholders such as pasture herders to ground policy in local priorities and needs.

This research explores the representation of pasture users through a collaborative web atlas of practices. Initiatives around the world such as New York City's OpenData use web platforms that visualize data through interactive maps (City of New York 2017). This project complements and advances these efforts by creating an open-access platform that emphasizes pasture user-generated data over the state's data. In effect, this project seeks to stimulate the civil society parallel to existing government web resources. A grassroots, participatory mapping approach affords local participants a medium to add, edit, and delete their information to self-represent their practices to national and international audiences. In contexts such as Kyrgyzstan's pasture sector where consultation of local stakeholders is institutionally undervalued, such a system works to empower community members, promote dialogue, and encourage citizen engagement. Cybercartography is presented here as a theoretical and applied approach that combines visualization with user-influenced data structure in the form of web atlases. Participatory mapping methods are applied to allow pasture stakeholders to contextually present community needs and uses that may not be captured by the Kyrgyz government's standardized approach. Lessons learned from this project are meant to uncover implications for a future e-governance system with active participation by both government and civil society.

The final distinguishing element of this research is a critical analysis of the role of traditional knowledge (TK) on pasture practices represented through cybercartography. The Soviet legacy of Kyrgyzstan has imprinted a mentality where pasture users are reticent about participating in policy, due to their experience under the former centralized government that wielded strong control over services (Jacquesson 2010). This legacy continues as many of Kyrgyzstan's policies are holdovers or inspired by Russian examples (*ibid*). A focus on TK enables the production and

renewed visibility of a set of knowledge that has been largely repressed by the Soviets, in hopes of rediscovering its applicability to contemporary pasture issues. Furthermore, traditional practices are typically low-tech and may be exceptionally suited for a contemporary Kyrgyz state that no longer has the cash transfers or infrastructure of the collapsed Soviet Union. Finally, TK tends to be highly contextualized and specific to the area it is practiced in (Kassam, Bulbulshoev, and Ruelle 2011). Adopting a local-level focus increases the probability that participants will uncover context-appropriate practices and pasture uses that are unknown by remote policy makers in the capital city of Bishkek.

1.1 Research Aims and Relevance

This research aims to better understand how spatially presenting TK in a cybercartographic approach can mediate differences between Naryn pasture users and government views on pasture management. I ask:

1) How can a cybercartographic atlas approach to visualizing pasture practices mobilize pasture users' engagement in pasture management?
    - ➔ How does an explicitly map-based visualization enable the depiction of different views/priorities of the same pasture landscapes?
    - ➔ Does a cybercartographic approach influence change in how stakeholders view their personal roles in managing pastures?
2) Do traditional knowledge and practices provide additional information that supplement or contradict official pasture policy?
    - ➔ How do various stakeholder groups perceive the value of TK?

These questions are to be answered through the process and product of creating a cybercartographic atlas (the Atlas). As part of the research, it implements an open, web-based atlas that allows Kyrgyz pasture stakeholders to add, edit, and download information on traditional pasture practices. The Atlas, based on open-source *Nunaliit* software developed by Carleton University's Geomatics and Cartographic Research Centre (GCRC 2012), is created to act as an interactive storehouse of information and online reference for pasture users. A cybercartographic atlas was chosen due to the technology's record of honouring indigenous knowledge and collaborative data creation (Taylor 2013). A specific focus on practices anchors the content in performative actions that take place in a space (ensuring it can be mapped) and are observable (assisting in verification and transmission to other stakeholders). The research also studies the impact of the mapping process on participants to assess the viability of a cybercartographic approach in improving citizen engagement in pasture decision-making. The extent of improved citizen engagement is measured by the number of atlas contributors and the number of features they add. The depth of change is evidenced by changes in perception towards one's role in pasture management and new dialogue/partnerships between different groups. These measures were chosen as a mix of qualitative and quantitative indicators that allow future research to easily target specific areas or groups that displayed high activity and engagement. The project adopts an initial focus on two villages and two national parks in Naryn province, chosen due to their involvement in prior citizen engagement projects (further discussed in Section 3.2).

Findings from this research are important as a case study of the influence of open, citizen-led data generation in pasture governance. Despite Kyrgyzstan's record of elected officials

compared to the rest of Central Asia's autocracies, corruption remains and slow economic and social progress have eroded the public trust in state institutions (Romanowski 2017). This is further compounded by the dispersed distribution of Kyrgyz citizens, with many leading semi-nomadic herder lifestyles that receive little in terms of government support. This project creates an online record of practices and a community of active local contributors to foreground the difference in pasture narratives between actual users and remote policy makers. In turn, identifying these differences and potential similarities can reveal common factors and concrete initiatives to rebuild collaboration. The ability for the Atlas to accept comments from users can also create dialogue between local resource users and experts. An envisaged application of the produced atlas would allow a rural citizen to submit a picture of a plant and an expert in Bishkek to offer a remote diagnosis on whether the plant is edible or suffering from a disease.

Kyrgyzstan also suffers from poor information accessibility, with many local-level institutions yet to digitize their data. Participant-submitted content on the Atlas promotes the visibility of pasture user knowledge and encourages drawing upon citizens' wealth of knowledge to complement, check, and even ground the state's efforts in areas where it has little reach. In specific regard to TK, publishing traditional practices recognizes the validity of pluralistic ways of understanding a landscape. Currently, the Kyrgyz state has adopted a strategy of unilaterally excluding all people from designated Protected Areas such as national parks to protect the environment (Dörre 2015). Acknowledging TK may reveal, for example, that pasture users reforest areas while grazing their animals on more mature grasslands. In practical terms, this translates to potential for avoiding simplistic binaries such as ecological protection versus local

livelihoods. Throughout this work, the general term 'pasture user' is used to mean not only herders but also those that collect timber, forage medicinal plants, and other activities to accept the diversity of challenges and opportunities facing these pastures.

This work is informed by two years of development work experience with the Aga Khan Development Network in mountainous parts of Nepal, Tajikistan, and Kyrgyzstan. My experience in education system reform and knowledge management in these areas has consistently highlighted the isolation and lack of information caused by difficult terrain, with a simultaneous pluralism of knowledge systems and creative adaptations due to this same terrain. This research aims to contribute towards the long-term goal of creating flexible, decentralized governance systems that respond equitably to both urban core and remote hinterland. A user-led atlas can be the first step in producing locally-based knowledge to inform such a governance system.

1.2 Thesis Structure

The following chapters aim to answer the research question of how cybercartography can mediate differences between official policy and traditional methods of pasture management. Chapter Two summarizes current Kyrgyz pasture management policies, defines TK, and outlines the theoretical rationale for cybercartography (as a narrative-centric participatory geospatial tool for stakeholder engagement). Chapter Three details the methodology adopted for generating user-contributed data and visualizing it for comparison with other practices in rural Kyrgyzstan. Atlas content is contributed by pasture users of the two study villages and two national parks. Chapter Four presents the spatial and interview results of the research. The fifth chapter provides critical analysis, a discussion of unexpected findings, and a reflection on the

limitations of a cybercartographic approach. Chapter Six identifies the main lessons learned and further avenues for research.

2 Background and Literature Review

2.1 Kyrgyzstan and The Pasture Struggle

An important link in the ancient Silk Road, Kyrgyzstan has been influenced in its traditions by numerous cultures including the Mongols, Chinese, and Uzbeks. With over 94% of the current territory of Kyrgyzstan at an elevation of 1000 meters or higher, its people have historically been nomadic herders migrating in Kyrgyzstan's high mountain pastures since the 1500s (Dörre and Borchardt 2012; Encyclopedia of World Cultures 1996). Pasture users continue to migrate seasonally and live in homes called yurts that can be disassembled, allowing herders to move throughout the high pastures with their herds during the summer season. Initially tribally allotted and later centralized by Soviet rule, the management of these pastures has since evolved through two major iterations (Jacquesson 2010).

2.1.1 Post-Soviet Transitions and the Fencing of Pastures

Kyrgyzstan was a member of the Soviet Union for the entirety of its reign, gaining independence upon the latter's collapse in 1991. Under Soviet rule, Kyrgyz pasture laws were oriented towards mass livestock-raising (primarily sheep, cows, and horses) to supply other Soviet republics with wool and dairy products (Dörre and Borchardt 2012). Pasture users were organized into collective farms and migration routes were strictly prescribed by state bodies, while customary management systems were replaced by state-led collectivization (*ibid*). These collectivized herding farms were supported by roads, water canals, electricity, and veterinarian services (Shigaeva et al. 2016). Following the Soviet collapse and the subsequent loss of this

infrastructure, an individual pasture leasing and auction system was introduced in 2002 to replace collectivization (*ibid*). Under this new system, private owners were responsible for maintaining their pasture plots, shifting the burden of infrastructure provision from the government to the individual (*ibid*). Pasture plots were auctioned to individual Kyrgyz bidders or leased to local, economically disadvantaged households for up to ten years in a formalized, state-controlled process (Dörre 2015). This system was a push towards privatization and a market economy favoured by international donors such as the World Bank (*ibid*). At the time, Kyrgyzstan was heavily dependent on foreign aid to support its economy after the Soviet collapse and was obliged to accept these demands (*ibid*). Western proponents of classic neoliberalist theory argued that privatizing the pastures would improve ownership security and provide herders with incentives to manage their plots sustainably (*ibid*). This privatized system was ultimately disastrous for herders, whose animals could no longer freely migrate among the now fenced-off pastures and inevitably overgrazed the individual plots they had access to (Dörre and Borchardt 2012). A rush for pastures conveniently close to villages occurred favouring those with connections and social power, while more remote pastures sat unused (*ibid*). The bureaucracy of the auction system also made it expensive and time-consuming to acquire all the seasonal pastures needed for the annual route of a herder (Dörre 2015). Both ecological damage to pastures and social inequality (between richer households that were able to acquire pastures and poorer households that could not) marked this period of pasture management.

2.1.2 Decentralization of Pasture Law

The failure of privatization led to a reform in 2009 called "On Pastures". It abolished the 2002 lease system and transferred pasture management responsibilities from provincial bodies to local level groups, namely Pasture Committees (PC) and Pasture User Association (PUAs; Crewett 2015). Every pasture user is entitled to be a member of the PUA. The governing PC is comprised of elected PUA members and members of the local, municipality-level institution called *ailyk okmotu* (Dörre 2015). The PC officially acts independently of other bodies and supports itself by selling pasture tickets to users (*ibid*). The pasture ticket's cost is calculated by the quantity and species of animals (goats, sheep, cows, horses, yaks, camels) a herder brings to the pasture (*ibid*). The income from these tickets is meant to enable the PC to repair road infrastructure, reforest, and regularly monitor the pasture conditions (*ibid*).

While the devolution of responsibility was meant to improve representation of pasture users, it caused the selection of PC members along local-level power relations. Shigaeva *et al*. (2016) note that studied PCs did not include any herders, thereby excluding their perspective on pasture management. While there have been pilot efforts to introduce e-monitoring schemes in Naryn province to consolidate data, these measures will ultimately be unsuccessful if they are built on a structural disregard for the full range of pasture uses (Abdylakykova and Usubaliev 2014).Local-level PCs also lacked the capacity and resources to fulfill their duties, with many still using paper documents and no computers (*ibid*). As a result, many PCs still use old policies such as a 1980s formula equating one horse to five sheep to calculate the carrying capacities of pastures despite climatic differences (Dörre 2015). Compounding the monitoring issue was the unforeseen incentive for herders to under-report the size of their herds to lessen

the cost of their pasture tickets (Shigaeva et al. 2016). The intersection of responsibilities between PCs, *ailyk okmotu*, and forest user groups was also unclear with vague common boundaries, no formal arrangements, and no infrastructure for information sharing (*ibid*). Figure 2 below illustrates the formal top-down structure of contemporary resource management bodies, highlighting the lack of formal horizontal cooperation between pasture organizations (left column), forest agencies (middle-right column), and park management (far right). Additionally, non-state organizations in pink such as the PC struggle to remain separate (perceived and in practice) when many of its members are elected from state bodies such as the *ailyk okmotu*.

Figure 2 - The official structure of agencies influencing pasture governance. Data on government structure: Kozhomberdiev 2017.

Due to the current pasture system's flaws, officials are perceived by pasture users to do the minimum to avoid intervention by higher authorities (Mestre 2018). Uncertainty around which bodies are meant to represent herders' interests has led to the herders adhering to rules such as payment of pasture fees on an uneven, ad-hoc, and individual basis (*ibid*.). Combined with the lack of PC resources to rebuild pasture roads, there is little motivation and ability to resume seasonal migration to more remote pastures. As a result, pasture users continue to overuse areas close to their villages, causing degradation.

2.1.3 Fragmentation of Pastures and Forests

Pasture users diversify their livelihood activities to draw upon all aspects of the pasture ecosystem, including timber products from the forests and grazing fodder from the grasslands. As Section 2.1.2 and Figure 2 show however, forests and grassy areas of pastures have been

legally zoned and separated into different branches of government. Further distinctions have been made in the case of national parks, designated as 'Protected Areas' that exclude almost all uses of the land by pasture users (Kirbashev 2017). The jurisdictional fragmentation of the ecosystem has led to multiple resource management bodies including PCs, forest committees, and park rangers that may or may not coordinate their activities (Kozhomberdiev 2017). As a result, pasture users must navigate a multitude of regulations while members of each authority fulfill their responsibilities to a token extent at best and compete with each other at worst. The unclear responsibilities, unarticulated mechanisms for cooperation, and mismatch between separate agencies and actual pasture use guided the selection of study sites for this research. To parse the list of stakeholders down to a manageable and local level, this project will focus on pasture users (some of whom belong to the PC or forest committee and are further analyzed by age and gender), park rangers, school children, and subject experts (e.g. animal husbandry, agriculture) in Naryn City and Bishkek.

2.2 Traditional Knowledge

Traditional knowledge (TK) informs this study methodologically as a reflexive attempt to promote deeper participation by Kyrgyz participants and as an underused source of knowledge. TK is defined as practices and knowledge that are passed through generations in a community and form part of that community's cultural identity (WIPO 2010). The specificity of a set of TK to a community means that it is uniquely adapted to the geography the community occupies, with adaptations occurring as new geographies are encountered (Trosper and Parrotta 2012). As a result, TK is a fluid process of continual interaction with the land and differs not only between different areas but also within its existing geography as conditions change. The

knowledge exists not only as data points but as part of a complete worldview specific to the culture practicing it (Trosper and Parrotta 2012). This distinction contradicts assumptions of universalism and positivism that are hallmarks of Western science (further discussed in Section 2.3.1). The consequence is that directly transplanting data from a given set of TK into another knowledge system (such as the Western scientific method) or vice versa frequently encounters problems of understanding and verification (Dutheil, Tester, and Konek 2015). Detached from the cultural moorings and value system of the TK's worldview, information is decontextualized and loses its value. For example in rural Kyrgyzstan, forests were traditionally managed by local communities who approved felling of trees only if it was 5km away from the settlement and then only permitting harvesting of dead wood (Bocharnikov *et al.* 2012). A centralized planning approach to forest management may interpret such local management schemes as aiming to preserve a certain amount of forest cover in an area, overlooking the traditional understanding that trees are also strategically placed to prevent wind erosion of soils (*ibid*). Implicit in this example are unequal power relations between the state and local communities, injecting political bias into valuing dominant systems of knowledge (e.g. Western science) over local TK.

2.2.1 Distinguishing TK in Naryn Province

In Naryn, nomadic Kyrgyz pasture users have developed a rich set of practices including seasonal migration and forecasting weather through star observation to ensure their sustainable use. This research focusses on the traditional practices of Naryn pasture users as they relate to managing pasture use. As such, TK in Naryn for this project is partly distinguished by its performative nature that allows it to be seen and demonstrated to others. This criterion was chosen so that collected data had a discernible/measurable impact on pastures that could

a.) be communicated to non-practitioners and b.) could be spatially mapped. Its performativity means that TK in this project is a hybridized mix of historical and modern techniques that have been adapted to fit the environmental, cultural, and livelihood changes Naryn residents have been a part of over the years. This parallels the World Intellectual Property Organization's (WIPO) description of TK as dynamic and ever-evolving (WIPO 2018). Both rare practices and widely known mainstream practices are accepted in this project as long as they are performed. The holders of TK (and therefore the participants in this study) are then defined as those that continue to practice the knowledge, rather than by an ethnic association. This definition keeps the project's focus on those actively depending on pastures and attempts to guide benefits back to these stakeholders.

The second criterion echoes Berkes's definition (in Inglis 1993) of a "cumulative body of knowledge and beliefs" (pp. 3). This project defines this body as any practices that impact how pastures are used in Naryn. Practices that take place in villages (such as weather-forecasting by the shape of the moon) are accepted as TK in this project because a.) there are pastures close to villages that are used in winter because of their accessibility and defend-ability against wolves and b.) pasture users grow fodder for their animals in the villages, which reduces the need to take animals to graze in the pastures. Furthermore, a practice to graft trees so that they grow back faster (and can be cut down as timber for on-pasture firewood) in NNR is accepted as TK for this project. A similar practice in the walnut groves of southern Kyrgyzstan is excluded not only for its geographic placement but also because it does not affect pasture use in its local context. Examples of TK will be shown in the Atlas through a web map and in custom visualizations that attempt to reflect that practice's sensory and performative nature.

2.2.2 Why the Focus on TK?

This project focusses on TK as it offers a resource-user based perspective on how to equitably and effectively manage pastures. As introduced in Section 2.2, TK is often subsumed and decontextualized by colonial forces (in Kyrgyzstan's case, Soviet administrators). Pasture TK among Naryn pasture users has typically been passed down through oral tradition and lived experience, and as such has seen limited exposure compared to written Soviet texts that were easily reproduced and distributed (Pawera et al. 2016). Often viewed as myth and illegitimate by policymakers who did not have first hand experience of the pastures, TK offers an alternative worldview of the landscape that may offer insights the current administrative system (detailed in Section 2.1.2) may have overlooked. TK is inherently context-specific and should not be considered a general, common body of practice (Jacquesson 2010). Each practice is a unique interpretation by the practitioner in response to their local conditions and environment (*ibid*). A focus on TK as the primary content for this research therefore offers a historical and political sensitivity to pasture user perspectives that were neglected during the creation of the ineffective 2009 "On Pastures" law. Acknowledging the historical colonial pressures at work increases the chances that local pasture users will engage in this research and work with authorities, rebuilding trust in Kyrgyzstan's public institutions.

It is important to note that neither TK nor centralized policy-making are presented here as replacements for the other. Rather, TK is solicited to highlight complementarities and differences with official prescribed practices. For example, some Kyrgyz pasture households traditionally interpret the movement of wildlife from high elevations to low elevations as an indicator of oncoming cold weather (Camp Alatoo 2016). Weather stations have also been

installed in the same area to log variables such as temperature and precipitation (Foggin 2017). By combining Kyrgyz TK and empirical scientific observation stations, complementary aspects of each knowledge system can mutually identify weather trends. The task of determining if these aspects can be itemized and separated from the system of belief they originate from to create a mixed-systems method is discussed in Section 5.5 but is otherwise beyond the scope of this research.

2.2.3 Connecting TK with Cybercartography

TK often offers fundamentally different ontologies and representations of concepts than the Western scientific method. As such, the medium in which TK is presented must be able to accommodate different data structures and types of information. Cybercartography has been employed to present traditional Inuit knowledge in northern Canada since 2005 (Taylor and Caquard 2006). Taylor (2013 pp. 188) notes that the cybercartographic approach does "not determine in advance what kind of material the Framework can ingest but rather respond[s] to the various kinds of input the community wishes in a flexible manner." Adopting these principles into a technical platform (further discussed in Section 2.3) helps visualize conceptual differences with other knowledge systems and makes TK more understandable to non-practitioners. In turn, this easier understanding can encourage broader awareness and exchange between TK practitioners, the broader public, and policymakers on how to apply TK to environmental decision-making. For example, communities in the neighbouring Pamir mountains of Tajikistan mark time using parts of the human body (Kassam, Bulbulshoev, and Ruelle 2011). Experienced individuals will monitor the placement of stars and the sun throughout the year in addition to sensory changes and assign a body part for specific

placements (e.g. the mouth to represent a four-day period of sunny weather; *ibid*). Here, the common understanding of time divided into specific and standard dates does not apply to this TK's system of belief since the latter focusses on weather events that may not occur at the same exact dates each year (*ibid*). Furthermore, this human-body calendar system weighs and measures transitional periods of weather with more importance (to guide herders in critical activities such as protecting their animals against flooding season), compared to the Gregorian calendar that accords each date equal importance. Discussion on how the Atlas in this project attempted to portray this event-based traditional conception of time for both practitioners and non-practitioners is found in Section 4.1.2.

2.3 Cybercartography

In 2005, advances in Web technologies and the share-ability of data led to the creation of "Web 2.0" and its geographic parallel "Geospatial Web", where mapping tools were extended beyond the confines of "expert" communities (Haklay, Singleton, and Parker 2008). Building on the increases in computational efficiency brought about by Geographic Information Systems (GIS) in the 1980s and easy-to-use platforms such as Google Maps, cartography's move to the online environment has enabled traditional research subjects, stakeholders, and even the public to map as neo-cartographers (Plantin 2014). However, the extent to which these neo-cartographers have been involved has widely varied, from acting as simple data sources or inputs to co-researchers with control over research design (Sletto 2009). Reflections on the success of participatory mapping both online and in community-driven projects has shown the increasingly prevalent symptoms of "information donor fatigue" and uneven participation from contributors (DeGrave 2015). Political and economic factors unequally position mapping

participants in terms of power, access to information, and the ability to shape discourses (*ibid*). For example, community participatory mapping in Honduras was done to equitably place hydro-microturbines funded by international donors. The mapping was mediated by local elites who gained their status due in part to American Peace Corps volunteers that concentrated their educational activities in the old part of town (*ibid*). These local elites affirmed to international donors that everyone in the community had attended mapping meetings, but follow-up interviews revealed that marginalized residents had only attended initial meetings; local elites had carried the mapping project to its completion and received a disproportionate number of turbines (*ibid*). In another case, Inuit participants in northern Canada expressed frustration at the written medium of communication chosen by Western researchers for a historical project on the Arctic community of Arviat (Dutheil, Tester, and Konek 2015). Inuit knowledge is transmitted through verbal cues and gestures, and the written communication utilized by project leaders significantly constrained Inuit understanding of the project (*ibid*.) Narrow participation by contributors, the partial or outright misrepresentation of local knowledge by external researchers, and a lack of meaningful feedback to contributor communities has fostered a wary and weary attitude towards participation in participatory mapping studies (*ibid*).

Cybercartography as a discipline has emerged to begin addressing some of these ethical concerns of fair representation. Taylor (2006) originally defined cybercartography as the structured organization, presentation, and analysis of information by location using interactive and multimedia interfaces. Cybercartography harnesses technology as a new medium of storytelling. Interoperable packages of code called “libraries” allow videos to be embedded in

maps and visualizations such as 3D landscapes to accommodate different forms of knowledge (e.g. video to represent Inuit verbal communication in Dutheil *et al.*'s 2015 study) and the various worldviews they inform. Through cybercartography's ability to accommodate different forms of knowledge and a collaborative, user-generated data approach to digital atlases, local stakeholders and researchers have attempted to reshape their relationship into a more equal partnership. A user-generated approach involves an emphasis on the participant's ability to define what is collected and how it is presented (Pulsifer *et al.* 2011). Specifically, there is shared ownership and access to generated data, as well as joint-decision making power over what information is captured and how it should be represented (*ibid*). These aspects are important in Naryn's context as pasture users have been historically excluded from decision-making in pasture management (Shigaeva *et al.* 2016). The following sections trace the origins of applied cybercartographic atlases and how a user-centric approach have exposed new geographies and conceptualizations of place.

2.3.1 The Critical Origins of Digital Participatory Mapping

The understanding that maps are products of human intentions, or social artifacts, rather than objectively scientific works has tremendously influenced the demand for participatory mapping (Mukherjee 2015). Following World War II, the field of cartography had been concerned with the ever-increasingly accurate and precise (or positivist) measurement of spaces, as well as the technical expertise to stylize these features (Plantin 2014). These functional maps were to be objective and universal representations of the geographic area they covered, due to the scientific rigour of the trained cartographer. Critiques of this technical approach to mapmaking emerged in the 1980s, with critical geographers such as Harley (1989) shining a spotlight on

"the margins of the text" to expose the politics driving the scientific depiction of space. A wealth of critical literature has developed to explore how Euclidean geometry, the separation of space and politics, and the neglect of qualitative data has masked imperialist initiatives (Mukherjee 2015). The homogeneity of cartographers at the time that were predominantly European, male, and trained in elite institutions contributed to such a uniform and narrow interpretation of space (Kitchin 2006). Harley (1989) used deconstructionism to demonstrate how the choice of symbols and omissions on a map constitute a social construction by the mapper, puncturing cartographers' assumed impartiality. During the Soviet Union, the placement of towns and borders (including Kyrgyzstan's) were deliberately manipulated to portray an ideologically-driven panorama of a homogenous state (Moran 2006). Contemporaries such as Harris (2004) have since demonstrated the colonialist and racist potential of such a centralized and exclusive mapmaking process, with cases such as the dispossession of indigenous people's land in British Columbia; maps were used to depict these lands as empty and unproductive to justify their takeover by European settlers (*ibid*). Centralized mapmaking continues in Kyrgyzstan's natural resource sector with the Kyrgyz Giprozem (Institute of Land Management) unilaterally producing pasture maps, raising the question of what narratives the state may or may not be including (Kozhomberdiev 2017).

To address these charges, geographers and cartographers turned to well-established methods of participatory mapping such as cognitive mapping. Participatory mapping is understood as a process of "empowerment through local knowledge production" (DeGrave 2015 pg. 33). Local knowledge production is enabled by assuming local participants are experts in their environments and giving them the tools to produce maps. It opens the scientific research

method to input from the research subjects, acknowledging their qualitative, subjective, and politicized input as legitimate (*ibid*). The application of participatory mapping includes efforts such as Bunge's (1969) "Detroit Geographical Expedition", which sought input from African-American communities in Detroit on their racialized and marginalized experiences to show injustice and catalyze social change. Due to the diversity of the participants or "folk geographers" that were not affiliated with the Academy, a much richer and under-represented alternative narrative arose highlighting the racial inequities in Detroit. "Countermapping" or the subverting of traditional mapping conventions by marginalized communities is performed to produce graphics that showcase and legitimize these alternative narratives. Figure 3 demonstrates an alternative narrative using data that city planners had previously discarded because they experienced the streets of Detroit differently. Here, Bunge (1969) and Black students from the Geographical Expedition illustrating the correlation between white commuters' routes and incidents where black children were run over by cars. The close correlation is meant to spatially show the injustice of white adults running over black children on their way to work. More broadly, the countermap represents racial inequalities on the supposedly objective and neutral streets of Detroit.

Figure 3 - Bunge's 1969 Detroit Expedition. Source: Kanarinka. "The Detroit Geographic Expedition and Institute: A Case Study in Civic Mapping". MIT Centre for Civic Media 2013 (https://civic.mit.edu/blog/kanarinka/the-detroit-geographic-expedition-and-institute-a-case-study-in-civic-mapping)

2.3.2 Going Digital: Computerized and Web-based Mapping Tools

The popularization of GIS and Web technologies in the 1980s in conjunction with a critical upwell (led by critics such as Harley) against positivist thinking contributed to the practice of digital participatory mapping, including participatory GIS. Although participatory mapping had

been a decades-long staple of field researchers in eliciting hand drawn sketches and cognitive maps, the shift to a digital and online environment profoundly altered the demographics and process of cartography (Mukherjee 2015). The automation of calculations by computers and GIS packages made maps much more reproducible in respect to their planning and design. This ease of production led to the proliferation of mapping techniques across disciplines, necessitating interdisciplinary approaches (Crampton and Krygier 2006). However, these technical systems were criticized for imposing a singular and dominant view of space, a measurable space expressed in points, lines, and polygons (Lake 1993). These clear lines assumed an objective accuracy and were argued to reinforce the divisionary/imperialist mentality of past cartography (Pickles 2003). The technical expertise and costly computer infrastructure required for the digital cartography of GIS were also decried as exclusionary of marginalized populations that could not access them (*ibid*). Where some cartographers ventured with their digital systems to solicit public participation, they still controlled the means of production and often had sole discretion over the final design of the resultant maps. As a result of cartographers' control over the process, research subject often only had a token amount of involvement in participatory mapping and the uses to which it was applied (Mukherjee 2015). For example, Pickles (2006) recalls the presentation of a GIS-produced map for the placement of a publicly unpopular power plant in West Virginia at an open citizen meeting. The map was designed not to gather feedback, but rather simply to be seen so that planners could claim there was "citizen participation" during the decision-making process (*ibid*). Such cases of dubious participation limited the extent to which GIS was made more inclusive.

The advent of Web 2.0 throughout the 2000s distinctly expanded the extent to which the public could be involved in mapmaking. Emphasizing interactivity, the second generation of World Wide Web applications introduced social media, mash-ups of user-made applications, and Application Programming Interfaces (APIs) to allow interactions between software (Redondo 2015). These new capabilities gave users the freedom to easily participate and share geospatial information compared to traditional GIS, from geo-tagging their social media posts to creating their own maps in Google Maps (*ibid*). In addition, the Web environment allowed multimedia formats to permeate maps, altering how they presented information. Maps were no longer 2D isometric views of the Earth, but rather visualizations that included video, sound, 3D modeling, time-based and real-time displays, and dynamic data (such as virtual globes; Redondo 2015). Any user with an Internet connection could participate on platforms such as Open Street Map (OSM, shown in Figure 4) and Ushahidi, which allowed geo-located reports from cellphones and truly open-access collaborative and crowd-sourced mapping of topographic features. With these web tools, a layperson could design and edit their own contributed information without relying on a specialized cartographer. A widening of the mapping community ensued, with varied use cases such as Kenyan citizens reporting and mapping instances of voting fraud in their 2008 presidential election (Dickinson 2009).

Figure 4 - Open Street Map's (OSM) "wiki" style allows any user to add, edit, and delete features on an online, collaborative map of the Earth's topography. Deeper structural considerations such as the definition of tags are discussed by the OSM community before being implemented. This open access and editing responds quickly to user feedback while relying on community oversight and automated pattern recognition *to detect errors. Source: Paulger J. "My first edit". FLOSS Manuals, 2015. (http://write.flossmanuals.net/openstreetmap/my-first-edit/)*

2.3.3 The Introduction of Cybercartography

It was in the early onset of such an online growth in mapping that cybercartography was conceived in 1997 (Taylor and Caquard 2006). Cybercartography sought to reconcile the positivist and humanistic cartographic schools of thought by presenting data in a structured and open-access manner. The growing availability of data online was utilized by designing digital atlases that could accept inputs in a variety of formats (such as photos, videos, and sound recordings), all tied together by location (Taylor and Caquard 2006). The critique of an insensitivity to power relations behind the process of mapmaking was answered by an emphasis on the user. Cybercartographic designers studied psychology and human cognition to guide the display and interaction with data to make it as intuitive as possible (Taylor and Caquard 2006). This focus has resulted in experimentation on multisensory interfaces such as oral narration of indigenous place names and scented/olfactory cartography (Caquard *et al.* 2008; Lauriault and Lindgaard 2006). Different worldviews and semantics are more easily conveyed to users by using a diverse range of data interaction, while contributions from local communities are encouraged due to the data being intuitively presented; consider for example the difficulties and nuance an oral-tradition culture would face trying to decipher a written, disembodied treatise. Pyne (2013) overcomes this by tracing the travels of key treaty actors of Lake Huron and representing them as individual narratives in a person-centric atlas. Local involvement is further encouraged by a mapmaking process that starts with relationship-building between researchers and research subjects. The objective of relationship-building is to determine what local priorities are and to ensure that the data captured addresses them,

promoting ownership of the project (Pipi 2016). This process aims to train and empower research participants to become shapers of data, rather than just being data sources.

An example of these principles in application has been the mapping of sea ice in Canada's northern Inuit communities (Pulsifer et al. 2011). The experience of Inuit elders on sea ice patterns, hunting, and navigation were captured to educate Inuit youth and to increase indigenous content in the public education system (*ibid*). Since these experiences have traditionally been passed down orally, elders contributed these stories through interviews which were captured in the atlas as video and audio clips. Hunters were also encouraged to participate by working with mobile applications that used their native language of Inuktitut and could be taken on trips (Laidler 2016). The traditional value systems of Inuit were interpreted by atlas developers by attributing content to the contributor; the trustworthiness of a map on sea ice routes is not based on each route's geographic accuracy or length, but rather by the reputation of the elder providing the route (Taylor 2016). By situating knowledge in its context and avoiding assumptions of universal applicability, the sea ice atlas acknowledges the subjectivity/political nature of data while presenting valuable and verifiable information. The differences between knowledge created by an indigenous-led system and a Western system are highlighted and explored for points of intersection, creating a different understanding that may surpass either system individually (Pulsifer et al. 2011). Figure 5 shows an atlas diagram of the specialized Inuit terminology for different ice conditions. To reconcile understanding between Inuit and Western audiences, each term is described in both Inuktitut and English with a supporting photo to provide a visual example. The circular shape of the diagram also conveys the seasonality and progression of ice between different states. In total, the atlas developers

technically structure the atlas to demonstrate their reflexivity and as a practical way to move beyond previous critiques of cartography and outcomes of participatory mapping.

Figure 5 - The Inuit Siku (sea ice) Atlas. Source: Laidler 2016 (http://sikuatlas.ca/cape_dorset_terminology.html)

3 Methods

The theoretical frameworks guiding my methodology are cybercartography and a critical analysis of its spatial visualizations through the principles of TK. A cybercartographic approach explores how visualizing practices can uncover the overlapping spatial relations of pasture management. "Views of the North" is a cybercartographic atlas in Northern Canada by Payne *et al.* (2014) that was successful in building connections between elders and youth by creating an interactive, historical account of indigenous experience. This project attempts to draw from lessons learned to bridge differences in practices between pasture stakeholders in Naryn. Field methods will overlay different participant maps of the same landscape along with supporting multimedia. Training in using both analog and digital mapping tools will be provided so that participants can map independently, to avoid the influence of myself (as a foreign researcher) and local hierarchies. This approach acts to counteract the on-the-ground impacts of the current legal approach in Kyrgyzstan of authorities unilaterally measuring out pasture areas and zoning them into individual silos, which oversimplifies uses of the ecosystem and discourages cooperation (Shigaeva et al. 2016). This cybercartographic approach works to answer the first research question of how atlas visualization can mobilize pasture user engagement in pasture management.

A critical analysis from a TK perspective is then applied to inform atlas features' representation and collection and analysis of supporting qualitative data regarding participant perspectives on the atlas-making process. This approach avoids a purely positivistic approach by using participant perspectives and corroboration on mapped features to acknowledge the underlying historical, economic, and institutional factors underlying current spatial relations of pastures. Pulsifer *et al*. (2011) demonstrate this need for qualitative methods and dialogue with participants through their sea ice atlas of Northern Canada; their database undergoes several iterations and community dialogue is the glue that connects mapped features to reality (*ibid*). This approach entails techniques such as participant observation during mapping activities and iterative participant feedback on mapped results to identify village and park-level patterns from interviews. It is the aim of this approach to answer the second research question of how TK may complement or contradict official policies, with a subtext of examining the validity and agency of user-contributed TK to shape pasture reform in Kyrgyzstan.

A mixed methods approach was required to address both varying technical capacities for mapping and participants' comfort in sharing their practices to both myself (a foreign researcher) and authorities. Table 1 outlines both fieldwork and analysis methods in the chronological order they were used and will be referenced throughout Section 3.

Table 1 - Summary of methods used. Source: Jason Wong 2018

	Method	Description	Participant group
A	Snowball sampling	Recruiting (through translator) participants through subjects of a previous UCA project	Initial cohort (Naryn City, Eki-Naryn, Dobolu, NNR, Salkyn Tor Park)

B	Verbal Consent	Explanation (through translator) of project and verbal consent to publish information and photos	All
C	Baseline interview	Audio-recorded participant interview through translator with four focus questions	All (except school children)
D	Facilitated board game	Board game on pasture adaptations facilitated by Camp Alatoo expert	Pasture users while living on pastures in summer
E	Class lecture	Researcher-led lesson through translator on mapping in local Geography classes	School children (Eki-Naryn and Dobolu)
F	Landmark mapping on paper maps	Participant-led mapping using marker and sticky notes on points of interest	All
G	Walking mapping tours	Researcher and local Geography teacher-led mapping excursions in villages	School children (Eki-Naryn and Dobolu)
H	OSM Digitization	Participants and researcher independently adding features to OSM	All
I	Thematic interview	Audio-recorded interview through translator on topic of TK selected by participant	All
J	Homework	Student-led paper mapping and interview on TK with local elders, assessed by researcher	School children (Eki-Naryn and Dobolu)
K	Grey literature	Thematic publications collected from third parties and uploaded to the Atlas	NGOs and research institutes
L	Atlas input	Participants and researcher independently adding features to the Atlas	All
M	Comments from external experts	Show atlas content through translator to experts and solicit comments to be posted on the Atlas	Subject experts in Naryn City and Bishkek
N	Endline interview	Audio-recorded participant interview through translator with four focus questions	All baseline participants
O	Baseline-Endline directed content analysis	Coding recorded interview responses to four focus questions and comparison of baseline to endline	All completed baseline-endline interviews
P	OSM Metadata analysis	Statistical comparison of OSM edits and editors in the study area from Oct. 2016 – May 2017 vs. June 2017 – Jan. 2018	All OSM contributions 8 months from prior project start to project end

Q	Atlas metadata analysis	Summary statistics of contributions on the Atlas by thematic category	All contributions

3.1 Background of Naryn Province

For this research, fieldwork was based in Naryn province. 30.4% of all pastures in Kyrgyzstan are located in Naryn province, 99.2% of Naryn residents are ethnic Kyrgyz (as of 2009), and 46.3% of all employed Naryn residents work in agriculture and forestry, providing a good knowledge base of lived pasture knowledge (Crewett 2012; Abdykalykov 2010; Statistical Committee of the Krygyz Republic 2016). All Naryn residents are nominally Muslim, with local power structures typically controlled by older patriarchal figures that have higher education and held social status under Soviet rule. Residents speak Kyrgyz as a native language, followed by varying levels of proficiency in Russian as a working language. For this project, all interactions with participants were conducted through Kyrgyz research assistants that translated between Kyrgyz and English.

The University of Central Asia (UCA) is an international university with a campus in Naryn City and acted as a local organizational partner for this research. As a non-state academic presence, I viewed it as a neutral institution to each of the stakeholder groups in pasture management in terms of reporting requirements (namely, none). As one of its research goals, UCA has advanced the framework of *Learning Landscapes* (LL). LL creates *in situ* research sites that are embedded in communities to foster research processes that respond to local priorities. UCA staff have installed weather stations in the villages of Dobolu and Eki-Naryn, trained community members to collect and upload the data, and encouraged local school teachers to record the previous week's weather trend data on physical bulletin boards within each community. Park

rangers of Naryn State Nature Reserve (NNR) and Salkyn Tor National Park (who variously live in Dobolu, Eki-Naryn, and Naryn City) have also been involved in monitoring local wildlife and flora with a UCA-designed smartphone app.

3.2 Study Sites and Sampling

Due to their experience participating in geographic research within UCA's LL and the adjacency of national park territory to village-used pastures, the villages of Dobolu and Eki-Naryn, as well as staff from the Naryn State Nature Reserve (NNR) and Salkyn Tor National Park in Naryn province were chosen as study sites (shown in Figure 6). These study sites were deliberately chosen to also include members from the different management bodies identified in Section 2.1.3.

Figure 6 - An overview of the study sites in Naryn district, Naryn province, Kyrgyzstan. The location of the study area is shown in red in the inset map. Geospatial data for the map: Diva-GIS 2017 and Open Street Map 2017.

Villages were selected as study sites as this allowed exploring the breadth of pasture TK and uses within a contiguous community. Key participants were identified from those who expressed interest in mapping at an end-of-project presentation for a concluding UCA initiative. This meeting was facilitated by UCA staff member who lived in Naryn, had extensive community outreach experience, and was well-respected to overcome participant wariness to my research team (which included foreigners such as myself). A snowball sampling methodology was used to build participant networks from these initial contacts to capture communities of pasture users. This sampling methodology was deemed most effective in minimizing the risk of conflict over mapped information since participants would likely recommend contacts they already have a relationship with. This sampling runs the acknowledged risk of non-representative and

biased sample sizes, which are to be addressed by breadth and inter-village and inter-park comparisons. This study aims to capture a breadth of different practices to maximize different views of pastures rather than an intensive focus on a select few practices.

Park rangers and pasture users were initially targeted as participants due to their extensive knowledge and stake in proper pasture management. Particular effort was made to stratify and differentiate "pasture users" to include females and school children as key participants (no women or children work as park rangers). Women are chronically under-represented in formal decision-making about pastures in Naryn, while elders (anecdotally) perceived young school children as uninterested in TK. Including these two groups would therefore allow comparisons of under-represented perspectives of pasture use and how they may intersect or diverge with other groups.

3.3 Ethics, Consent, and Funding

The representation of TK in a system reflecting participant views requires a relationship of trust between the researcher and participants and clear deliverables to each side (Pulsifer *et al*. 2011). Several household and pasture-visits to these stakeholders over the first two months were essential in building a relationship for future mapping. Individuals participating in baseline-endline interviews were also visited approximately every eight weeks throughout the fieldwork period. This was done not only to explore different practices by season but to also be actively seen in the study communities, to be accessible for questions/training, and to receive iterative feedback. Where possible, activities were done with each participant separately to minimize influence from others and allay privacy concerns.

The project was explained in Kyrgyz through a local research assistant at the beginning of the fieldwork process to each participant. I presented myself as a researcher associated with UCA so that participants could contact the locally-known university directly if they wished to express discomfort about my research methods without my interference. The majority of fieldwork was done with two assistants from Naryn City who were not connected to participants but were knowledgeable about the local context and provided English-Kyrgyz translation. Verbal consent was acquired for the publication of contributed information on the Atlas and anonymity was guaranteed for interview responses. On the advice of a UCA staff member living in Naryn City and respected by the study communities, participants were not exposed initially to the full range of possibilities their contributions could be used for, as this may have intimidated people from participating. Instead, risks and opportunities were explained to the participant gradually throughout the process as contributed information became more individually identifiable. Contributors to the Atlas also had to read and accept a Terms of Use Agreement when creating their account. The option to stop participation, edit, or delete self-contributed data was always offered throughout the project.

The Atlas was hosted and protected by UCA's servers. Participants were free to make an account and download the data, while the general public was able to view the Atlas. Having participants not only volunteer information but also review and download content promotes dialogue and can help find commonalities between different interests in policy-making (Király et al., 2016; Kasymova and Gaynor, 2014). Concerns over UCA misappropriating Atlas content were mitigated by signing a memorandum of understanding with them, requiring bilateral agreement to re-use any material.

This research was funded by Carleton University and Mountain Partnerships, a United Nations voluntary alliance of partners supporting mountain regions. Neither organization placed any conditions on the methodology or methods of this project.

3.4 Fieldwork

Fieldwork was conducted from June 2017 to January 2018, with Figure 7 showing the general process. Generating data first required educating participants on what web mapping was and why it was useful in revealing spatial insights of local priorities. Rural Naryn households have limited exposure to web mapping tools outside of sporadic projects conducted by international development agencies, and broadly do not view maps as providing any strategic insight aside from navigating from point A to B. Training in map-making and collecting data was consistently a component of field data collection to promote participants' control over the process, towards a point where "the system model itself is developed by the members of the group concerned" (Király et al., 2016, pg. 502). Documentation was also needed to gauge how the process of mapping influenced participant perspectives on pasture governance.

Figure 7 - A summary of the fieldwork methods used, including adaptations for specific groups (in orange), and different stages of training (in yellow). Source: Jason Wong 2018

After acquiring consent, semi-structured baseline interviews were conducted in a location of the participant's choosing (Table 1 row C, or 1C). These interviews established a benchmark to later conduct direct content analysis of changes in participant perceptions of their role in pasture management. Participants were asked:

1) How involved do you feel in decision-making or participating in environmental issues and water usage issues? How would you measure this involvement?

2) How accessible is information that helps your decision-making? What are the current sources of information?
    - Who do you feel is interested in these issues? Do you think younger people (grade 11 and younger), middle aged people (after grade 11) or older people (pensioner-age) are more involved?
    - What is the best way/medium to make this information more accessible?
3) What gaps exist in environmental policy that you feel you can answer? Do you have specialized knowledge that can help solve an environmental problem?
    - How do you think traditional practices can/are adapting in their practice to be useful in modern times, alongside new technology?
4) What do you think a web map is? What do you think the value is of creating a web map of this knowledge together? Who does it benefit (locals, foreigners, certain groups)?

These guiding questions did not explicitly identify a specific environmental issue to allow participants to decide which aspects of the environment would be discussed. This was done because of my position as a foreign researcher who did not have in-depth knowledge of Naryn TK, making interviews structured by myself inappropriate. Exceptions to this initial baseline step are discussed in Sections 3.4.1 and 3.4.2

3.4.1 Adaptations for Pasture Groups

In pastures, the lack of built features posed a challenge of how to easily introduce concepts of adding information to maps. Naryn pastures are commonly rolling hills with few demarcations, and widespread phenomena such as soil erosion are difficult to pinpoint. In response, a board game (Table 1D) designed by Kyrgyz rural development organization Camp Alatoo was used to

introduce participants living on pastures to livelihood adaptations to climate change (Kozhomberdiev 2017). Pasture users played a turn-based game shown in Figure 8 with an expert facilitator from Camp Alatoo guiding participants in focussing on the spatial dimensions of their adaptations (such as migration routes or growing fodder near villages). This step was to educate and prepare participants for the need to map practices in a low-tech, hands-on manner compatible to life on pastures. Participants who expressed an interest after the game in further participation then completed a baseline interview.

Figure 8 – Inside a yurt on summer pastures, participants play a board game to learn about practices and adaptations. Players work in teams to adopt different strategies each turn to minimize damage to the pasture ecosystem and maximize their earnings. Photo: Jason Wong

3.4.2 Adaptations for School Children

For school children, class sizes of up to 50 students and lesson lengths of only 1.5-hour blocks in Dobolu and Eki-Naryn made individual baseline interviews unfeasible. To overcome the first problem of class size, I gave an introductory lecture on mapping and spatial thinking in each village's geography classes (Table 1E), followed by walking mapping tours of the town supervised by myself and local teachers (Table 1G). School children were divided into groups and given paper maps to make annotations of simple topographic features (e.g. roads, canals) and their attributes, supervised by teachers or research assistants. These methods used local contexts to illustrate the utility of mapping to local priorities, while conducting mapping in a familiar and comfortable environment for the students. This strategy is in line with UCA's efforts to contextualize their curriculum to its Naryn campus to connect theory to application and with theories of user-led mapping (Foggin 2017; Peters 2018). Students that expressed an interest in further work then completed the baseline interview.

3.4.3 Paper and OSM Basemapping

Following baseline interviews, participants were shown a large-scale satellite imagery map of the study region and asked to map places of interest using sticky notes and markers (Table 1F). These sessions (shown in Figure 9) were meant to assess the familiarity of participants with mapping, how they perceived the spatial implications of issues such as clean water sources, and to introduce participants to contributing geospatial information (consisting of both geographic location and attributes such as type of terrain, condition of road, or photos).

Figure 9 - A participant maps identifies local pasture landmarks and their names to research assistants. Photo: Jason Wong

With an understanding of paper mapping, participants were then trained on they could participate in web mapping through OSM, its shareability/reusability advantages, and its privacy risks. OSM was chosen as an initial web-mapping tool because of its simple in-browser editing interface and because it could also be used later as a basemap for the Atlas. Internet access and computer equipment permitting (Table 1H), participants were trained in digitizing data from Table 1F onto OSM. Where people did not own computers or could not access the Internet, the process was demonstrated by myself using my personal computer and an Internet USB modem: data from Table 1F was digitized by myself, an updated map was printed, and the paper map was presented to the original participant for feedback. This was done so that participants without access to OSM could still provide feedback on the updated features the project was producing online. The produced feedback map also incorporated anecdotes exposed during the landmark mapping exercise to begin to educate participants on maps as a narrative, storytelling tool (see Figure 10). This method's improvement of basemap features

such as streets and building footprints for the previously under-mapped study areas is an ancillary benefit for anyone working in Naryn province.

Figure 10 – An updated OSM map of participant-contributed landmarks (shown as red points) on pastures with pasture-user-submitted vignettes in grey boxes. Source: Jason Wong 2018

3.4.4 Eliciting and Inputting TK into the Atlas

Participants then completed an unstructured thematic interview on a traditional practice of their choice (Table 1I). Depending on the content, this interview may include walking alongside the participant in the field, viewing their specimens of medicinal plants, and shooting video or photos of the participant doing the practice. This step was the primary method of eliciting TK from participants. An unstructured format was chosen to allow the participant full control over what aspects of the TK would be emphasized, and thus tacitly defining the data structure of how this knowledge would be represented in the Atlas. For school children who faced a problem of having little experience doing traditional practices themselves (children have significantly fewer responsibilities than adults while on pastures), they were tasked with a homework assignment during their local geography class to interview local village experts or elders (Table 1J). Students led an interview on a specific practice of their choice, under the themes of ecological monitoring, pasture management, and medicinal plants (these realms discussed in Section 4). Each student was given a print-out map that incorporated the updated basemap from the previous OSM digitization to demonstrate the iterative results they were achieving (see Appendix A Figure 20 for a sample). Interview results were both written and mapped on this print-out by the student to build intergenerational dialogue, raise awareness of traditional knowledge, and improve spatial thinking. The use of youth-led interviews was

inspired by the success of the Siku sea ice atlas in engaging youth technologically to connect with their elders (Pulsifer et al. 2011). I then collected the results and only submissions with in-depth accounts that referenced spatial points in addition to the student expressing interest in continued participation were accepted for upload. These selection criteria were based on quickly identifying students who were able to contribute immediately (since the school year and students' availability before they left for summer holidays was closing soon) and significantly winnowed down the number of eligible submissions. Students who did not fit these criteria were referred to OSM where they could independently contribute features to an online map or instructed to follow-up with their selected classmates for additional help.

Data from Table 1I and 1J were combined with grey literature from external organizations (Table 1K). The Mountain Societies Research Institute (MSRI) of UCA provided information on pasture practices. Information and templates on medicinal plant collection was taken from the Aigine Cultural Research Centre in Bishkek and Edith Welker, a researcher studying Tajikistan's Pamir region. For ecological monitoring, staff from NNR and Camp Alatoo provided booklets of official park reports and traditional monitoring practices produced by Naryn residents respectively. I contacted these organizations and individuals with the criteria of possessing data on traditional practices in Naryn province and with data aligning in at least one of the thematic themes mentioned by participants in Table 1I and 1J. These criteria were chosen so that comparisons could be made by myself and Atlas readers between a thematically similar practice in a different location from the study sites, connecting the grey literature back to the project. Material from grey literature was attributed to the individual who contributed the original information and the organization that published it.

Data from Table 1I, 1J, and 1K formed the bulk of initial Atlas content. In Table 1L, participants who had access to a computer and Internet were trained in inputting their own contributed information onto the Atlas. All participants were assisted in creating their own account on the Atlas where they would be free to add data, comment, and download content. Areas without reliable Internet access and all grey literature was input by my research assistants and myself. The data structure for the contributed information was an iterative process of asking each participant what information was valuable for the feature and what types of data were missing, and then updating the template with *Nunaliit's* object-oriented database system. This database's ability to extend existing templates ('objects') with new data fields and relations to other features provided exceptional flexibility in accommodating various data sources. For example, the season in which each pasture is used was added as a data field to pasture features upon the request of PC members. Each template contained a "Notes" field to allow users the flexibility to submit information that did not fit existing data fields, as well as an entire layer called "Local stories and practices" to assign features that did not fit project-identified themes (further discussed in Section 4). In all cases, following Table 1L I revisited each participant and showed the entire Atlas's content on my personal computer with a USB Internet modem. This was done to ensure each participant had final editorial control on how their knowledge was presented, to comment on other features, and for me to observe their reactions and comfort with the atlas. Each participant then completed the endline interview (Table 1N) following the same methods as the baseline interview. The link to the atlas was given to each participant along with encouragement for continued submissions and interaction with other features on the Atlas.

In Bishkek and Naryn City, subject matter experts were identified through UCA and Camp Alatoo's professional networks. I demonstrated the Atlas to each of these experts (Table 1M) and noted their feedback. The experts were invited to explore the Atlas and to suggest revisions to the content by writing a comment that was linked to the relevant Atlas feature. This was done to demonstrate the possibility of remote dialogue between Naryn pasture users and remote experts. This step also provided material to help answer the research questions of how visualization and TK can change perceptions of pasture users' role and validity in pasture management.

3.5 Analysis

Analysis of qualitative materials was first done by my research assistants transcribing and translating all interviews into English. I coded these interviews by directed content analysis in relation to the four focus questions asked at baseline and endline (Table 1O). A directed content analysis is effective because it builds on the existing theory and body of knowledge of participatory mapping in cybercartography. For this project, the focus questions drew on issues of accessibility raised by Pulsifer et al. (2011) and Taylor (2013), and past UCA project experience in citizen engagement and user-submitted information in Naryn (Kozhomberdiev 2017; Schumacher 2017). Known theoretical weaknesses of potential researcher bias in creating coding categories were partially offset by thematic analysis of the remainder of the interviews not pertaining to the focus questions, and participant observation during each field activity (Hsieh and Shannon 2005). Participant observations and the atlas-making process were documented in a private journal to provide perspective over the entire project. Qualitative

analysis was balanced and corroborated among these materials to answer the research questions.

Quantitative results were generated by looking at the metadata of both OSM and the Atlas (Table 1P and 1Q). Back-end systems built in to each platform allowed a time-wise comparison of the number of submitted features and contributors before the project and after the project. These numbers are presented in Section 4.1 as a measure of the reach of the project in reaching stakeholders. Statistical comparisons of coded baseline to endline results are presented in Section 4.2 to answer research questions of how cybercartography and TK change perceptions of pasture users' involvement in management.

4 Results

Results from fieldwork are separated into:

1) geospatial outputs from mapping sessions with participants and any individual contributions made on OSM or the Atlas
2) interview results comparing participants' baseline answers against their endline answers
3) Personal reflections on challenges faced

Participants identified pasture management, medicinal plants, and ecological monitoring as key categories of traditional practices in pastures. These themes were identified through my thematic analysis of initial interviews, corroborated by participant feedback in subsequent meetings. Users defined pasture management as features that impacted their ability to graze their animals, including forests, water sources, and predators. Medicinal plants were defined as

plants that were foraged as a supplement to herding; given the knowledge to identify plants and edible mushrooms, participants expressed interest in the nutritional benefits to themselves, economic benefits of selling berry jams to tourists, and in preserving TK (primarily voiced by elder participants). Ecological monitoring was identified as local methods to determine when to begin certain livelihood activities such as crop planting in the absence of information sources and infrastructure such as weather stations. For each of these three topics, the template or schema of various data to be collected and uploaded to the atlas was created based on participants' responses to interview question one: How involved do you feel in decision making or participating in environmental and water usage issues?

The methods used were successful in engaging a broad demographic. Figure 11 shows the 17 females and 21 males involved in the study, including pasture users, herders, park staff of NNR and Salkyn Tor, school children, forest user committee members, school teachers, and subject experts. Of these, 11 participants did in-depth baseline and endline interviews that Section 4.2 will discuss further.

Figure 11 – Gender representation was much more imbalanced in villages and parks than in larger cities, except for Eki-Naryn. Geospatial data: Open Street Map 2017.

Additionally, seven university students, 80 school children and two Geography teachers from Eki-Naryn and Dobolu received training on georeferencing and digitizing features onto both OSM and the project atlas. Figure 12 compares the added changes to OSM for Dobolu and Eki-Naryn. Basemap changes aside from the external boundaries of park territory were not included for NNR and Salkyn Tor following the wishes of park staff, citing fears of data exploitation by poachers.

Figure 12 - OSM edits 8 months prior to the project (left) vs. the 8-month project period (right). Differences in the number of edits and editors were also compared between Dobolu (top) and Eki-Naryn (bottom). The bars represent the number of features added, and the person icons represent the number of unique contributors for those features. Source: Jason Wong 2018

The cybercartographic atlas shown in Figure 13 was created at http://31.186.50.219:8080 with a backup version hosted on http://develop.gcrc.carleton.ca:8050/. Submissions to the atlas were assigned to separate layers, depending on its theme. Two custom visualizations were also created on the Atlas (see Section 4.1.2) to demonstrate the value of web interactivity to depict traditional practices to non-practitioner audiences unfamiliar with their context.

Figure 13 - The Atlas's main page displaying submitted features thematically assigned by both the researcher and participants as Stories and Practices, Pasture Management, Ecological Monitoring, and/or Medicinal Plants. Source: Jason Wong 2018

4.1 Geospatial Results

4.1.1 Atlas features

Under the theme of pasture management, 25 features were uploaded to the atlas. Information such as the seasons in which a pasture is used, the number of households present, the weeds and beneficial plants present, and the available infrastructure were provided. Pasture details were submitted by both pasture users and the relevant PC responsible for their upkeep.

For medicinal plants, nine unique plants were identified. Details on how to identify, collect, use, and store each plant were provided by predominantly elder male traditional medicine practitioners, and women of various ages during thematic interviews (Table 1I).

For ecological monitoring, seven submissions were uploaded. These features were collected from the broadest range of participants, across age and gender. The nature of the content varied greatly, ranging from scientific tree-grafting experiments in the national parks to low-

cost observational techniques of the stars and local landmarks. These features share a common connection as methods to monitor factors that influence pastures' ecological health (i.e. promoting reforestation and forecasting weather respectively). Additional practices from Camp Alatoo's (www.camp.kg) study in the nearby At-Bashi region were also included to allow participants to compare content from a different district.

A fourth layer of "local stories and practices" was created to capture submissions that did not align with the templates of the first three categories. This was done to recognize that participants' interests and uses of the environment likely encompassed aspects not included in the templates I designed. This fourth category allows users the autonomy to submit information not conforming to the first three formats, while affording it the same visibility and status. 38 features were submitted to this layer.

4.1.2 Atlas visualizations

Two atlas data sets were used to create custom visualizations. First, medicinal plants submitted by users were organized into a grid-like catalog (shown in Figure 18) with individual photos to allow participants to identify plants and their properties rapidly. This visualization has strong potential to be developed into a pamphlet that may be easily carried by collectors in the field.

Secondly, a Pamiri practice of using the human body as a marker of time was also translated into an interactive schema of the human body. This schema was created to demonstrate ways of presenting practices other than through a web map to participants. Doing so raised participants' awareness that a user-defined atlas can better present TK faithfully, rather than simply submitting information to an externally defined system. Source information for this schema was taken from Kassam *et al*. (2011). Practitioners observe the movement of the stars

throughout the year and over years of experience link them with weather events such as four days of frost. These expected periods of weather are then associated with a part of the human body (this practice of tracking seasonal time is documented in detail by Kassam, Bulbulshoev, and Ruelle 2011). The atlas's visualization shown in Figure 14 demonstrates an interactive graphic I developed to show the connection between observable events and their association with a person's senses. Here, each body part is linked with the event it represents. This is meant to convey to non-practitioners the traditional view that the human body perceives weather changes in sensory ways. A possible contributor-driven narrative from this TK visualization would be to emphasize policy-making around critical transitional weather events that are marked by this human body calendar. These learning points prompted participants to request a similar, future visualization of different aspects of a pasture system to educate their children with.

Figure 14 - Users can click on different portions of the body and their metaphorical relation to weather. For example, the intestines mark a time in spring when avalanches are common, reflecting the churning of the stomach (Kassam, Bulbulshoev, and Ruelle, 2011). Image source: Jason Wong 2018

4.2 Interviews

The interviews asked questions on how involved the individual felt in environmental decision-making, the accessibility of relevant information, areas that the individual felt they could assist in through their TK, and their perception of a web atlas. 11 participants (four women and seven men) completed the baseline-endline set of interviews. The results are divided here into baseline-endline changes and demographic comparisons.

4.2.1 Baseline to endline changes for original research questions

Baseline perspectives on environmental management and practices indicated a dominant view that a governmental body was solely responsible for the upkeep and conditions of pastures and forests. Park staff at NNR and Salkyn Tor were particularly explicit that they were concerned only with the territory of their respective reserves, and that partnerships with the broader public were not desirable. Simultaneously, 65% of respondents indicated that their main source of information about environmental issues came from ad-hoc, word-of-mouth conversations with their neighbours. Only 36% of participants identified their own knowledge as useful in informing policy, and 64% remarked instead that there were no environmental problems. Respondents were familiar with web maps as locational/navigational services such as Google Maps, and identified multiple uses for them. NNR staff felt a shared web map with the communities could show clear boundaries to help steer pasture users away from protected park grounds, while village stakeholders stated it could show sources of clean water and ideal routes for tourists.

At endline, participants showed little change on their opinion that the relevant state body should have the final say on resource management (e.g. PCs for pastures, forest committees for forests). This provides evidence for local support and the perceived legitimacy amongst pasture stakeholders of such devolved institutions. Such as result provides evidence that future efforts in user-led reform in pasture management should continue to include PCs as a key actor, rather than adopting an entirely new reporting structure. The atlas did spark significant conversation on the (in)accessibility of information, and strong support for the upload of respondents' own views and knowledge. Participants were eager to contribute their own information using the

formats established by the atlas's templates and expressed pride in publishing their knowledge online. 63% of respondents felt they had useful knowledge that could help solve problems, an increase of 27% from baseline values. All participants affirmed the value of traditional practices such as maintaining a forest planted by an ancestor as both ecologically and culturally vital. Park staff, initially reticent on cooperation with the study villages, expressed interest in practices by other community members and acknowledged the utility of openly publishing practices for discussion.

Participants showed mixed perspectives on the use of a cybercartographic atlas at endline, with 45% stating that they were not familiar with maps or that they were only useful in showing location. Respondents that were familiar with maps continued to mention a wide range of uses for maps from pasture boundaries, tourism, and even mineral exploration. These results indicate that although participants value visualizing TK, they have difficult independently contributing information to the Atlas and view themselves as part of the Atlas only to a limited extent. The accessibility of the Atlas is further discussed in Section 5.5.3.

Overall, these results indicate the continued importance of TK to local communities and its suitability as an approach to mobilize citizen engagement. A cybercartographic atlas was effective in visualizing different forms of knowledge and encouraging reflection on personal agency in pasture management. However, the mixed responses of who will benefit from the atlas does raise the challenge of motivating participants to independently sustain the atlas. The limitations of a cybercartographic approach are later discussed in Section 5.5.

4.2.2 Variations by demographic and study site

Four women participated in interviews compared to seven men. Female responses on involvement and agency ranged widely depending on the opportunities for professional development afforded to the individual. A herder's housewife expressed that she did not play any special role, while local schoolteachers and a member of the local council readily self-identified environmental knowledge they possessed. A gendered difference in valuing one's own knowledge is evident with a higher proportion of males than females reporting that their knowledge is useful and important, both at baseline and endline. This gendered theme of recognizing valuable information is further discussed in Section 5.2.

Among age demographics, a pattern emerged where youth identified youth as being most interested in the geospatial dynamics of pastures, while working-age respondents and the elderly similarly identified their own age cohort. This self-identification pattern speaks to the need for a visualization system to generate intergenerational dialogue on different pasture uses. There may also be generationally-differentiated knowledge and forms of presenting them that an atlas may be able to bridge using multimedia. Integrating the Atlas with in-person forums and the educational content of local geography classes may present a locally appropriate way to bring these cohorts together, based on Taylor *et al.* (2014) teaching high school students in Nunavut, Canada through cybercartography. Youth were more digitally literate and adopted OSM and the Atlas quicker than older age cohorts. Students' motivation to participate in this project may differ than older groups, evidenced by Eki-Naryn students' interest in mapping out ore deposits (for their town's economic development) in additional to

traditional practices. For students, this research process represented an educational opportunity to learn new skills and tools, while also documenting and preserving TK.

Turning to results by study site, Eki-Naryn showed more evidence of citizen engagement and perception change (from both geospatial and interview results) through cybercartography than Dobolu village. This may be because Dobolu is closer to Naryn City and is less reliant on pastures as a main livelihood. Eki-Naryn's remoteness may also render it less likely to receive up-to-date information sources as it represents a smaller and less dense population for both state and commercial initiatives. As a result, an accessible database of information may be more valuable to the more remote village of Eki-Naryn. Finally, there was a correlation of higher gender parity in terms of involvement in field activities with higher perception changes (i.e. Eki-Naryn had a higher ratio of female students and pasture users participating than Dobolu), but this link could not be further verified by the results at hand.

In addition to these interview results, numerous participant comments were unexpected and led to new insights. These comments are discussed in greater detail throughout Section 5 as supporting evidence for confirming, debunking, or highlighting possible spinoffs from previous assumptions of pasture management by both myself and the government.

4.3 Personal Reflections on Fieldwork

Conducting fieldwork in Naryn was a challenge in illustrating the strategic insights and benefits of participating in this project to participants. Establishing a relationship with participants to collaboratively map practices required several field visits where no research was conducted, including visits to participants who were hospitalized from a separate car crash and joining horse-back expeditions in Salkyn Tor park. Although I speak conversational Russian, Naryn

participants were much more comfortable in Kyrgyz and the language barrier affected the translation of concepts such as citizen engagement and spatial data management. Extensive back-testing of interview questions between English and Kyrgyz is required to ensure presented concepts are clearly understood to Naryn participants.

Due to my positionality as a Chinese-Canadian, I perceived participants to be less apprehensive to me since my physical features are similar to Kyrgyz features. As a foreign researcher however, I was occasionally perceived as wealthy or working for a foreign government, with a participant asking money for contributions. In this case, the project was explained again to the participant by my research assistant and myself, and the participant's request was refused to avoid uneven compensation amongst contributors. I was also pressured by park staff to use my GIS background to produce maps concentrating on park territory, risking a bias towards park management's interpretation of the landscape. Navigation of these local power dynamics were greatly assisted by hiring research assistants from Naryn. I often relied on their understanding of the cultural context to guide conversations. At the same time, I was also aware of dynamics such as participants cutting off my assistants during conversation if my assistants were younger or female. I attempted to slow the pace of the fieldwork activity to counteract this to make sure each person was heard. I found that an effective method for detecting these issues of positionality was to hold a debriefing with my assistants at the end of each activity, where they would state what worked well and what did not. Differences in experience were quickly identified and addressed for the next activity.

Operating in rural Naryn meant that everyday life for community members is closely connected to concrete livelihoods. As such, it was often difficult to initially engage participants in mapping as it was an abstraction of their landscapes. Participants did not see the value of a map in terms of improving their everyday life. Furthermore, rural activities such as hay threshing are typically seasonal, and I had to contend with uneven availabilities of participants and assistants. To overcome this, I tried to provide examples of the practical benefits of spatial insights such as improving how water canals are maintained. This was difficult as I did not have the connections to act on the insights and actually construct new water canals. By far, the output most appreciated by participants were my school lectures about geography and mapping (demonstrated by the number of participants and participant observation). Community members universally appreciated the value of education and strongly supported this aspect of my fieldwork. Other outputs given back to the participants were improved village basemaps on OSM and digital and offline copies of these maps given on USB drives to geography teachers. Future work should ensure outputs in a variety of formats that are accessible to those even without Internet.

5 Analysis and Discussion

The process of mapping was successful in bringing together various stakeholders and building dialogue, shown by interview results and the number of practices submitted to the Atlas. There were significant differences between the government's policies and actual practices, evident in both the process and output of our interactions with participants. Even at the preliminary stage of identifying the topics of interest to be mapped, the specific categorization of environmental views showed different worldviews. Pasture users defined "pasture management" as issues

concerning the forests, the pastures themselves, and water sources. In contrast, the government has officially divided jurisdictions into individual pasture and forest agencies working at different scales and separate information systems (Crewett 2012). This section will identify the insights of a TK-based approach in relation to engaging communities, gender, and geographic worldviews. TK's interaction with cybercartography is also discussed in terms of its visualization impacts and suitable for the Naryn context.

5.1 The role of TK

This research initially posited that TK could offer both knowledge in terms of its content, and as a methodology to encourage local representation.

5.1.1 TK as a Knowledge Source

The quantity and specificity of mapped features through this study's outreach efforts unequivocally improved the visibility and accessibility of knowledge. Official data are often inaccessible (i.e. not publicly available or digitized) and disaggregated to the district level at the most (Tursunbai 2017). By focussing on TK which is inherently context-specific, data was produced at the village and individual pasture level. TK also uniquely offered theoretical conceptions of the landscape that differ from the government's view, discussed in Section 5.3. 100% of endline interview participants stated that TK remained useful in contemporary times, with one respondent offering a nuanced answer on how Western science could be configured to work alongside TK.

> "In August, you can watch the deer and determine how late fall will come. [TK] is necessary knowledge because before, there was no Internet. It will be somewhat difficult to introduce ancient knowledge into modern techniques, but some parts can be implemented." – elderly traditional medicine practitioner, Dobolu village

In the case of the Pamiri human body calendar discussed in section 4.1.2, joint efforts between Central Asian practitioners and Western scientists are underway to recalibrate traditional ecological calendars (Holden 2017). Climate change has disrupted well-understood weather patterns and researchers are using mixed-methodologies such as identifying context-specific calendars alongside records from weather stations to adapt (*ibid*). In the same vein, TK could be used to inform future research in measuring pasture degradation alongside satellite imagery analysis.

5.1.2 TK as a Methodology

As a methodology, it is first important to distinguish between local knowledge and TK. TK (or indigenous knowledge) is a subset of local knowledge with a common cultural and historical denominator, while local knowledge is more broadly information that is informed from living in a geographic area over time (Semali and Kincheloe 2011). Conflating the two terms poses problems in areas with heterogenous communities, as it may be harder to derive a common approach with local knowledge. This project's focus on TK enabled us to use a more socially-cohesive and identifiable frame (to our Naryn audience) of respecting past generations and their well-known pasture practices. The research team emphasized to participants during thematic interviews the value of the practices and participants' agency when performing them, promoting the respondent's ability to define how they had evolved TK from its past variations. As a result, our mapping efforts were generally successful in raising participant interest across a wide demographic, with 50 students in the village of Eki-Naryn leading individual, thematic interviews with village elders. Presenting cybercartographic mapping as a sense of pride and educational initiative facilitated this intergenerational dialogue and allowed us to connect our

work with two schools and two universities. Involvement can also offer professional development for students as they use GPS devices, improve digital literacy, and connect TK to current societal issues.

The effectiveness of TK in re-centering the focus and agency of research towards local pasture users must be tempered against a homogenous narrative of “tradition”. Jacquesson (2010) notes that traditional, local methods of governance are also based on uneven political and economic relations. Kyrgyzstan's uncritical rush to decentralization in 2002 based on the perceived wisdom of “custom” overlooked the experience of decentralized, pre-Soviet collectivization herders: “permanent conflict” and “overwhelming” competition for pastures (Jacquesson 2010 pg. 115). As discussed in Section 2.2.1, TK in this project is partially defined as practices that continue to be performed and includes hybrid experimentation with modern methods. Due to the currency of such performed TK, produced results from a TK-centric methodology can then be synthesized into a resource user’s narrative for contemporary policy recommendations. This project demonstrated how a pasture-user and TK-led atlas could address structural inadequacies of earnest consultation with resource users in Naryn, and how TK can be applied to contemporary problems such as pasture overgrazing.

5.2 Gender and Pastures

Fieldwork found a general undervaluing by both female and males of the knowledge and impact women have on pasture environments. In asking one female herder’s knowledge of the pastures, she responded by saying that the males in the household possessed valuable TK because they were the ones who rode off with the herd each day, while she knew nothing. Outreach efforts encountered gendered difficulties in working with adult female participants. In

grade school facilitation sessions, girls were active and at times more engaged with mapping exercises than boys. However, women of pasture user households were reluctant to meet for interviews without their husbands. Where women would participate without their husband, they were frequently expected to multi-task during interviews such as holding a baby, preparing a meal, or supervising a group of children. These activities are likely to have divided the attention of the participant and obscured the full depth of women's knowledge. It was also impossible to interview female park or forestry rangers because none existed.

The lack of recognition and representation of women's knowledge has significantly negative consequences as women are predominantly in charge of milking animals and managing the yurt (Scalise and Undeland 2016). Women also play a large role in managing the entire household on pastures when the male head travels to town to purchase and sell supplies (*ibid*). Ignoring the practices associated with the entirety of household issues represents an enormous knowledge gap in pasture management. This research suffered from limited female involvement, and further work is needed to educate participants on the value of knowledge such as waste disposal and alternative foraging that Naryn women are well versed in. Higher female participation could also bring additional household-level insights into how women and men can mutually support each other and find new intersections between traditionally gender-segregated roles. Finally, exposing the practices of female-headed households (those that may be voluntarily so, divorced, or whose male head is working abroad) would serve to destigmatize these non-traditional arrangements and improve their socially-constrained access to pastures.

The limited participation by women can be attributed partially to the dominant discourse of pasture management. Road infrastructure is promoted as the main issue because men simultaneously dominate the PC membership and are responsible for grazing the animals, which requires transportation routes (Scalise and Undeland 2016). The economic benefit of selling an animal is easily visible and measured, leading to a high value and strong association with "pasture management" (*ibid*). In turn, PCs dedicate their budgets towards repairing this road infrastructure. In contrast, women's work of managing the pasture household and selling dairy products is less legible because the per-transaction income is smaller and more temporally dispersed throughout the pasture season (Scalise and Undeland 2016). This equates to a lower value on women's work, a weak association with pasture management, and therefore no PC budget for women's priorities such as electricity and sanitation. An accounting of women's work and how their sales can equal or surpass a man's sale of a few animals can help educate pasture users on the value of women's knowledge and bring about greater female participation in cybercartography.

There are avenues for increasing female participation through existing village-level groups called Women's Committees. Established by past development agencies, these committees gather a group of women to run micro-enterprises, with variable success. In our study sites, only the Women's Committee in Eki-Naryn remained operational. Further study is required on whether both the data structure and interface of the atlas need to be adapted for greater female participation. Scalise and Undeland (2016) note that explicitly stating the benefits of project intervention for women (e.g. learning about zoonotic diseases directly relates to their role in livestock health on pastures) were more effective in improving female participation than

just gendered membership quotas. In Naryn's context where many males migrate to Russia for work, specifically engaging women may bring about broader and more in-depth TK as they spend more time in Naryn and have more current knowledge of pressing pasture priorities.

5.3 Geographic considerations

5.3.1 Herd Mobility vs. Areal Management: Different spatialities of the same pasture

Park officials and PC authorities consistently emphasized the area of the land they were responsible for. These actors looked to the official pasture maps given to them by Kyrgyz Giprozem, the central state Institute of Land Management in Bishkek, to delineate the area (represented on maps by polygons) that they had control over. However, actual pasture users' and herders' traditional understandings emphasized mobility as the defining quality of pasture areas. Pasture users that seasonally stay on the pastures stressed during interviews the heavy reliance on drivable roads to access their spot on the pasture, to return to town to buy simple household goods not available in the high mountains, and to move their herds. Pasture users informally recognize their customary place to place their pasture yurt based on the relative positions of the road and water sources. The road network directly affects pasture users' choice of places to graze their animals, as well as the foregoing of older routes that have since collapsed.

> "There are good, large *jailoo* [summer pastures] but you have to get there by horse. Machines cannot go up there. We need to build roads there, then the pastures of *Chyrpik* and *Artak* will be unloaded. If cars could reach those pastures, many would go there, but because of the difficulty of moving there on horseback, only two or three families go. And these pastures are not used all four seasons. Therefore, everyone uses the same nearby pastures, thereby depleting them." – endline interview, Eki-Naryn herder

Participant observation during participatory mapping exercises also revealed that pasture users commonly referred to lines (roads) to orient themselves and to gauge relative distances. Pasture boundaries are unclear, in part because there are no physical demarcations or signage of different pastures, but also because a herder's use of them is migratory. To underscore this, one herder mapped a mountainous area not as a polygon, but as a line. He explained that the main feature of interest there was the presence of a valley that allowed him to move his animals to and from remote grasses, rather than the size or extent of mountains. Another herder provided evidence of a similar mobility-centric perspective by showing his separately-created, personal, hand-drawn map for tour-guiding purposes of the region around his home. Figure 15 shows in detail the topology and distances of the routes that connected points of interest, with no regard for jurisdiction by area despite a technical obligation to pay pasture fees when crossing into different pastures.

Figure 15 - A herder's map of the nearby pastures, emphasizing routes (represented as lines) over any other aspect of the landscape. Photo: Jason Wong

In this situation, TK was effectively articulated by extending the ability to map overlapping geographies on the Atlas to these pasture users. The atlas's ability to accept public input not only represents a technical improvement (digitized and sharable, reduction of human error using online references) to previously pen-and-paper participation, but also enabled the visualization of an entirely alternate conception of pastures compared to that of pasture authorities. Visualizing such differences also emphasizes the need for multiple perspectives to complement each other, builds broader inclusion, and assists in reaching consensus. Further research into how pasture users view and map their usage of pasture lands compared to their

occupancy of pastures may help nuance a mobility view and how PCs can support pasture users more effectively.

5.3.2 Complementarity of Practices Around Naryn State Nature Reserve

The Atlas was able to show multiple overlapping layers and to relate features to one another. Additionally, one feature could be marked by the user as belonging to multiple layers (themes), reflecting the interdisciplinary nature of TK. These two functionalities were crucial in highlighting complementarities and overlap between different sectors. Geographically, it was possible to connect a series of different practices within the same area or to highlight the same practice found over many areas.

Figure 16 - A mapped instance of weather foretelling practice on the atlas is linked with other related items shown in the right-hand side pane. Photo: Jason Wong

Visualizations of interconnectedness such as Figure 16 prompted participants to continue exploring related features, akin to a reader following several related Wikipedia links. While appreciated by all participants, this functionality influenced park staff the most in changing perceptions. During endline interviews and demonstration of the Atlas, seeing mapped village stakeholder cases of medicinal plant foraging and the number of households using adjacent pastures impressed on park staff the commonality of environmental problems such as soil conditions, even outside of park territory. Conversely, seeing the scope of such problems caused the park manager of NNR to understand that his staff had access to knowledge that would be useful to nearby communities. Park rangers routinely conduct scientific experiments such as tree-grafting to produce hardier and quicker-growing species (Umote 2017). Even under an institutionalized methodology, rangers also deviate from exact instructions based on their

extensive local knowledge of Naryn's context. Instead of the prescribed four trees per plot, rangers plant six to accommodate for higher die-off (colder climate), to combat soil erosion (steeper slopes), and to provide timber for local use. The Atlas's juxtaposition of this practice in park territory alongside pasture user-submitted features expressing fears of pasture deforestation showed how the staff's knowledge could answer community concerns, while possibly lessening demand for (illegally harvested) timber from park territory. During endline interviews, NNR's park manager expressed a new interest in inviting university students onto the park territory to jointly conduct soil studies with the rangers.

While it is unlikely due to political inertia that legal reclassification of land to allow multiple uses (e.g. creating new zoning classifications to permit foraging of medicinal plants on current "protected area" zones) will occur at this time, this research can provide a stimulus to informal partnerships. Shigaeva *et* al. (2016) provide examples of two Naryn villages where local residents communally agreed on resting certain pastures and fixing a price on herder services (an example of herder services includes younger men shepherding the animals of many households so that not every household must travel to the pastures). These decisions were respected by higher authorities because the resolutions did not compete with the authorities' interests (*ibid*). A cybercartographic atlas can provide the information infrastructure for residents to easily express their priorities and view others' needs over a larger geography, enabling strategic partnerships. Specifically, mapped practices of using smoke as an animal parasite deterrent can guide a livestock expert to the pasture users and pastures where a joint-study on zoonotic diseases would be most locally supported.

5.3.3 Divergences and Contestation

Among the features submitted to the atlas, few were contested between participants living in the same community. Pasture borders and landmarks mapped by PC members and pasture users respectively were challenged the most between community members during paper-mapping and atlas review sessions. Landmarks such as a named mountain drew significantly more debate over its location, reinforcing the hypothesis that pasture users emphasize pastures as routes and points rather than distinct areas. A worthwhile future question would be to examine whether a non-areal view of pastures by pasture users (discussed in Section 5.3.1) holds true when considering forest usage. Forests are used both as additional grazing grounds and as a fixed source of timber; as a much more limited resource in Naryn's pastures compared to extensive hectares of grassland, it is unclear whether herders would consider demarcating trees as an area to be carefully managed or be considered as part of a linear route. Consistent methods of demarcation between pasture users and park staff are crucial in preventing illegal usage of park forests and grasslands by adjacent pasture users.

Debate on the content/attributes of each feature by local community members was limited largely because of the context-specific nature of TK, lack of knowledge, and social pressure against contradicting one's neighbours. In contrast, agricultural and veterinarian experts in Naryn City and Bishkek openly provided critique of submitted information. They suggested numerous edits to the names of medicinal plants, the conditions in which they could be found, parasites and insects harmful to livestock, and identified inedible pasture weeds. The Atlas served as a platform to create a dialogue between pasture users and experts, where both sides could independently post comments on the Atlas's features. While systems for online

identification of ailments and medicinal plants are well established elsewhere (Kumar et al. 2018), this cybercartographic implementation allows local participants equal footing to frame the research questions and pose them to experts. Shifting the research-forming process to pasture users in turn encouraged an attitude change towards citizen engagement in pasture management; 55% of participants indicated an endline change of being more committed and involved in decision-making processes, compared to 18% at baseline. The extent to which TK informed citizen engagement is questioned in the following section.

Notably, village respondents did not mention collaboration with participants from the other study village. Potential factors include low social cohesion, limited interest in traveling to other villages, or perceived lack of authority between peers. These results should temper enthusiasm for a fully devolved, grassroots atlas that is run solely by pasture users. Advocating for fully local representation without an organizing structure to coordinate inter-village exchange could lead to exacerbating local level power hierarchies and data accuracy issues (Jacquesson 2010; Dörre 2015). Future research should question the trade-off between the diversity of pasture user knowledge against the government's structure when proposing a government-civil society partnership to visualize pasture management.

5.4 Usability of a Cybercartographic Process

The accessibility of a mapping and cybercartographic process is critical in judging the potential to scale-up to a provincial and national strategy. Ensuring the process is intuitive to a large range of users also impacts its authenticity and perceived accuracy, discussed later in section 5.5. This section discusses the user-friendliness of the atlas implementation and its effects on participants.

Participants in general had difficulty orienting themselves and judging distances on a real-colour satellite-imagery paper map with a top-down view during initial baseline exercises. This was particularly evident during group sessions on the pastures with herders, who may not perceive of pastures as areas. A hybrid basemap of real-colour satellite imagery combined with roads and town points was most intuitive for participants to judge relative distances and identify objects respectively. 3D visualizations such as Google Earth were requested by park staff and rangers. In contexts like Naryn with significant elevation variance, showing elevation takes on an added importance as practices done at 2000 meters may no longer be applicable at 1500 meters (due to different climate, soil conditions, and wildlife). Future research should examine the applicability of a 3D Earth Browser such as Google Earth to visualize the impact of elevation differences on traditional knowledge, and whether a metre-based metric is compatible with how traditional practices differentiate between elevations.

The responsiveness of the atlas to user input and localization to both Kyrgyz and Russian (shown in Figure 17 and Figure 18) were reported as key functions that encouraged further contributions by participants.

Figure 17 – Any user can add a new medicinal plant on the main atlas page and has their choice of entering information in English, Russian, and Kyrgyz. Source: Jason Wong 2018

Figure 18 - The atlas's separate catalogue of medicinal plants is automatically updated every time a new plant is added to the map display (here showing at bottom-right the newly added Yshgen Root from Figure 17), aligning with principles of user responsiveness. Other users can suggest edits and corrections via a commenting system that is directly attached to each feature. Source: Jason Wong 2018

Initial participant interactions to define atlas features were very difficult as participants were reticent in answering. 63% believed at baseline that they were not qualified or had no worthwhile knowledge to add during interviews, with this mentality possibly a result of the institutional legacy of centralized control. Soviet rule emphasized officially designated experts and state institutions as the holders of knowledge, while the everyday practice of community members were captured only as ethnographic studies from an "expert" perspective (Hirsch 2005). As a result, local users are less experienced in having control over research design. Participants were much more forthcoming when initial templates had been established by other users or organizations (such as supplementary publications by external sources in Section 4.1.2). Future implementations of atlases could begin with an established template to provide structure but stress that the local participant is free to edit or add new attributes to be collected. For this project, the flexible technical design of *Nunaliit's* database system behind the web atlas afforded an ability to adjust what information was collected and how it was sorted based on user feedback. A key example involves the gradual accumulation of data for any one point: a user does not have to enter all the attribute fields available when creating a new feature. *Nunaliit*'s framework acknowledges that TK is often fragmented among its practitioners and accommodates this by allowing the user to input just what they know or are willing to divulge, making the process less intimidating. The power to edit and comment on other features also allows other users to constructively fill in the gaps with their knowledge, building a collaborative dynamic around the atlas.

Respondent views on the atlas's purpose showed mixed understandings at endline. 45% of respondents continued to view the atlas as a tool to show the location of physical objects,

rather than as a communications infrastructure to share TK and adapted practices. Additionally, 27% of respondents believed that the atlas was most useful for foreign tourists rather than local stakeholders. These responses indicate limited acceptance in Naryn of the atlas as a tool for self-representation despite high interest in mapping exercises. Influencing factors include the lack of Internet access in villages, inability to pay for Internet modems, low digital literacy, cartographic literacy, and reluctance to share information on areas that overlap with illicit activities such as poaching or gold panning. To overcome digital illiteracy, our team reached out extensively to youth who were more familiar with using computers. This was partly successful, although students were hampered by not having their own computers or consistent Internet access. Our approach also reached out to geography teachers at the local schools, who typically have access to a computer. The teachers in turn were ill-equipped to support this mapping initiative due to their low pay and the requirement for them to provide basic mapping materials (such as paper) out of pocket. Future implementations should identify motivated individuals in each study area and to train them as facilitators for the rest of the community. During our endline interviews, our team identified university students from the nearby international campus of UCA and American Peace Corps volunteers as ideal, well-equipped, embedded facilitators. Long-term considerations of overcoming this 'digital divide' for pasture user involvement in governance should look towards the experience of Nama Budhathoki of Kathmandu Living Labs in Nepal (Tanaka 2017). By using the open-source platform of OSM, investing in numerous training workshops for the public, and promoting local trainees as champions of the cause, Budhathoki's team has built a sustainable community of digital mappers that has expanded to rural Nepal (*ibid*).

The medium of cartography may place too bright a public spotlight on areas such as contested pasture borders or may be ill-suited to the problems at hand, such as social relations with no geographic anchor. For example, the transfer and loan of pasture spots for households' yurts may shift by season, economic ability, or social requests by other households, making a cartographic point feature a poor representation of this variability (Kozhomberdiev 2017). This research adopted alternative facilitation methods such as a custom, turn-based board game to demonstrate local pasture users' agency and the spatial implications of the practices. Players were engaged in a tactile sense (allocating currency represented by real dried beans) and chose which livelihood strategy (represented by cards) to pursue per season (turn), assisted by an expert facilitator. Both children and women intuitively understood the importance of citizen involvement in pasture governance far quicker through this board game rather than through mapping exercises. The board game's style of interacting with participants was also more effective in acting as a model simulation (the "what-ifs" of pursuing different livelihood practices) than the Atlas which focussed more on documenting practices. While the expert facilitation of these board game sessions was cost intensive, its success highlights the limitations of a cybercartographic approach. The most detailed atlas of practices and differences will not create change in pasture governance without links to forums of dialogue and concrete cooperation with government agencies.

5.5 Limitations of Cybercartography for Pastures

The creation of an open-access atlas to all participants inevitably raises concerns over its use, representation, and potential negative consequences for the users. This subsection will address issues encountered in the Naryn context.

5.5.1 Privacy and attribution

The produced atlas connected contributed information with name and photo of the individual providing it, with their permission. The inherent tension in this application of collaborative mapping is one where an individual's privacy may be compromised, against the need to be able to contact the individual in case other atlas users would like to learn more about the practice submitted. Other issues include an individual falsely attributing a submitted feature to another person, which could include an illegal practice such as ibex trophy hunting on protected park territory.

In the Naryn context, participant concerns over privacy were not an issue because of the TK-based approach. In many instances, participants expressed a desire to openly share TK with a broader audience as they feared continued generational loss of knowledge. This was most evident when conducting interviews with practitioners of traditional medicine, who crafted and distributed compresses of medicinal plants for others for free. Having a photo of oneself linked to a feature was positively viewed, appealing to a sense of pride that the individual was a knowledgeable source. Deliberate misattribution was also not evident as atlas users generally contributed information about their own localities, where they faced social pressure to represent and attribute features correctly. For example, multiple students in Eki-Naryn mapping on the Atlas at the same time were motivated to show their knowledge (competitively against the other students) and sense of hometown pride by mapping features accurately. Technical solutions to tier the visibility of contributed information also served to accommodate tension over the sensitivity of certain data. For example, the extent of NNR was generalized to its overall territory rather than displaying the individual sectors the park's management team uses

internally. This was done to address park management's fears of hunters strategically targeting larger and potentially under-monitored sectors. All media were also subject to approval by an atlas supervisor before it was publicly visible, to ward against irrelevant images.

A TK approach in Naryn encouraged the accurate publicization of knowledgeable individuals. Despite the various media used to represent the content on the atlas, TK is intrinsically generated from extensive lived experience within a local context and is difficult to transplant to other areas without the know-how of the original contributor. In turn, the original contributor benefits from being publicized by being socially recognized as an expert. This was evidenced by Dobolu villagers deferring to two elders who still practiced collecting medicinal herbs to add relevant features on the Atlas.

5.5.2 Data accuracy and divergent perspectives

The geographic and thematic accuracy of open-access platforms has consistently been questioned since any user (amateur or expert) can contribute information (Haklay 2010). The definition of an 'expert' or an 'amateur' in turn has been critiqued as increasingly ill-fitting as technological advances and recognition of local knowledge have blurred the lines (Sieber and Haklay 2015). A verification system is required to ensure Atlas data is accurate and can be acted upon by decision-makers, yet only 36% of Naryn respondents asked for external experts' opinions to verify Atlas features.

> "In the past two years, Internet in Naryn has improved. Therefore, many people get information through the Internet and sometimes people are better informed than any specialist." – Salkyn Tor park management

Shifting sources of verification to the online realm presented challenges in the perceived authenticity of accepted Atlas data. Naryn pasture users believe in the accuracy of something

based on their personal experience or on the word of a trusted, personal relation. The atlas however showed practices from around the province, and it was unlikely that a user would have a social connection to a feature that was geographically distant. To partially adapt, the atlas structured its data based on what participants shared as pertinent indicators to monitor. Technological solutions to structure input (e.g. requiring certain data fields, attribution, photos) and remote sensing are a well-accepted method to streamline verification (de Leeuw *et al*. 2011). This project made certain data fields (e.g. photos for medicinal plants) necessary to try to enforce a technical standard and to help other Atlas users edit created features. In doing so, participants expressed a deeper sense of collaboration, of trust, and of mapping towards the same goals.

The application of these technological solutions must be guided by the ontology of the contributing communities and their priorities (Wellen and Sieber 2013). In lieu of a personal connection, many pasture users turned to the PC as the primary verifier. The PC was perceived as occupying a 'trustworthiness niche' since they are legally mandated by the state, while also being locally-based and comprised of local members. The traits of being responsive and easily accessible were proxies for local authenticity, which would provide a trusted interface with technological measures such as the atlas. For example, a technocratic approach to geospatial accuracy could be to employ an averaged location of wolf spottings in concert with its known climactic range to estimate wolf distribution in an area. However, pasture communities are likely to be deeply interested in outlier spottings as they represent unexpected threats to their herds that would otherwise be masked by an averaged approach. These pasture users would look to the PC to articulate this local need. Sieber and Wellen (2011) emphasize that point-line-

polygon geometry does not encapsulate all spatial relations, and that attribute or thematic data have bearing on a feature's spatial accuracy. In Naryn a cybercartographic approach must contend with cases such as a high mountain pasture being defined not by geometric boundaries, but rather by which parts of it are accessible and in which seasons. Failure to do so risks inappropriate measures of pasture health set by national agencies, the manipulation of statistics by local and provincial level bodies to meet these measures, and therefore inaccurate data (Mestre 2018). Including a variety of local pasture users in the design of any technological tool can help set suitable and locally-relevant indicators.

The thematic accuracy for this atlas is a constant negotiation between its users because it is based on both traditional and current practices. As the information is user-contributed, cases such as herders being incentivized to under-report the number of animals they bring onto pastures (to reduce their usage fees) present accuracy challenges (Shigaeva et al. 2016). Collaborative platforms such as Wikipedia use the power of many users as crowdsourced oversight to detect and correct errors (Haklay 2010). I suggest that this user oversight should be combined with official data from PCs to improve both transparency and adherence to policies. Affording pasture users the ability to edit and suggest improvements on the atlas will add a level of responsiveness in the PC to buttress the existing institutional trust it enjoys. This in turn will incentivize accurate reporting by pasture users as the information on the atlas is open-access and can be used by all to inform household-level decisions (Kozhomberdiev 2017). Divergences between the PC and pasture user practices can also be explored for improved management and accuracy. During interviews, herders recommended that pasture maps should be redrawn using high ridges as borders since their animals would not expend the effort to

cross those ridges to graze. Similarly, park staff suggested that park boundaries should also be edged by mountains to make it harder for poachers physically enter park territory. Both these cases can combine local knowledge with technical expertise (such as remote sensing and digital elevation models) to improve oversight and accuracy.

5.5.3 Accessibility of data

The atlas was hosted on UCA's internal servers and was publicly accessible, with the ability for users to export data. UCA was chosen because it had an existing campus presence and infrastructure in Naryn City. However, most pasture users were unable to independently access the atlas due to inability/unwillingness to pay for an Internet modem, a lack of desktop computers, outright unavailability of Internet signal, or limited digital literacy. The simplest solution would be to take thematically related data and produce paper-based publications that are easily distributed. Researchers in Uzbekistan have created a pocket-sized booklet of pasture weeds and medicinal plants that is easily carried by pasture users as a reference (Murataly 2017). Alternative low-tech facilitation methods such as board games (discussed in Section 5.3) can continue to intersect with the web atlas by using the latter as a living storehouse of data that serves as a public record. The facilitation methods can be seen as instruments of citizen engagement that are informed by the most up-to-date information found on the atlas. Digitally, a significant potential improvement would be the development of a smartphone-based app to both collect and visualize data, as smartphone ownership is much more ubiquitous and intuitive to Naryn participants. A basic Android app for *Nunaliit* is available for data collection, but to date lacks some of the functionality of the web-based variant (Hayes 2017). For Internet availability, overtures were made to Beeline (a major Kyrgyz telecommunications company)

who were interested in sponsoring Internet modems as part of their corporate social responsibility portfolio. Due to Beeline's proposal timelines we were unable to reach an agreement, but this remains an option for future work in the area. Other suitable partners to connect local stakeholders with the atlas include Naryn State University, UCA's vocational school, and a nascent municipal GIS-user group based in Naryn City.

This research has shown the importance of lowering the barriers of accessibility to enable pasture users to participate in sharing their TK. It is critical in the Naryn context that the atlas remains open-access so that communities build trust and understand that the data are for their own use (Sieber and Haklay 2015). Sieber and Haklay (2015) note that contributed information is most valued only when it is up-to-date, particularly when discussing current pasture practices and events. Keeping atlas information current requires an open disposition towards citizen input, given the state's limited resources and reach in the area. Yet opening the gates to data does not guarantee effective and widespread participation, as usage of the atlas may devolve into "hobbyist interaction" where stakeholders contribute infrequently and at a whim (Gladwell 2010; Sieber and Haklay 2015). Connecting accessibility to structured action is discussed in the following section.

5.5.4 Misappropriation of data

Maintaining the atlas as open-access invites issues of external parties using the information for their own purposes, such as overharvesting mapped medicinal plants. Concerns also arise when the government may use contributed information to strategically reject dissenting datasets and confirm others for political reasons (Sieber and Haklay 2015).

Obscuring the precise locations by generalizing a feature to a larger area (a process called *k-anonymity*) is a common practice to prevent inappropriate data usage (Huang, Kanhere, and Hu 2010). *K-anonymity* was used to hide the individual sectors that NNR is divided into and to generalize animal spottings to the entire territory of the park, to prevent poachers targeting specific points. In terms of government misappropriation, the structure of Kyrgyz pasture management offers an opportunity to check these excesses. Recall in Figure 2 that PCs are formally separate bodies from the government, yet pasture users are largely unaware of this and the PC's role to advocate on their behalf (Dörre 2015). Integrating a cybercartographic atlas within a PC's mandate would clarify the PC's independence, since the atlas's processes are driven by the pasture users themselves. The transparency and depiction of local priorities would strengthen PCs' ability to represent their users to a larger audience while structuring contributed data and incentivizing pasture users' participation. Formalizing the atlas as part of a PC's jurisdiction would also allow support from national-level advocacy groups such as the National Association of Pasture Committees, affording users more leverage to protect their contributed information.

Enforcement of the proper use of atlas data cannot be guaranteed through only PCs' and pasture user efforts. For targeted illicit activities, inputs must come from other institutions. As an example, NNR's initiative in establishing motion-sensor camera traps in their territory to photograph wild snow leopards has also had the effect of discouraging hunters and foragers in protected areas (Kirbashev 2017). There is potential in forestry committees and PCs collaborating together to mutually patrol and ensure oversight of pasture lands, along with atlas-based reporting.

5.6 Placing TK and cybercartography in the policy-making landscape

While this research has used TK and cybercartography to show differences between local and government perspectives, the challenge of harnessing these insights for systemic change remains. The digital and online nature of cybercartography has potential as a technological solution, while the process of participatory mapping with TK addresses institutional deficiencies in Soviet-legacy management. At its core, this combined approach speaks to the critical need to re-explore social relations along with technological innovation for effective pasture governance.

However, the connection between TK and influencing official policy-making remains unarticulated. This disconnect was evidenced by significant difficulties in sustaining contributions and usage of the atlas despite high participant interest, which can only partially be attributed to Internet accessibility issues. It is the lack of the atlas's influence in the legal sector that marks the limitations of a cybercartographic approach in Naryn. Policy change, enforcement, and intellectual property lie beyond the scope of the atlas and will require political will amongst the various state agencies. The application and limitations of cybercartography should be contextualized within the broad spectrum of challenges and solutions facing pasture governance. Table 2 offers an overview of the pasture reform landscape in Naryn and the atlas-making process's role in red:

Table 2 - Cybercartography and TK's roles in the pasture governance problem landscape. Source: Jason Wong

Problems	Technical	Institutional	Legal
Inflexibility of policy to local contexts	• Fund capacity-development of PCs • Publicize best practices and TK	• Promote citizen science & TK • Connect PCs with	• Create a mechanism for local bodies to appeal governance decisions

		advocacy groups[1]	
Lack of stakeholder interest and adherence	• Establish signage and deterrence (e.g. trap-cameras)	• Solicit local priorities (through user-driven atlas)	• Reform PC election process to include herders and women
Competing pasture interests (economic vs. environmental)	• Visualize overlapping and complementary interests spatially	• Create joint partnerships for research on alternative uses (e.g. share NNR tree-grafting[2])	• Support branding and licensing of eco-tourism to generate revenue for pasture management[3]
Unclear responsibilities of various authorities	• Establish pasture checkpoints to inform users and enforce rules	• Hold forums to discuss initiatives • Experts provide remote support online	• Strengthen mechanisms for PCs and Forest Committees to communicate
Missing knowledge management infrastructure	• Allow open data exports of atlas data • Partner with telecoms (Beeline)	• Partner and share data with NGOs and research institutes (Camp Alatoo, UCA)	• Adopt Open Government Partnership (OGP) standards[4]

6 Conclusion

Kyrgyzstan stands at the cusp of a regional economic and political reordering. China's construction of a new Silk Road for trade across Central and Middle East Asia is a geopolitical

[1] The National Association of Pasture Committee is an NGO dedicated to advocating for PCs in Kyrgyzstan (Kozhomberdiev 2017)
[2] Methods to grow trees faster for both timber and ecological services were discussed in section 5.3.2
[3] Government-branding of eco-tourism has supported alternative incomes in Mongolia (Robinson 2014)
[4] In 2017 Kyrgyzstan joined OGP, an agreement to hold governments' national plans accountable through an independent reporting mechanism (Ostrow 2017)

gambit with investment implications of US $500 billion, while Russia works to maintain its political sway in Bishkek to check American influence (Alff 2016; Bruce-Lockhart 2017). Kyrgyzstan's ability to draft environmental and pasture policies that suit its national context and priorities instead of external trade demands will be challenged by these expansionist pressures. Continued degradation and mismanagement of Kyrgyzstan's pastures risks ongoing out-migration of men to Russia for employment, radicalization due to poverty and environmental damage, eroding public trust in the government, and a weak Kyrgyz economy susceptible to foreign demands. A modern method of flexibly governing Kyrgyzstan's dispersed pastures that is responsive to local variations is urgently needed.

This research demonstrated that a cybercartographic approach centred on TK effectively engaged a broad Naryn demographic in considering overlapping local uses of pastures. The *Nunaliit* Atlas offered an open-access and flexible platform to accept a broad range of knowledge, allowing for meaningful visualizations of differences and similarities. The process of citizen-led mapping itself revealed gender-differentiated perceptions that constrain women's agency in environment decision-making. TK was widely effective across all demographics in drawing attention to the importance of local adaptation and citizen representation for sustainable pasture management, to the extent that NNR park staff invited students to conduct soil studies on their territory.

Three key insights from this research bear special consideration and further exploration. First, adopting a citizen-led approach that accommodates the ontological structure of a set of TK maximizes the chances of that TK's interoperability with the current knowledge system. Rather

than government officials picking select data that fit their worldview from citizen-contributed TK, presenting the TK in its entire context makes its relevance to contemporary issues most obvious. An example of this was the suggestion from Naryn participants that pasture borders should be based on mountain ridges rather than equal pasture areas; their lived experience indicated that grazing animals avoid expending the additional energy needed to climb across a ridge, while the tough terrain also naturally deters poachers. This concept of ridges as borders benefits both users and authorities as an effective and visible method of demarcation grounded in lived experience. Further research should focus on fora to transparently and inclusively discuss the differences between a set of TK and the government's knowledge system.

Secondly, a resource-user centred approach geographically demonstrated the fundamentally different areal vs. mobility perspectives on pastures and sheds insight on the poor performance of PCs: how can local-level bodies be expected to effectively monitor vast areas when a remote pasture is accorded the same official recognition and financial support as a busy pasture road? Understanding the motivations behind a mobility view can guide policy such as sharing the costs of new road construction with park staff (who can also use the road for monitoring purposes). Such complementarities demonstrate the high potential for new partnerships in pasture governance and the benefits a collaborative cybercartographic approach brings.

Thirdly, visualization can play a valuable role in contextually communicating new methods to the state and public to influence policy change. Data from the Atlas can be exported and repurposed as targeted narratives that are easily digested by the public and government. Key organizations in pasture reform such as Camp Alatoo and the National Association of Pasture

Committees can also have their data incorporated into the Atlas to further the body of evidence for policy changes. Figure 19 shows a separate example of this I created using Mapbox (a Javascript code library) to synthesize this research for the general Canadian youth audience as part of an online publication by the Ontario Council for International Cooperation. Developing such interactive visualizations with transparency on data sources can be an effective method of presenting evidence-based narratives.

Figure 19 - A separate, interactive narrative created from exported atlas data. Mash-ups take select data and create directed messages that can mobilize both public and political will for policy reform. Source: Jason Wong 2017 (https://jasongeospatial.github.io/Naryn)

The lesson on the value of TK shines through the successes and limitations of this cybercartographic project. Focussing on TK emphasizes the local agency of resource users, building citizen engagement. Visualizing this information through a cybercartographic atlas's storytelling creates dialogue that highlights interoperability and cooperation. Both process and product create hope for a working model of the next era of government-civil society governance. In Naryn, improving policy in the peaks rests on listening to the multiple views on the ground.

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8 Appendix A

Figure 20 - An empty example of the map supplied to Eki-Naryn students in Table 1J to conduct their own interview with local elders on TK. Students were tasked to both map where the practice takes place and to document it textually in the white space provided. Geospatial data from: Open Street Map 2017