COMPREHENDING BIOPHYSICAL CHANGES: A SEASONAL CALENDAR OF THE UPPER ALAI VALLEY, KYRGYZSTAN

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ABSTRACT

Seasonal calendars are a type of place-based local knowledge of annual phenological events (biophysical, and sociocultural events) that may contribute to our understanding of a particular region's climate and seasonality. Small-scale farmers are impacted by climate change: fluctuations of annual temperature and precipitation. They rely on farming and herding within the seasonal limitations. Seasonal variability, especially in spring and fall, and the short growing seasons require accurate tracking of phenological events to achieve successful crop and livestock production. There is a need for ecological calendars that link multiple ecological and social systems to improve the ability of farmers and time farming and herding practices. As a result of the Belmont Forum-funded project titled "Ecological Calendar and Climate Adaptation in the Pamirs," this study represents the seasonal calendar from the upper Alai Valley of Kyrgyzstan. Based on qualitative interviews among herders and farmers, we developed a seasonal calendar for the villagers and a team of transdisciplinary scholars. We conducted a workshop with 24 male informants in the Village of Sary Mogul, Kyrgyzstan, in 2016. We also interviewed 39 informants in 2017 (n= 19 males and 20 women). We validated these findings with 25 elders in 2018 (n= 3 females, 22 males). As a result, a revitalized seasonal calendar builds anticipatory knowledge that facilitates small-scale decisions in the context of seasonal variabilities. The social, cultural, historical, and ecological context was vital for re-contextualizing the ecological calendar of a particular people and place. Understanding the interrelationships between biophysical, and social-cultural events provided insights into how people utilized the calendar to inform their seasonal decisions. In order to further monitor the biophysical variables in the Alai Valley, I proposed further research recommendations.

BIOGRAPHICAL SKETCH

I grew up in the Murghab District of Gorno-Badakhshan Autonomous Province (GBAO) in Tajikistan. Having completed the local High School in Murghab (2001 - 2011), I was awarded a scholarship by the U.S. Department of State's Future Leaders Exchange Program. After completing the program in Grovetown High School, GA, USA (2011 – 2012), I was awarded a scholarship by the Open Society Foundation to undertake his B.A. degree in Bishkek, Kyrgyzstan. I majored in Environmental Management and Sustainability, and minored in Anthropology, at the American University of Central Asia, Bishkek (Kyrgyzstan). My B.A. thesis, "Community Resilience and Commodification of Nature in Eastern Pamirs of Tajikistan" (2017), established a pathway towards studying socio-ecological research in the Pamir Mountains of Central Asia. In 2016, I joined the Belmont Forum funded, transdisciplinary and collaborative, project "Ecological Calendars and Climate Adaptation in the Pamirs" (2016-2021); it was a five-year international project led by Dr. Karim-Aly Kassam, Cornell University. As part of his Graduate Research Assistantship (GRA) program in the Department of Natural Resources and Environment (2018-2021), my M.S. thesis contributes to the process of anticipatory knowledge building for agropastoral communities in the Alai Valley of Kyrgyzstan within the broader context of studying environmental change and adaptation to climate change in the Pamir Mountains.

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INTRODUCTION

Various traditional ecological calendars, specifically in the Pamir Mountains (Tajikistan, Afghanistan, and China), foster climate change adaptation in the region (Kassam, 2009a; Kassam, et al., 2011, Kassam, et al. 2018). For instance, the traditional calendar of 'the human body' developed in the Western Pamirs of Tajikistan had the capacity to anticipate seasonal uncertainties and serve as anticipatory knowledge in securing livelihoods, especially food systems (Kassam, et al. 2011). The knowledge embedded in ecological calendars, however, had been seriously diminished because of many historical conquests. Both the Tsarist Russian conquest and the industrialization of Central Asia during the Soviet era had significant impact on the use of calendars. In addition to this historical pressure on local livelihoods and community knowledge, researchers have noticed the increasing effects of seasonal variations on small-scale farming decisions. The mountain communities (farmers, herders, and hunters) are at the vanguard of seasonal uncertainties and climate change (Kassam, 2009a). Therefore, revitalizing seasonal calendars through traditional knowledge systems in Central Asia has become important to anticipate year-to-year seasonal variabilities.

Building on the previous research in the region, a Belmont Forum-funded project titled "Ecological Calendar and Climate Adaptation in the Pamirs" (ECCAP), an international and transdisciplinary project, was initiated in 2016. Applying the action-based participatory research method, the collaborative project aimed to revitalize traditional ecological calendars among several small-scale communities. They included two communities in North America, and five communities in the Pamir Mountains of Central Asia. The seasonal calendars included a body of complex human knowledge of ecological systems and were co-generated in collaboration with a *community of inquiry* (scientists of diverse backgrounds), and with a *community of social* *practice* (farmers, herders, hunters, and fishers). Collaborative work on ecological calendars can not only foster further adaptions to seasonal uncertainties, but also this work may secure food systems in different villages (Kassam et al., 2018).

Within the ECCAP project framework, my research focused on developing ecological calendars for Sary Mogul Village, in Alai Valley, Kyrgyzstan. In this research, I ask how people in the Sary Mogul Village utilize their practical knowledge of ecological calendars, and how the biophysical variables contribute to their seasonal decisions. How does community knowledge of seasonal decisions reveal physical events (e.g., snow cover, growing season, temperature change) and biological cycles (animal and plant life)? The overall purpose of this research was to demonstrate the interconnectivity of ecological cycles. In other words, we mapped the environmental variables and seasonality the upper Alai Valley working with farers and scientists.

Without understanding the geopolitical, socio-cultural, economic, environmental, and historical transformations of Alai Valley, it is challenging to situate the importance of the ecological calendars. Therefore, in Chapter 1**,** I re-contextualized the study area summarized below. As for the broader context, Sary Mogul was located at an elevation between 2900 to 3100-meter a.s.l., and sandwiched between the Zaalai-Alai and Alai Mountain ranges. At the foothills of glaciated and permafrost zones of Alai Valley of Kyrgyzstan, various tribes (n= 5156 people) have survived for generations. Changing seasonal pasture migration, and harvesting of barley and potatoes (utilized during short growing seasons) still plays a vital role for livelihoods. However, the traditional life like herding and cropping were transformed by the Tsarist Russian and Soviet colonization of the Alai Valley. Therefore, Kyrgyz ecological calendars were significantly impacted by these historical transformations.

Reviewing the previous literature on ecological calendars of Kyrgyz people, throughout Chapter 1**,** we demonstrate that past ecological calendars existed in the region. However, the knowledge of seasonal land-use practices had been disrupted due to geopolitical transformations. Despite these geopolitical implications, people of Sary Mogul retained their sacred ecological information, along with local knowledge of the biophysical, and social-cultural cycles in their environment. Geopolitical history also resulted in the formation of a pluralistic community composed of tribes with different ethnicities that included critical knowledge for crop management from different elevations. Besides seasonal herding and farming, another layer of environmental struggles in the Alai Valley included a continual quest for natural resources, which originated with the Soviet exploitation of them. Combined with the political aspect of environmental issues, the local herders and farmers experienced challenges in adapting to climate change.

Given these historically unfolded changes, especially the food crisis that occurred at the end of the Soviet Union, we recognize the need for revitalizing ecological calendars in order to assist local decision-making (e.g., planting, harvesting, and herding) in the context of environmental and climatic change. Then, I emphasized how villagers became sovereign in their local decisions after the end of the Soviet Union. Thus, the role of the ecological calendars contributed to their specific challenges with context-dependent year-to-year seasonal variabilities.

Based on three years of summer-field work, a Seasonal Round Workshop in 2016, semi-structured interviews in 2017, and community validation in 2018, I reflected, in Chapter 2, on the methodological development of a Seasonal Calendar and attempted to interpret seasonal activities in the Alai Valley. To make it clear, I reduced the main Seasonal Calendar into 8

Seasonal Rounds; I first introduced the main four seasons (winters, spring, summer, and autumn). Winter lasted from October to April in the upper Alai Valley. Spring was very short: April and May. Summer occurred from late May to late August, and overlapped with autumn. Autumn lasted from late July to mid-October, depending on the signs of seasonal transitions. Focusing on specific physical, biological, and human livelihoods decisions, I then explained physical changes that marked these seasons. The word cue is used in order to specify a particular ecological event that tells farmers to take action. Words like marker or indicator point out what signs informed seasonal transitions. The brief spring transition included snow melt, ice thaw, increased soil heat, snow melt on slopes, and last-snow. In the Alai Valley, the summer growing season is short from June to mid-August. The autumn transition included temperature changes, frost, wind, and ground freezing from mid-August to October. The long winter snows in the Alai Valley continued from October until April. Then, I showed how livestock and crop-related decisions depend on these biophysical variables. For example, herding practices depended on snow cover and snowmelt. The timing of sheep breeding occurred in the fall so that lambing occurred during warmer spring temperatures.

Similarly, physical changes inform livestock management. I show how physical events like snow guided herding practices throughout the year. During the short growing season, especially in snow-free times, people herd livestock in summer pastures. In the fall, farmers bring their livestock to the village and herd around the village until the snow begins to fall. When the snow cover begins in winter, local farmers lose options. The only choice was hand-feeding livestock in the village. With snowmelt in spring, people grazed their livestock around the village and then moved them to summer pastures. Any vegetation related markers in the spring were determined by the shifting snowmelt times, which varied from April to July. Animal cycles revealed seasonal hibernation of marmots, and breeding and lambing seasons for wild sheep and goats. As spring continued, yak calving season seemed to vary depending on mating time. Finally, the short growing season in the Alai Valley was measured through the presence of various summer birds, the arrival and departure of birds, and the occurrence of insects demonstrated in the Seasonal Calendar. The ecological calendars hence open a holistic perspective to study the social-ecological constraints, seasonal changes, and importance of specific environmental variables in mountain areas.

In Chapter 3, I have expanded my understanding of phenological events in the calendar and suggested specific recommendations for future research. Multiple ecological factors influenced the events in the calendar. It is imperative to focus on snow accumulation (fall), snow cover (winter), snowmelt (spring), and snow-free (summer) in the future. Because my research is limited to assess the growing season, spring and fall phenological changes are vital for cropping and herding decisions. Remote sensing technologies seem to provide the best tools to assess the situations of snow cover and the growing season. However, local people lack technologies to monitor the thawing of soil and ground freeze in spring and fall. Meanwhile farmers could utilize digital cameras, drones and other locally available technologies to continue monitoring the changes in their seasons including animals and plants.

CHAPTER 1

RE-CONTEXTUALIZATION OF SARY MOGUL VILLAGE, ALAI VALLEY, KYRGYZSTAN

Introduction

The study of traditional ecological calendars informs how people whose livelihoods depend on herding and cropping activities in various ecological zones coped with seasonal changes in their natural environment at the local scale (Makuritofe and Castro, 2008; Prober et al., 2011; Londono et al., 2016). The study of ecological calendars engages place-based human adaptation to changing temperatures and precipitation. It also potentially informed the livelihood decisions of villagers by engaging local knowledge with scientific methods. Similar seasonal calendars have been extensively researched in the Pamir Mountains of Tajikistan (Kassam et al., 2011; Kassam et al., 2018), but very little was known about the ecological calendars from the Alai mountains of Kyrgyzstan (Фиельструп, 2002; Басилов, 1986; and Schuyler, 1877).

The homeland mountain communities in Central Asia (the Pamir Mountains) provided a source of knowledge for many scholars, especially since the end of the Cold War. There has been an abundant production of scientific knowledge on various research areas, including climate change adaption among the mountain communities. However, most of the existing literature from this region showed a strong emphasis on the Soviet history that shaped mountains of Asia. Previous regional literature also provided very little space to establish a context for the role of community knowledge in the context of climate change discussions in the region. Climate change adaption at the village level needs re-contextualization of social, cultural, and historical background. Therefore, the study of ecological calendars in the mountains of Central Asia cannot be removed from their historical context.

The Village of Sary Mogul has been contextualized by a strong reference to the Soviet era. Therefore, a lack of post-colonial perspectives in the regional sciences limits our understanding of the place and people. According to recent literature, for example, Sary Mogul was founded in 1946 as a result of an artificially created Soviet enclave (Sonntag, 2016). However, history of tribes in Alai Valley does not begin from Soviet era. Especially, when we think about community adaptation to weather changes through local knowledge. I first joined the research team in 2016, and I asked how can there be a long-term adaptation to climate change if Sary Mogul was established only in 1946? Our collaborators have argued that 74 years of human establishment in the Alai Valley provided sufficient time to adapt to changing seasons, but this answer was insufficient. Therefore, the overall purpose of Chapter 1 is to re-contextualize the study and establish grounded knowledge for Chapter 2 and Chapter 3.

The re-contextualization of Sary Mogul, in return, sheds light on our understanding of people and foraging cultures, and the use of ecological calendars in Central Asia. Human activities in the Alai Valley did not begin with Soviet collective farms. I emphasize extending our knowledge of agropastoral tribes in the Pamirs Mountains of Central Asia for several reasons. I acknowledge that the people of the Pamir Mountains were tribal nations (Taipov, 2002, p.20; Shahrani, 1979, p.151; Dor, 1993, p.9-14; Kreutzmann, 2012, p.112). The tribal diversity of the region adds another layer of complexity for understanding local identities and self-determination. The divisions of nomadic people of Central Asia and settled people existed in historical literature, but both could not have survived without each other in history (Khazanov, 1994). Therefore, the people of the Alai Valley have extensively experimented with both nomadic and settled livelihoods (Huntington, 1907, p. 130; Karmysheva, 2009, p.60). Moreover, many tribes of Central Asia already had ecological calendars (Фиелюьструп, 2002; Басилов, 1986; and Schuyler, 1877). Finally, I must admit that these regions have been at the vanguard of ongoing historical dispossession produced by the external and internal geopolitics. As a result, some Kyrgyz tribes ended up as refugees in Turkey (Dörre et al., 2016).

The rest of Chapter 1 contextualized the study area by pointing out the importance of herding practices and cropping activities. The livestock keeping and land use are essential for people's survival. The sacred landscapes of the Alai Valley included the presence of diverse animals and plants in the valley are acknowledged. Considering the presence of flora and fauna, I contributed to revitalize local knowledge of plants and animals, including birds and insect. Considering the previous literature in the Pamirs, I connected the dots from many regional studies to ground the Alai Valley in the context of global climate change. I do acknowledge the historical influence of Soviet Industrialization. I also mentioned the history of land use practices, which includes the human's interaction with the natural environment. Considering the ongoing colonization of the region, I revisited the historical use of seasonal calendars. Finally, I examined how post-Soviet transformations shaped local people ability to sustain cropping.

Context

Situated in the Alai Valley of southern Kyrgyzstan, and bordered with countries like Tajikistan and China, the people of the Sary Mogul area are one of the collaborating partners of the project ECCAP in Central Asia (Kassam et al., 2018). The area is surrounded by various mountain ranges, such as the Zaalai and Alai. Together, these ranges are known as the Pamir-Alai Mountains (Watanabe et al., 2014, p.103; Shirasaka et al., 2014, p.84). The settlement Sary Mogul is situated at over 2900 - 3100 meters elevation above sea level, and Lenin Peak is the highest point with an altitude of 7145 meters (a.s.l.). Surrounded by such high mountain ranges, the region has a short season (spring, summer, and autumn) and a long (seven-month) cold and snowy winter. The lowest temperature in winter can be -35 °C to - 40°C (Sonntag, 2016).

Figure 1. Map of the Sary Mogul, Alai Valley, Kyrgyzstan

Administratively, Sary Mogul *Aiyl okmoty* (administrative village) is part of the Alai *Rayon* (district) of Osh *Oblast* (province) of Kyrgyzstan since 2004 (Figure 1). Osh is also the name of the provincial city, which is essential for Sary Mogul in terms of administrative governance, trade, mobility, and food provisioning. There were 5156 people currently living in the village (Ayil Okumotu Sary Mogul 2018, January). The inhabitants had various professions such as teachers, doctors, drivers, entrepreneurs, and veterinarians. In addition to these local state provisioned jobs, herders' knowledge of seasonal livestock management and land-use practices played a significant role in maintaining their livelihoods and survival (Ibraeva et al, 2016).

Livestock keeping

There were various livelihood strategies in the village. Livestock keeping (yaks, horses, sheep, and goats) was the primary source of the local economy (Figure 2). Animal husbandry (or pastoralism) has long been a source of survival among many semi-nomadic and semi-settled tribes of the region (Khazanov, 1994, p.17-25). The rich pastures of the valley have been seasonally utilized by the local nomadic tribes for generations (Shirasaka et al., 2014, p.86). Livestock-keeping still remains economically vital for many communities in the Alai Valley today (Liu and Watanabe, 2014; Shirasaka et al., 2016; Watanabe and Shirasaka, 2016). It was estimated that out of 61,583 hectares, only 33,228 hectares were classified as pasture, whereas 3,932 hectares were arable land. Of the total area, 24,374 hectares were considered unsuitable for production during the Soviet era (Taipov, 2012, p.78). Currently, of the 23,493 hectares of farmable land, 22,707 hectares were considered pastureland, whereas 786 hectares were suitable for agriculture (Ayil Okumotu Sary Mogul 2018, January). The administrative territory of the village is small because of the many reasons explained throughout this chapter.

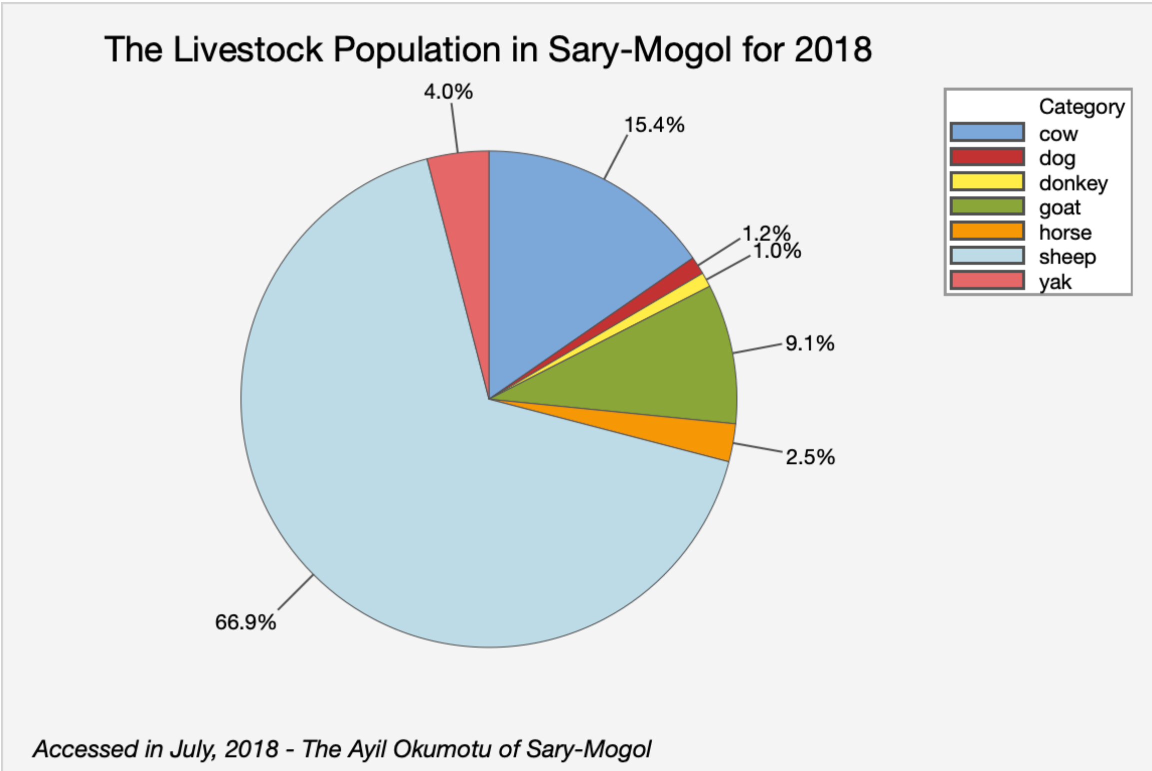


Figure 2. The statistics of domestic animals in Sary Mogul, 2018

Land use

While there is a long history of land use practices herding livestock as well as cultivating crops in the Alai Valley (Bernshtam, 1950; p.187-188; Maanaev and Ploskikh, 1983, p.38-40), agriculture in Sary Mogul began intensifying after the forced sedentarization of tribes in 1946. The establishment of Sary Mogul was mainly due to the food crisis (deficit) that happened after the establishment of Soviet farms in the neighboring region of Gorno-Badakhshan Autonomous Oblast (GBAO) of the Tajik Soviet Socialist Republic (TSSR). Since the Alai Valley was known for its rich grasslands, the Soviet administration resettled tribes to cultivate fodder and transport grass to the farms in GBAO of Tajik SSR. A few years after the establishment of Sary Mogul, barley and Espartset (*Onobrychis*, known as Common Sainfoin) were planted. After the forced resettlement of tribes by the Soviets, people of Sary Mogul began actively growing barley, Common Sainfoin, and *talaa chop* natural fodder. Today, farmers have relatively huge fields outside of the village where these fodder crops are cultivated. Households own around 0.15 hectares of land inside the village, and 5 to 30 hectares of land outside of the village. The farmers use all types of fodder grass, including barley, to support their livestock throughout the winter and spring. Due to the short growing season, barley does not reach full size, and therefore, it was not processed or consumed by farmers. Barley was only used to feed livestock.

In addition, villagers had a small garden plot in front of their houses where they grew potatoes (Sonntag, 2016). Growing potatoes was locally considered a positive sign, especially since 2000. Over the past two decades, growing potatoes at elevations of 3000 meters became a possibility. Although potatoes also do not reach full size due to the short season, they were still cultivated, eaten, and stored for winter and spring. Some potatoes were sold in the market, and some were kept as seedlings for the next year. I do not know if potatoes were harvested in the Soviet era, but our interviews suggested that potatoes were rarely planted during the Soviet era. Our data analysis revealed that the potato cultivation began only after 1997. Because Sary Mogul was part of Tajikistan, food crisis, poverty, and the Civil War (1992-1997) in Tajikistan (Bliss, 2006, p.271-343) impacted the food sector in Alai Valley. I discuss the details of potatoes harvesting below as part of the food crisis, followed by the collapse of the Soviet Union. To address the food shortage in the region, several international organizations and a Mountain Societies Development Support Program (MSDSP) encouraged communities to become self-sufficient. Several agriculture projects (experimenting with multiple seeds) were implemented with the support of the Aga Khan Development Network (AKDN) in Sary Mogul village (Sary-Kol, 2002; Sary-Kol, 2003). Since then, potatoes, barley, common sainfoin, and natural fodder became fragile food sources that provided survival during the short growing summer season.

Therefore, revitalizing ecological calendars contributed to timing of seasonal activities as well as securing the local decisions during planting and harvesting times.

Sacred Habitat

Based on my ethnographic observations, people in Sary Mogul considered their land sacred, especially the glaciated lakes. The many sacred sites in the Pamir Mountains (Middleton, 2011; Mostowlansky, 2017, p.63-66), were ecologically important, social-culturally appreciated, related to seasonal festivities, shared by diversity, and indicated indigenous knowledge (Kassam, 2009a). The Tuplar-Kul lakes (glacial lakes) for example, situated at the foothill of Trance-Alai Range, were a sacred site for the community. Every year in summer, before the official date of the seasonal festival (Yak and Horse Games) for tourists, a special gathering took place at Tuplar-Kul. A team of young girls and boys prepared a meal to honor the *aksakals* - knowledgeable elders. This gathering aimed to get *dua* – elders' blessing before the festival. The unique gathering at the sacred site not only mediated the importance of the elders' experiential knowledge of the habitat, but also it reflected the villagers' relationship to their natural landscape. Thus, locals show gratitude to the massive landscapes. For example, after the successful harvest in fall, the community celebrates the period of food abundance. Therefore, sacred sites were the crucial attribute of the socio-ecological context of many communities in the region.

There are relationships between sacred sites and spirituality in ecological calendars. As far as I know, natural environments are valued as a sacred because of their symbolic meaning of life. In the Pamir Mountains, the natural forces and landscapes have a sense of geographical domination. Another reason of sacred spirituality is that people benefit from the habitat they live. For example, fall is the rich season of the year where many community festivals occur. Local resources attract people and exchange. Therefore, people pay homage to the nature and landscapes in their seasonal activities. Sacred and spiritual aspects of the ecological calendars is still limited in my study and need further research.

Flora and fauna in Alai Valley

Since the end of the Soviet Union, only a few studies have been conducted research on local knowledge of flora and fauna that were a key component of their ecological calendars. The Alai Valley and the surrounding mountain ecosystems were home for rare and endemic biodiversity (Maikhuri et at., 2015). The region provided habitat for various local, breeding, and migratory birds (Ayé, 2012) as well as for an incredible range of butterflies (Toropov and Zhdanko, 2007), and diverse species of plants (Nowak et al., 2016b). Since the end of the Soviet Union, the human interrelationship with ecological surroundings has changed due to socio-economic transformations. Some studies have demonstrated that the number of wolve (*Canis lupus*) attacks on livestock has been growing (Izumiyama et al., 2009; Maikhuri et al., 2015, p.230). This is partly because people hunt mountain goats *Capra ibex*) and mountain sheep (*Ovis ammon*) which impacts the ecological food chain. While the game management is a complicated issue, these studies highlight that the local people are aware of the presence and mammals such as Long-tailed Marmot (*Marmota caudata*), Argali *(Ovis ammon),* and Ibex (*Capra ibex*). Local people observe seasonal behaviors in their ecological calendars (see Table 1). Scholars have visited 7 school in the Alai Valley and surveyed the presence of various animals in fall 2008 (Izumiyama et al., 2009). Although scholars do not specify the labels on the table (e.g., reference, questioner and hearing), I find this table important to show the presence of flora and fauna, which is part of the animal cycles in the ecological calendar.

Table 1. List of Mammals in the Ali Valley, Kyrgyzstan.

Table 1. List of larger mammals in the Alai Valley of the Kyrgyz Republic.

Order	Species name	Nomenclature	Reference	Questionnaire	Hearing	Observation
Lagomorpha	Mountain Hare	*Lepus timidus*	●	●	●	● (Footprint)
Rodentia	Long-tailed Marmot	*Marmota caudata*	●	●	●	
Carnivora	Wolf	*Canis lupus*	●	●	●	● (Footprint)
	Red fox	*Vulpes vulpes*	●	●	●	● (Observe)
	Brown bear	*Ursus arctos*	●	●	●	
	Weasel sp.	*Martes* sp.	●	●	●	
	Stone Marten	*Martes foina*	●	●	●	● (Footprint)
	Badger	*Meles meles*	●	●	●	
	Lynx	*Lynx lynx*	●	●	●	
	Snow leopard	*Panthera uncia*	●	●	●	
Artiodactyla	Wild boar	*Sus scrofa*	●	●	●	
	Ibex	*Capra ibex*	●	●	●	● (Footprint)
	Argali	*Ovis ammon*	●	●	●	

Source. Izumiyama et al., 2009, p.16.

During the past two decades, community knowledge of habitat contributed to some fields such as ecology, geography, and wildlife conservation in the region. It is important to mention the ecological calendars included these animal and plant species. The villagers across the Alai Valley, including Sary Mogul, demonstrated a wide range of knowledge of mammals, birds, plants, pastures, pathways, and valleys. For example, 125 place names had been recorded, and all of these places were named after flora, fauna, physical shapes, and color of the mountains, valleys, and pastures (Watanabe et al., 2014). Some conservationists have assessed the historical distribution and occurrence of Snow Leopard, Argali, Ibex, Lynx (*Lynx lynx*), and Brown bear in collaboration with local communities in Alai Valley (Taubmann et a., 2016). Furthermore, some studies have reported a growing number of wolves and their impact on livestock due to human and wildlife conflicts (Izumiyama et al., 2009). Studies related to hunting were a sensitive issue in the region. Human relationships with habitat demonstrated the value of habitat, which was a fundamental aspect in revitalizing the ecological calendar for the Alai Valley (see Table 2).

Table 2. Villager’s knowledge of animals in the Alai Valley, Kyrgyzstan.

Table 1. Local residents' knowledge about the major fauna in the Alai region (N = 354).

	Q 1: Do you know the existence of the following wild animals in this region?		Q 2: Have you actually seen the following wild animals in this region?	
	Number of respondents	Percentage	Number of respondents	Percentage
Wolf	332	93.8	249	70.3
Red fox	327	92.4	286	80.8
Long-tailed marmot	326	92.1	293	82.8
Argali	96	27.1	76	21.5
Snow leopard	74	20.9	38	10.7

Data collected by the questionnaire survey conducted in the Alai region, Kyrgyz in 2008.

Source. Watanabe et al, 2010, p.29.

Local knowledge of birds

The ecological calendar represented a rich community knowledge of various biological species, such as mammals, birds, and plants. Building on some of the existing literature on the community knowledge of habitat, I re-considered the villagers’ awareness of birds and plants reflecting on my fieldwork during July 2018. By categorizing the birds into resident, breeding, and migratory, my research identified 19 resident birds (Table 3), 18 breeding birds (Table 4), and 8 migratory birds all known by the members of the community (see Table 5). The book, *Birds of Central Asia* (Ayé, 2012), made a significant contribution towards revitalizing local knowledge of birds and identification. As a result, I noticed that villagers possessed a rich knowledge of birds, and some were used as key seasonal markers of change.

Table 3. A list of resident birds known by the community in the Alai Valley, Kyrgyzstan, 2018.

	Kyrgyz name	Common English Name	Science Name
1.	*Koguchkon or kok kabutar*	Hill Pigeon	*Columba rupestris*
2.	*Pahtek*	Eurasian Collared Dove	*Streptopelia decaocto*
3.	*Ala Partang or Sagyzgan*	Common Magpie	*Pica*
4.	*Taan*	Yellow-billed Chough	*Pyrrhocorax graculus*
5.	*Choko-taan*	Red-billed Chough	*Pyrrhocorax*
6.	*Ular*	Himalayan Snowcock	*Tetraogallus himalayensis*

7.	*Kurtek*	Tibetan Snowcock	*Tetraogallus caspius*
8.	*Kekilik*	Chuckar	*Alectoris / Phasianidae*
9.	*Kara-kash torgoi*	Horned-Lark	*Eremophila alpestris*
10.	*Joru (Ak-Bash)*	Lammergeier	*Gypaetus barbatus*
11.	*Gajyr*	Himalayan Griffon	*Gyps himalayensis*
12.	*Gajyr*	Eurasian Griffon	*Gyps fulvus*
13.	*Byrkyt*	Golden Eagle	*Aquila chrysaetos*
14.	*Bai Uulu*	Eurasian Eagle Owl	*Bubo*
15.	*Bor-Bash*	Spotted Great Rose finch	*Carpodacus severtzovi*
16.	*Karga*	Carrion Crow	*Corvus corax*
17.	*Karga*	Common Raven	*Corvus corone*
18.	*Gijik*	Eurasians Tree Sparrow	*Passer montanus*
19.	*Chyt Chymchyk*	Plain Mountain Finch	*Leucosticte nemoricola*

In the process of identifying birds, I encountered several challenges. Nonetheless, some of the birds may become crucial seasonal markers as villagers continue to monitor the seasons. When migratory birds arrived in spring, *Ala partang* arrived, but this term referred to two different birds, Common Magpie (*Pica pica*) as well as Northern Shoveler (*Anas clypeata*). The local name comes from Persian sources. While *ala* from the Altaic language family refers to white and black, *partang* comes from Persian language. Apparently, it seems Turkic speaking tribes and Persian ethnicities share some words. I used the guidebook *Birds of Central Asia* (Рябицев et al., 2019) to identify the *Ala parting* or Smew (*Margellus albellus*) where the arrival of ducks was used as a sign of spring in Tajikistan. Local people use one name to refer to several birds. Likewise, the name *Kashkalduk* was used to identify three similar birds: Common Coot *(Fulica atra)*, White-Headed Duck (*Oxyura leucocephala*), and White-headed Ruby Throat *(Luscinia pectoralis)*. These three birds were characterized as having a white and black stripe on their heads. The bird *Kashkalduk* was mentioned generally arriving along with other migratory ducks.

Similarly, the name *Kaldugach* applies for three birds with similar tales: Common Swift (*Apus apus*), Northern House Martin (*Delichon Ubricum*), and Barn Swallow (*Hirundo rustica*).

When *Kaldugach* is seen in flocks during migratory bird departure, it indicated the end of summer and the arrival of autumn. Surprisingly nobody mentioned the *Kyky* or Common Cuckoo (*Fulica atra*) that was present in Alai Valley all summer, while the occurrence of *Bai ulu* (*Athene noctua*) Little Owl was mentioned (generally) as a sign of spring. Despite such generalizations and inconsistencies with bird names, it was vital to acknowledge the awareness of birds.

Table 4. A list of breeding birds known by the community in the Alai Valley, Kyrgyzstan, 2018.

	Kyrgyz name	Common English Name	Science Name
1.	*Kyiko*	Lesser Kestrel	*Falco noumanni*
2.	*Kyiko*	Common Kestrel	*Falco tinnunculus*
3.	*Jooru*	Egyptian Vulture	*Neophron percnopterus*
4.	*Itelgi*	Eurasian Sparrow hawk	*Accipiter nisus*
5.	*Kyky*	Common Cuckoo	*Cuculus canorus*
6.	*Kyrgyek*	Hume’s Warbler	*Phylloscopus humei*
7.	*Chakchagai*	Isabelline Wheatear	*Oenanthe isabellina*
8.	*Kurchulduk*	Northern Wheatear	*Oenanthe*
9.	*Chandyloch*	White Wagtail	*Motacilla alba*
10.	*Sasyk-Ypup*	Eurasian Hoopoe	*Upupa epops*
11.	*Angyr*	Ruddy Shelduck	*Tabdorna ferruginea*
12.	*Ordok*	Goosander	*Mergus merganser*
13.	*Kashkalduk*	Common Coot	*Fulica atra*
14.	*Kaldugach*	Common Swift	*Apus*
15.	*Kaldugach*	Northern House Martin	*Delichon Ubricum*
16.	*Kaldugach*	Barn Swallow	*Hirundo rustica*
17.	*Kyzyl-Koinok*	Guldenstadt’s Redstart	*Phoenicurus erythrogastru*
18.	*Kyzyl-Koinok*	Black Redstart	*Phoenicurus ochruros*

Table 5. A list of migratory birds known by the community in the Alai Valley, Kyrgyzstan, 2018.

	Kyrgyz name	Common English Name	Science Name
1.	*Kok Kytan*	Grey Heron	*Ardea cinerea*
2.	*Karkyra/ Turna*	Demoiselle Crane	*Grus virgo*
3.	*Karkyra / Turna*	Common Crane	*Grus*
4.	*Kyrgyek*	Sykes’s Warbler	*Iduna rama*
5.	*Kyrgyek*	Greenish Warbler	*Phylloscopus trochiloides*
6.	*Churok*	Mallard	*Anas platyrthynchos*
7.	*Kashkalduk*	White Headed Duck	*Oxyura leucocephala*
8.	*Ala partang*	Northern Shoveler	*Anas clypeata*

9.	*Baiuulu*	Little Owl	*Athene noctua*

Local knowledge of plants

It was impossible to discuss ecological calendars without people's knowledge of plants. The mountain communities in Central Asia have a rich knowledge of medicinal plants, especially in the Pamir Mountains of Tajikistan and Afghanistan (Kassam et al., 2010), some of which w seasonal cues. The Wakhi and Kyrgyz people of Afghanistan's Wakhan corridor have developed a sophisticated knowledge of medicinal plants (Soelberg and Jager, 2016). The book *Les plantes medicinales du Pamir Oriental et leur utulisation en medicine populaire* (2010) by Raimberdi Abilazovich Mamatumarov was an excellent local source, which helped me to identify many plants known by the people of Sary Mogul. Some plants like dragon head *Mamyry* (*Dracocephalum paulsenii)* or Artemisia *Ermen Chop* (*Artemisia macrocephala*) were widely distributed both in Alai Valley and the Pamir Mountains of Tajikistan (see Table 6). The author of this book was a local botanist from the Village of Shaimak in Murghab District of the GBAO province of Tajikistan.

Table 6. Plant Knowledge from Sary Mogul, Alai Valley, Kyrgyzstan, 2018.

Local Name	**Common Name**	**Science Name**	**Purpose of use**	**Notes**
Ermen Chop	Mugworts	*Artemisia macrocephala* Jacquem. ex Besser	Used as medicine / anti-flea	
Mamyry	Dragon Head	*Dracocephalum paulsenii* Briq.	Herbal tea	
Mamakaimak	Dandelion	*Taraxacum spp.*	Indicators of spring	
Espartset	Common Sainfoin	*Onobrychis spp.*	Fodder	
Koyrgon	Onion	*Allium kaufmannii* Regel.	Food	
Sorusyn	Onion	*Allium spp.*	Food	*I do not know the exact sub species?*
Chykyry	Rhubarb	*Rheum reticulatum* Losinsk.	Food / Seasonal marker	*I do not know the exact sub species?*
Kyzgaldak	Poppies	*Papaveraceae spp.*	Markers of spring	
Kiyak	Grass	*Leymus secalinus spp.*	Fodder / Seasonal marker	
Baichechekei	Snowdrop	*Galanthus spp.*	Indicators of spring	
At Kulak	Common Sorrel	*Rumex acetosa spp.*		
Boznoch	Dragon Head	*Dracocephalum heterophyllum spp.*	Herbal tea	
Saasyk Dana	Onion	*Allium Amaryllidaceae spp.*	NA	
Chekendir	Ephedrales	*Ephedra regeliana* Florin.	Food	
Yshkyn	Rhubarb	*Rheum spp.*	Food	*I do not know the exact sub species?*
Sary Gul	Sweet Yellow	*Achillea spp.*	Used for stomach problem	*I do not know the exact sub species?*
Jorgomysh	Buckwheat	*Polygonaceae spp.*	Food	
Kymyzdyk	Knotgrass	*Polygonum coriarium* Grig.	Food	
Byydai bashy	Grass	*Poaceae spp.*	Fodder/ Seasonal marker	*I don't know which exact species?*
Kara Bash	Grass	*Poaceae spp.*	Fodder/ Seasonal marker	*I don't know which exact species?*
Zire	Carawey	*Carum carvi spp.*	Added in bread	
Ak Bash Godo	Needle Grass	*Stipa orientalis spp.*	Fodder / Seasonal marker	
Kumuru	Perennial plant	*Dracocephalum Stamineum* Kar & Kir.	Herbal Tea	

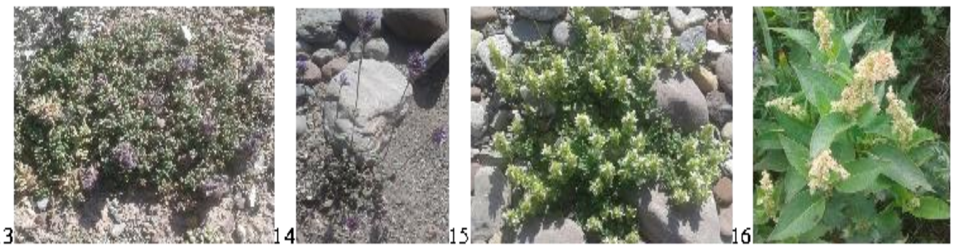
During the fieldwork in 2018, I collected local plant knowledge in Sary Mogul. I had to double-check the local names of plants and identity them, considering scientific names as well. I not only recorded the local names, but I also photographed the plants (Figure 3). In the process of revitalizing local knowledge, visual methods played a key role not only in identifying plants, but also for documentation. I provided the images of plants (Figure 3), and insects (Figure 5), known by the local community, as specific as possible. Wild onions were known and gathered by farmers, and several species of wild onions were present in the region. It is for this reason that I used a camera to photo document their knowledge (Figure 4). There are, for example, three types of onions. Also, people may use one word to generalize Dandelions, but there are many species of Dandelions.

Figure 3. Field note I: Plants in Sary Mogul, 2018

Plant Identification in the Sary Mogol Village 24.07.2018

10 11 12

10) *Ermen Chop* Mugworts *Artemisia macrocephala* Jacquem. ex Besser.
11) *Sary Gul* Sweet Yellow *Achillea spp.*
12) *Zire* Carawey *Carum carvi spp*.



13 14 15 16

13) *Mamyry* Dragon Head *Dracocephalum paulsenii* Briq.
14) *Kumuru* Perennial plant *Dracocephalum Stamineum* Kar & Kir.
15) *Boznoch* Dragon Head *Dracocephalum heterophyllum spp.*
16) *Kymyzdyk* Knotgrass *Polygonum coriarium* Grig.

13 14 15

17) *Chykyry* Rhubarb *Rheum reticulatum* Losinsk
18) *Chekendir* Ephedrales *Ephedra regeliana* Florin.
19) *Yshkyn* Rhubarb *Rheum spp.*

Figure 4. Field note II: Plants in Sary Mogul, 2018

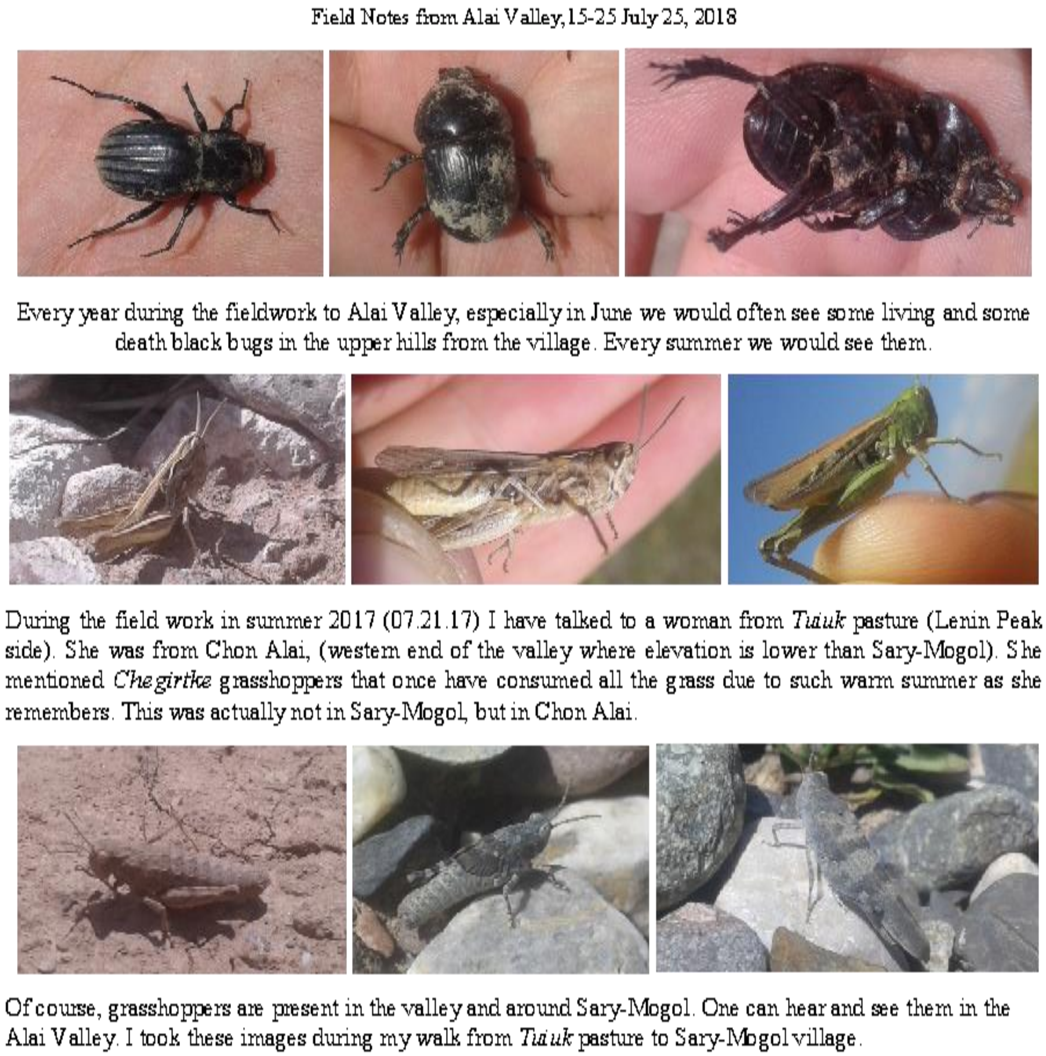


Figure 5. Field note III: Insects and amphibians in Sary Mogul, 2018

Local knowledge of insects and amphibians

In the study of ecological calendars, local people provided their knowledge of insects and amphibians. However, they did not provide us with specific details. I know very little about the status of insects in ecological calendars. Therefore, I have revisited my field notes and have visually documented the insects (Figure 5). The phenological responses of insects in the Alai Valley is limited in the findings my research. During the research process, we have learned that frogs vocalize in autumn. I was curious about frogs in summer 2018, but I only found a tadpole (juvenile) frog in the clear waters of Kyzyl Suu River. For example, during the fall, frogs vocalized. I have pointed out the frog vocalization and the insect periods both in the ecological calendars as well as in this document.

Theoretic Framework

While research on ecological calendars is context-dependent (Kassam et al., 2018), an in-depth social, cultural, ecological, and geopolitical understanding of each collaborative study area needs to be re-established. Existing scientific knowledge (mostly literature) from the Pamir Mountains of Central Asia makes it extremely difficult to provide a contextual understanding of the study area and local communities. The Pamir Mountains became a laboratory of various disciplines. Furthermore, the existing regional literature provided limited knowledge about local ecological knowledge, people and identities. This was partly because there is no such field as Pamir Studies. Therefore, the tribal history of the community, the effect of Tsarist Russian imperial policies, and the impacts of the Soviet Union on local ways of life needed to be contextualized in order to understand the history of transformation of traditional livelihoods (herding and farming cultures).

Historical, socio-cultural, geopolitical and, more importantly, the ecological challenges, and opportunities of the mountain communities in the Pamir Mountains of Central Asia were context-specific and complexly interconnected (Kassam, 2009a). In his research in the Pamir Mountains, Kassam not only pointed out the importance of human ecological research in the Pamir as an emerging science, but also provided other ways of thinking about the regional science in the broader context of global change. I adopted the notion of “Intellectual Pluralism” from Kassam and argued that it can be a useful theoretical framework for this chapter within the broader framework of diversity and inclusion. “Intellectual Pluralism” can be defined as human problems that cannot be solved based on homogenous disciplines, especially in developing countries where complex "wicked problems" such food sustainability, energy shortages, environmental problems, and socio-economical inequalities are being exacerbated by climate change (Kassam, 2015). Academically, it is becoming difficult to catch up with local socio-cultural, geopolitical, ecological, and economic transformations in the region because the environmental change was completely interlinked with geopolitical transformations. Therefore, building on some of the existing scientific knowledge in the region, as well as integrating local knowledge perspectives, Chapter 1 was dedicated to re-contextualize the study calling for "Intellectual Pluralism" in regional science.

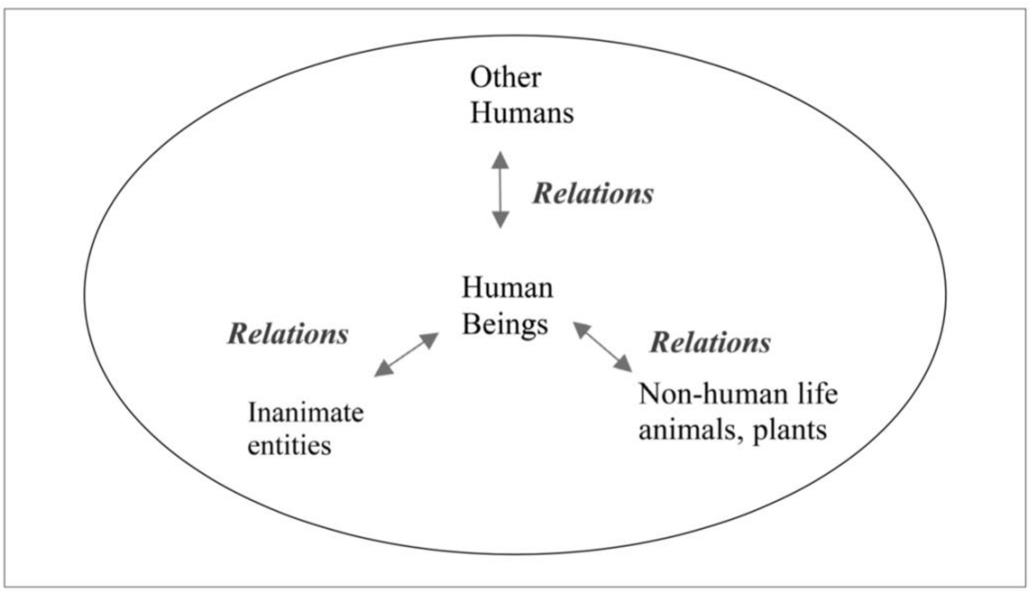


Figure 6. Concept of Human Ecology. Kassam (2009b, p.72).

Not all people in the Alai Valley live based on traditional livelihoods, herding livestock and growing crops. Like elsewhere in the world, historically people of Alai Valley contributed to climate change because they were part of Soviet Empire. Since Soviet times, natural resources extraction (e.g. oil and coal), in the Alai Valley has negatively impacted the environment (e.g., pasture and water), and even contributed to global climate change (Figure 6). The acceleration of climate change began with the industrial revolution and expansion of the industry since the Eighteenth Century (Sayre, 2012, p.58; Ogden et al., 2013, Malhi, 2017). Since the beginning of the Industrial Revolution, people have been drastically altering their ecological landscape on a global and local scale. According to scientists, “Furthermore, the concept of the Anthropocene involves the recognition that the Earth’s system includes human societies and that these humans are an integral component of the planet” (Kassam, 2015, p.133). The industrialization of the Soviet Union not only impacted local people, but also impacted the animal and plant life around the Alai Valley (Figure 7).

Figure 7. Oil Reserve near Sary Mogul, Alai Valley, Kyrgyzstan, 2018.

Because the Soviet Union was an industrialized empire, it exploited natural resources (e.g., gold, silver, and coal), some of which still continues in the Alai Valley of Kyrgyzstan (Figure 8). As a result of the impact of coal mining on the pastures, agropastoral tribes grazed their livestock far from the coal mine on the other side of the valley. Pasture grounds seasonally utilized for generations have long been threatened by extractive human activities like mining activities. Scholars have conceptualized these issues as “Wicked problems,” which collectively is used to understand climate change related issues. Kassam identified “Wicked problems” as “chronic poverty,” “environmental degradation,” “intolerance,” and “food and energy insecurity,” all of which were highly context dependent. In other words, due to changing socio-cultural, economic, ecological, and political situations, “wicked problems” were context-specific, continuous, complex, and challenging to solve (Kassam, 2015, p.133). When scholars refer to climate change, they include much more complex issues that surround us that are context-specific and complexly connected. Therefore, notions like environmental injustice were common in the Alai Valley within larger context of environment change in Central Asia.

Figure 8. Coal Mine “Osh Prim” near Sary Mogul Village, Kyrgyzstan, 2018.

Scholars further extended that, “Historically, these regions have experienced the effects of colonialism and have been at the frontiers of the Cold War. They continue to deal with imperial machinations in the form of outright war or the unsustainable exploitation of natural resources that threatens their ecosystems and their long-term survival.” (Kassam, 2015, p.135). Therefore, regional experts and scientists considered historical and geopolitical contingencies such as colonialism and imperialism as part of climate change struggles of mountain communities. In this way, scientists think of climate change beyond biophysical, socio-ecological impact on land and people. The state of natural resources in the Alai Valley, therefore, remains open for further research and alternative approaches.

In his important works in the Pamir Mountains, especially in addressing the emerging issues in the region, Kassam (2009a) has shown that the concept of pluralism fostered and contributed to the resilient abilities of the Pamir communities. This concept has particular use in this chapter, especially in showing the ecological context of the Sary Mogul community. For example, despite the history of colonization and forced settlement of many tribes in an enclave, the history of the village unfolded in a way that formed a plural community comprised of many tribes coming from different ecological contexts. Bringing different professions benefitted local resilience and adaptation. The Kyrgyz government re-settled several families to the Alai Valley from the little and big Pamirs of Afghanistan, which were above 4000 meters a.s.l. There was hope that people from the lowlands would teach them how to grow barley and potatoes. The winter in Alai was even longer than in the Pamir Mountains of Afghanistan. Kassam's work (2013) showed that under the conditions of ongoing social-ecological and geopolitical transformations in the region, the concept of pluralism benefitted the coping strategies of local communities in Afghanistan. If local people do not work together or share knowledge, they cannot survive. The case from the Pamir Mountains of Afghanistan was a testimony of how spiritual, religious, cultural, linguistic values of diversity of ethnicities like Kyrgyz and Wakhi, and Pashtu and Shigni in the Pamirs of Afghanistan were key in their adaptation and mutual survival under the conditions of climate change (Kassam, 2013). Therefore, the notion of "Intellectual Pluralism" informed the re-contextualization of the study area within the framework climate change adaptation.

Methodology

I conducted a literature review on the ecological calendars from Kyrgyzstan, focusing on the past literature from the Alai Valley. For example, colonial knowledge significantly shaped the indigenous knowledge of mountain communities during the Great Game, the nineteenth-century geopolitical struggle of imperial powers in Central Asia. The Game enabled many colonial expeditions, especially the British, American, Danish, Swedish, Russian, and early Soviet explorers. Colonial expeditions offered occasional documentation of community knowledge of ecology that was interlinked to traditional livelihoods (herding and planting), though these livelihoods were simultaneously disrupted, transformed and even lost as a result of colonial interventions.

Currently, there is a need to revitalize local knowledge systems in response to the increasing impact of climate change on traditional livelihoods (herding and planting). Revisiting colonial documents was one of the least preferred ways to revitalize community knowledge. However, they contained particular knowledge about herding and farming practices contributing to the study of ecological calendars from Kyrgyzstan. Reading diverse colonial sources on ecological calendars from contemporary Kyrgyzstan, I examined how local ecological expertise may be recovered from colonial records. Bringing together the past and present systems of climate-adaptive calendars, I explored the existing literature in order to revitalize community knowledge.

Multiple methods have been applied to provide a contextual understanding of ecological calendars from Kyrgyzstan. I first focused on ethnographic findings of pre-colonial, colonial, and post-colonial literature. For Soviet sources, I reviewed essential sections from Fedor Arturovich Fjelstrup (2002), who documented the presence of phenological calendars of many tribes from the Yssyk-Kul region, as well as Osh region. I reviewed some sentences from Bassilov (1986), where he wrote about the presence of timekeepers among agropastoral tribes of Central Asia. As for reference from outside of Kyrgyzstan, I considered the French anthropologist Remi Dor

(1993), who was well known for his study of Kyrgyz tribes in the Pamirs. Furthermore, I reviewed American ethnographer Eugene Schuyler's Book *Turkistan* (1877b). To describe the natural environment (flora and fauna) of the Alai Valley, I reviewed the existing literature on local biological diversity. I not only recorded the local names, but also visually documented them (Figure 3 to Figure5). I identified local knowledge of plants. The book *Les Plantes Medicinales du Pamir Oriental et leur utulisation en medicine populaire* (2011) by Raimberdi Abilazovich Mamatumarov[1] was a key reference to identify local knowledge of plants. In the study of ecological calendars, local people provided their knowledge of insects and amphibians, all of which are visually documented. However, they did not provide us with specific references. Therefore, I have revisited my field notes and have documented the visual representation of insects (Figure 5).

Because the ecological calendars from Alai Valley contained rich knowledge of birds, I needed to revitalize these birds in the local language. I needed knowledge in order to be able to monitor birds mentioned in the ecological calendar. Based on my fieldwork, I have corroborated local knowledge of birds with the book, *Birds of Central Asia* (Ayé, 2012). By categorizing the birds into resident, breeding, and migratory, I identified 19 resident, 18 breeding, and 8 migratory birds, all of which were known by the members of the community. I also used another field guide *Birds of Central Asia* (2019) by Ryabtsev to identify unknown birds. This book

[1] Les plantes medicinales du Pamir Oriental et leur utulisation en medicine populaire (Raimberdi Abilazovich Mamatumarov 2011). In addition, see "the Botanist" by Maude Plante-Husaruk and Maxime Lacoste-Lebuis (http://thebotanist.husaruk.com).

provided an excellent field guide to the study of birds from Central Asia in multiple languages such as Turkmen, Tajik, Uzbek, Kyrgyz, and Kazakh.

Results

A critical discussion of the notion Sary Mogul

A photograph taken in Alai Valley during winter 1928 represented an empty land (Sonntag, 2016, p.156) as if there was no human trace before the Soviet Union. It was a frontier-oriented representation of the local history in the Alai Valley. In other words, frontier-oriented representation of land emerged during the colonial times when empires represented empty land ignoring the existing human relationship with habitat. This was done to claim lands in order to further exploit the natural and other resources in the colonial period. Alternatively, the early human history in the Alai Valley can be traced back as far as the Paleolithic period. Farming and herding in the Alai Valley were extensively practiced at least from the Bronze Age throughout the Medieval period, which was before the establishment of the Silk Road trade history in the Eurasian continent (Taylor et al., 2018).

The term Sary Mogul actually refers to the name of the river in Alai Valley mentioned by A.N. Bernshtam, a well-known archeologist of Central Asia. With his team of archeologists, he conducted many excavations along the Kyzyl Suu (Red Water) River in Alai Valley between 1946 -1948. Bernshtam's team excavated a site called Archa-Bulak located right next to the Sary Mogul River, which was one of many archeological sites in the Alai Valley. Overall, their research found 75 ancient dwellings on the right side and 167 on the left side of the Alai Valley, some of which belonged to the period of Scythian (Saka) and the Wusun era (1000-100 B.C.) (Bernshtam, 1950; p.187-188). While their findings revealed that the ancient humans of the Alai Valley were both herders and farmers, other studies asserted that hunting and gathering were common in the region (Maanaev and Ploskikh, 1983, p.38-40). Thus, ecological calendars have been used for generations in Central Asia, “at least several hundred years” in Tajikistan (Kassam, 2011, p.152).

Only by recognizing this long history of Alai Valley and its people do I learn that the Sary Mogul region was one of the major pathways used in the Silk Road trade. The Great Silk Road connected many civilizations of the Eurasian Continent. The tribes of Alai Valley were not only herders or land users, but also participated in many other livelihood activities such as trade. They were vital to the Kyrgyz nomad and settled people in Central Asia. Of course, a dichotomy between mobile, nomadic pastoralists of Central Asia and settled people existed, but both could not have survived without each other (Khazanov, 1994). Therefore, the people of Alai Valley have extensively experimented with both practices (Huntington, 1907, p. 130; Karmysheva, 2009 p.60). The local tribes of the Alai Valley have actively participated in the Silk Road trade passing through the high Pamir-Alai Mountains of Central Asia (Kreutzmann, 2003, p.218-227; Kreutzmann, 2012, p.13). Sven Hedin (19th-century Swedish traveler) mentions a number of the high passes in Alai Mountains. Surprisingly, one of them was the 4,300 meters high pass Sary Mogul (Hedin, 1889, p.117; Watanabe et al., 2014, p.111). During the Silk Road history, native tribes of the region used these high passes (Shirasaka et al., 2014, p.85). Consequently, human activities were well established before the establishment of the Soviet Union, and the creation of so-called ‘socialists’ settlements.

With respect to studying local ecological calendars, another factor that widens our historical understanding of the people of Sary Mogul was to recognize their tribal diversity (Figure 9). Tribal diversity exists even today. The herders of Pamir Mountains were tribal nations (Taipov, 2002, p.20; Shahrani, 1979, p.151; Dor, 1993, p.9-14; Kreutzmann, 2012, p.112; Fihl, 2002, p. 199-200). Not all local tribes moved to Alai Valley during the 16th to 17th centuries. Some scholars suggest that the *Teit* tribe is local to the Alai Valley (Bliss, 2006, p.194-198). Others claim that the *Utuz Ugul* tribe was native to Alai Valley (Sykes and Sykes, 1920, p.241-264; Imanaliev and Mukumbaev, 1966). Each had their own historical records (Jumabaev, 2009, p.33). However, there was a collision of local tribes with Turco-Mongolic tribes (Khazanov, 1994, p.141; Cobbold, 1900, p.70; Bliss, 2006, p.54-58). Historically, the *Naiman* tribe, for example, traveled from eastern Mongolia and arrived in the Pamir-Alai Mountains around the 12th and 13th centuries (Juvayni, `Ala' al-Din `A.ta Malik, 1997, p.67). When Kuchluk, the leader of *Naiman* tribe, escaped from Mongolia through Kashqar to the Pamirs, local people who were present in Alai met him. Similarly, the *Kipchak* tribe was also present in the region, at least since the Middle Ages (Масальский, 1913; Valikhanov, 1835, p.70). These historical records of tribal diversity inform the long history of the traditional calendars.

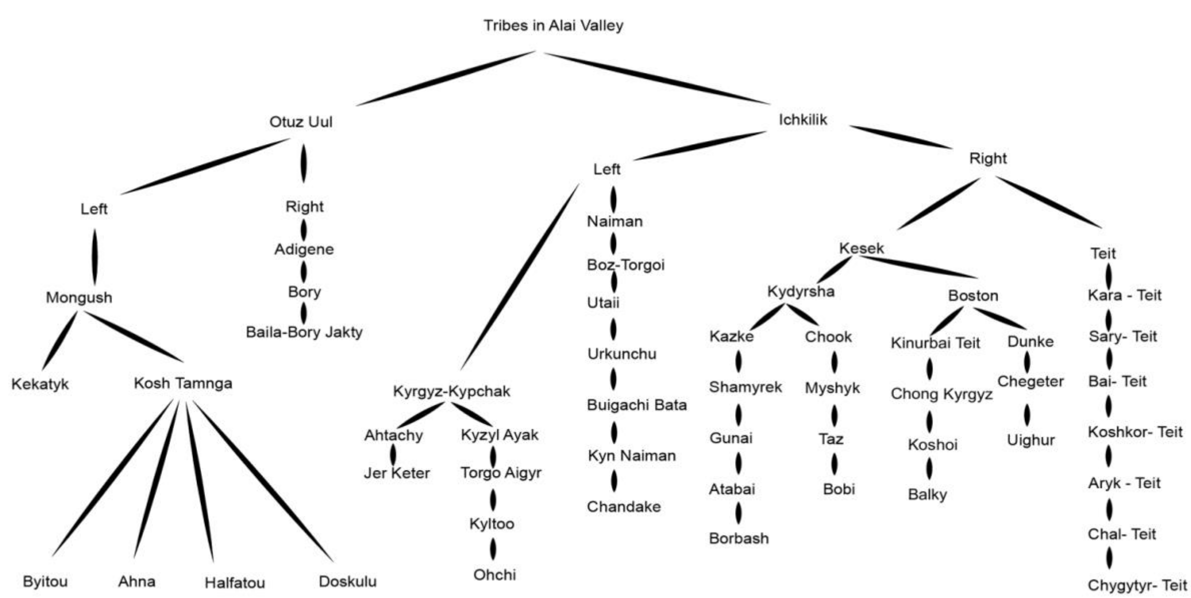
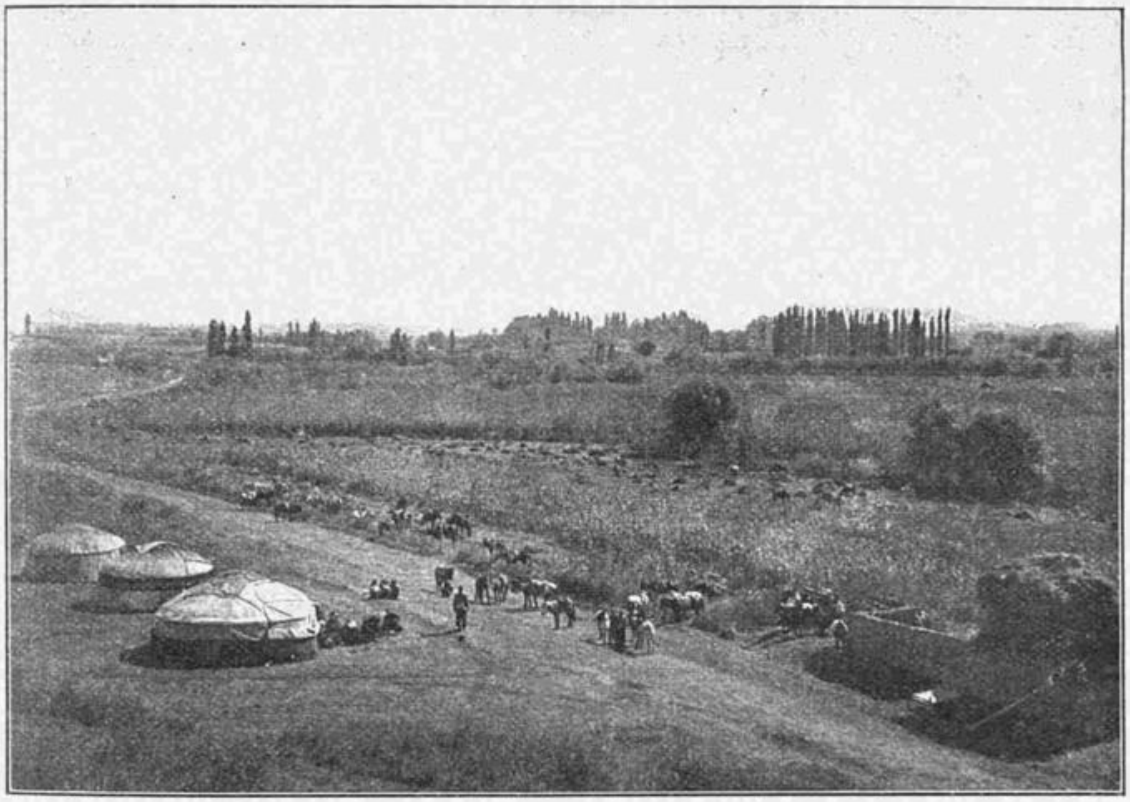


Figure 9. Tribal System of Kyrgyz in Alai Valley. (Karmysheva, 2009)

Colonization in Central Asia: Tribes of Pamir-Alai Mountains.

The nomadic local tribes have always utilized the pastures in the Alai valley, but changes started to occur with the Tsarist Russian conquest of Central Asia in the 19th century. Although there were no permanent settlements in the upper Alai Valley, in more recent years as pastoral tribes were living in yurts. Due to the long winter, cold temperature, and too much snow cover, the seasonal pastures in the upper Alai Valley were never used during winter and spring. According to George Littledale, a British traveler, the winter in Alai Valley continued 9 months (Littledale, 1891, p.9). Only during the summer, the Kyrgyz tribes grazed their animals in the upper Alai Valley (Valikhanov, 1904, p.81; Jumabaev, 2009, p.35; Jumabaev, 2012, p.128). In winter and spring, the herders moved and camped near the settled farmers near Fergana or Kashqar, ancient cities in the current Xinjian Province of China (Khazanov, 1994, p.176, Jumabaev, 2012; Fihl, 2002, p. 208). However, the lowlands in the Alai Valley were utilized during winter and spring, especially the Fergana Valley (Figure 10). Although the images below were captured precisely at the establishment of the Tsarist Russian regime, they revealed not only the significance of the seasonal mobility among the pastoralists of Alai Valley in the early 20th century, but also they emphasized the role of mobility in seasonal migration. People move around but they may have retained their local knowledge of places depending on their seasonal mobilities.



Зимнее стойбище киргизовъ въ Андижанскомъ у. Ферганской области среди культурнаго оазиса. *(Фот. С. А. Меликъ-Саркисова).*

Figure 10. Winter Pasturelands of Kyrgyz in Andijan, Fergana Valley.
(Photo by S.A. Melik-Sarkisova) in (Масальский, 1913, p25).

It is crucial to point out that there were permanent winter settlements in the highlands of the Alai Valley, especially in the western part. The Fergana Valley or Kashqar were not the only places where tribes spent the winter seasons. In the western valleys of Alai (lowlands), there was a fertile place called Jerge-Tal or Kara-Tegin (Imanaliev and Mukumbaev, 1966). It was situated inside the border of current Tajikistan, where I find settled Kyrgyz and Tajik people with a long history of farming practices co-evolved with settled farmers from the region (Figure 11). This was well documented by Ellsworth Huntington, an American geographer (Huntington, 1907, p. 130). Thus, the ecological information in the calendar could speak to these different regions.

AN "ARBA," OR SLEDGE FOR HAY IN A VILLAGE OF SEMI-NOMADIC KHIRGHIZ

Figure 11. Kyrgyz farmer in Karategin, the western lowlands of Alai Valley.
(Photo by Ellsworth Huntington) 1907, p.219.

The colonization of the Pamir-Alai Mountains by colonial powers such as Russia, China, and Great Britain in 19th - 20th centuries not only disrupted the life of the agropastoral tribes (Jumabaev, 2009; Bliss, 2006, p.213), but also it affected the local knowledge of farming and herding practices. Well-known experts of Pamir studies consider the 'Great Game' as the 19th - century geopolitical colonial struggle between the British, Russian, and Chinese in the Pamir Mountains of Central Asia (Middleton, 2008, p.295-513). After the Tsarist Russian occupation of the region, the tribes became restricted in their seasonal pasture use, and many issues related to grassing rights emerged (Bliss, 2006, p.195). In other words, Russian colonial policies towards land in the region had completely altered the traditional ways of life (Brower, 2012, p.126). The creation of new geographic units and administrative borders, provinces, and counties were against the traditional lineage-based or tribal ways of understanding the territories (Ismailbekova, 2012, p.30). The local people were forced to settle in newly re-created territories with harsh climate conditions in winter. While some tribes were able to escape these forced re-settlement places, other tribes resisted the colonial practices. During 1896-1899, the Danish explorers noticed this tension. The Danish explorers wanted to cross from the Pamir Mountains to Kashgar, but this was impossible due to the highly militarized situation between the Russian and Chinese borders in the Pamir-Alai Mountains (Fihl, 2002, p. 198-p.210). As British sportsmen, Ralf Cobbold documented, “At this period the Kirghiz were in a great state of excitement about the revolt in Ferghana. Nomads had fled from the Alai region into China-occupied territories, notwithstanding the fact that the Russian authorities had stationed Cossacks at every known pass to prevent all persons coming or going without a passport.” (Cobbold, 1900, p.213). That was when many local tribes of Alai Valley (listed above) had to leave their homeland, faced restrictions, and suffered to maintain farming and herding practices, all of which resulted in loss of local knowledge and ecological calendars in their everyday life.

Beyond this tragedy, the colonization of Alai Valley by Tsarist Russian Empire detached Kyrgyz tribes from their seasonal pasturelands used by tribal ancestors for generations, which destroyed their local knowledge systems. People of Alai Valley had to abandon their pasturelands used by seven ancestors. Today many farmers and herders still value the idea of knowing one’s *jeti-ata* seven ancestors (Ismailbekova, 2012). This concept was directly related to lineage-based tribal pasturelands known as *jurt* (ancestor’s land). The notion *jurt* referred to a particular place (often seasonal pasturelands) that has been used by certain tribes for generations. These concepts reflected tribal place-based knowledge. However, the lands used for generations by the local tribes were brutally disturbed by the Tsarist Russian colonial policies (Brower, 2012, p.128). Thus, many tribes were displaced from their *jurt* in colonial times. The severe implication of Tsarist Russian, British, and Chinese colonization of Central Asia was experienced among many other Kazakh, Mongols, and other people of Central Asia as well (Brower, 2012).

Historical Overview of Ecological Calendars

While contextualizing the history of the ecological calendars, the many tribes from Sary Mogul faced colonialism in Central Asia. This research also provided an opportunity to learn new insights about the presence of many, perhaps tribal-specific, phenological calendars in Kyrgyzstan (Фиельструп, 2002 p.210-217; Басилов, 1986; Schuyler, 1877). Because people of Altaic roots were shaped by the Persian - Arabic history and the language script, my research was limited to investigating Kyrgyz calendars through Persian-Arabic scripts. At the end of the 19th century and early 20th century, Belek Soltonoyev (1878-1937) documented his ethnographic knowledge about Kyrgyz ways of understanding calendars in Persian Arabic scripts. Belek Soltonoev[2] was a writer, ethnographer, historian, and local scholar from the Chon Kemin region of Kyrgyzstan. Near the collapse of the communist Soviet Union, his works were transcribed from Persian-Arabic into Russian Cyrillic (Kyrgyz) script, and was published in *Ala-Too Journal* by Karasartov Abdilda[3] and Jalkychy Japiev (Karasartov and Japiev, 1989). From their work, I learned that agropastoral tribes in Yssyk Kul and Chong Kemin regions of Kyrgyzstan had their own seasonal calendars.

[2] He was killed during the geopolitical transition from colonial Tsarist Russia to Imperial Soviet Union due to false accusation.

[3] Karasartov Abdilda was born in Xinjian and studied at Pedagogical institute in Urumchi, Xinjian (China). Later, he has returned to his historical homeland Kyrgyzstan and continued his contribution in preserving Uighur and Kyrgyz languages.

When revising the history of the Kyrgyz calendar, the Chinese Zodiac calendar was still commonly used among Kyrgyz of Alai Valley. Commonly, every twelve-years, the Kyrgyz people in the region celebrated *muchol* (the year in which people were born according to the Chinese Zodiac calendar). This was recorded by Eugene Schuyler in 1873, who was born in Ithaca, New York. As an American ethnographer, he traveled to Kurama in the Fergana Valley of Central Asia, and encountered the Kyrgyz when they were experimenting with mixed-farming. According to Schuyler (1877a),“The Kirghiz have no era by which to date their years, but use the twelve-year period which they call *Mutchal*, or *Milshel*, originally introduced from China by the Mongols…If a Kirghiz should be asked how old he is, he would seldom tell the number of years, but for example would simply say, ' My year is that of the Horse,' leaving you to guess how many twelve-year cycles back he was born, or if he wished to be more precise he would add, ' and I am in the third *Mutchal*,' which, supposing the question to be asked in 1875, would make him out to be thirty years of age” (p.333). In reviewing Kyrgyz calendars, the notion of *muchol* played little role among Kyrgyz of Alai and the Pamirs, as they always have a slightly different perception of the Chinese Zodiac calendar.

While the concept of *muchol* retains its social-cultural meaning today, the Kyrgyz tribes perceived animal characters embodied in the Chinese Zodiac calendar as cues. In the Chinese Zodiac calendar, each year was followed by individual animals such as hen, dog, horse, boar, mice, cow, tiger, rabbit, and others. In the Pamir-Alai Mountains, each animal was perceived as a sign for different caracter or nature of the year**.** In other words, local people historically attempted to make *jooruu* forecast about each animal year. In the book *The Music of Central Asia* (2016), Uljan Baibosynova asserts that “Only certain people are destined to become *jyraus*. *Jyrauly* – the art of being a *jyrau* – is an ancient tradition among many Turkic peoples that was associated with beliefs in animal spirit -patrons and ancestor spirit. The Kazakh *jyrau* was not just a performer of beautiful oral stories, but also someone who could foresee the future and foretell the outcome of events” (Levin et al., 2016, p.70). While the notion of *jooruu* is used among both Kyrgyz tribes as well as Kazakh tribes to interpret ecological events, this knowledge retained its application in the use of Kyrgyz ecological calendars. Hence, revisiting these local notions became crucial in communicating ecological calendars with local people and further implementation of their calendar.

Although this knowledge is disappearing in the Pamirs, the findings of the French anthropologists Remi Dor (1993), who studied the *Ichkilik* tribes of the Pamir of Afghanistan, documented the tribe’s ability to see sure signs and make sense of certain events. For example, if one encountered a wolf or rabbit, especially during travel, it was a good sign. By observing the behavior of a Bactrian camel, local people knew the arrival of rain (Dor, 1993, p.74-75). Moreover, in the second volume of his book *Turkistan* (1877b), Schuyler highlights that “Among the Kirghiz the magpie (*aka*) is a very ominous bird, and they carefully watch its comings and goings. If a Kirghiz hear one of these cry, he goes out to look. If the magpie be on the east, it means guests; if on the west, a journey: if on the north, bad luck; if on the south, some remarkable event. With regard to the crow, there are similar superstitions, and among others it is said that the *karga*, or ordinary crow, and the *kok-karga*, or green crow of the steppes, never met until the Tsarist Russian empire came. Before that the black crow flew away before the green one came; now both birds are seen together” (Schuyler, 1877, p.30). All of these findings, hence, revealed that the Kyrgyz had knowledge of ecological calendars and they were attentive to seasonal markers in their environment.

With the introduction of the Gregorian calendar in the 19th century, Kyrgyz people replaced their flexible ecological calendar with the names of the Russian calendar. What is wrong with the current calendars of Central Asia is that, in 19th century, ethnographers have attempted to measure and mark the phenological events with Gregorian time. Today, for instance, Kyrgyz people all over Kyrgyzstan use following month names such as *Kulja* (May), *Teke* (June), *Bash Oona* (July), *Ayak Oona* (August), *Toguzdun Aiy* (September), *Jetinin Aiy* (October), *Beshtin Aiy* (November), *Ychtyn Aiy* (December), *Birdin Aiy* (January), *Jalgan Kuran* (February), *Chyn Kuran* (March), *and Bugu* (April), all of which was recorded by Fedor Arturovich Fjelstrup (2002, p.210-211). These local concepts were flexible in Kyrgyz ecological calendars indicating biophysical variables, livelihoods activities, and ecological indicators. As a result of assimilated Russian calendar (fixing the ecological events with Gregorian dates), the Kyrgyz calendar has lost its regional and seasonal patterns. Nonetheless, it provided the translation of the historical ecological calendar of Kyrgyz people from this Russian source and contributes to my research. According to Fedor Arturovich Fjelstrup (2002):

Month names: Traditional Etymology, Clarifications, and Additions

The Kyrgyz

> *Jalgan Kuran* – (Fake Kuran) Incorrect, the mountains goats are not fully ready to mate
>
> *Chyn Kuran* (True Kuran) – Correct, the peak season of goats mating.
>
> *Toguzdun Aiy* (9th months) to *Birdin Aiy* (1st Months) carry the names of the dates in which Pleaides and Moon collides (19th September; 17th October; 15th November; 13th December; 11th January) – These days are very cold.
>
> *Bugu* (Red Elk) - The males are lagging behind females, who should soon be relieved of their burden.
>
> *Kulja* (Argali) – Mountain goat (female is *arkhar*)
>
> *Teke* (Ibex) – Goat with beard (female - *echki*)
>
> *Bash Oona* (beginning) – beginning of goat mating season (the lambing season of these animals)

Ayak Oona (end) – end of the goat mating season (the lambing season of these animals)

Kulja (Argali) - The peak season of goat mating (the lambing season of these animals)

Teke (Ibex) – The longest and hottest days, in which ice melts (the lambing season of these animals)

Chyn Kuran (True Kuran) – Horse milk becomes available

Tokol ai (Collision) – round months, when Pleiades collide

Kyrk Kyn Childe (Forty days of winter) – January through February 10th, the coldest days of the winter

The Etymology and month names for Semirechie (Issyk Kul Region of Kyrgyzstan)

January – *Mai belek* (Butter Gift) – when livestock are slaughtered for winter

February – *Kelsinnel* (let people come) – if you want, come. We have more meat, we will feed you.

March – Shurash (whispering) - no meat left to feed guests. Have to get advice from wife.

April- *Chi Tartma* (special grass rug used to dry cheese) - emergence of *airan* yogurt

May- *Sende bir, mende bir* (you have one and I have one) - everyone has milk and other products.

The names of the animals refer to the periods in which they give birth (p.211).

The language of the Ecological Calendars

Identities and languages of Central Asia were extremely complicated, complex, and challenging for the study of the ecological calendars. I learned, however, that the ecological calendars have their own language with context-specific ecological meanings, expressed differently through many local languages and intensities. The Kyrgyz tribes kept diaries about moderate weather in summer corresponding to the same weather events in winter such frost, rain, wind, and storm (Фиельструп, 2002, p.205). In the past, farmers and herders had *esepshi* – timekeepers who informed people of the right time to begin land use activities and move to pastures (Басилов, 1986, p.55). The word *esep*– comes from *hisob* means count in Persian language. The noun ending with - *shi,* - *chi,* and- *lar* in the case Turkic speaking people of

Central Asia, especially the Kyrgyz and Kazakh, refers to a person belonging to a particular profession. Hence, the '*hisobdon*' timekeepers were historically common in the region (Kassam, 2011, p.150). Surprisingly, timekeepers existed in the Sary Mogul Village, which I had not anticipated. Some farmers had diaries, whereas others kept old books produced in Uzbek language (written in Cyrillic scrips) containing knowledge related to calendars. I learned that local elders Alimov Kadyr Ali, Karimov Babanazar, and Koshonov Juma (head of the pasture committee) inform the community when to do certain livelihood activities based on their knowledge of ecology, as well as their ability to make sense of the changes in their environment.

When we think about the timekeepers and their role in realizing the ecological calendars, historically different communities had their own elders or wise timekeepers who informed communities when to make farming decisions. These skills were passed from one generation to another, mostly through the oral traditions and engaged relationship with the land. My research is limited to investigate the historical ecological calendar of the Altaic tribes through various scripts (Turkic, Persian, and Arabic). Time keeping remained as long as people had an ecological relationship with the land (herding and cropping), which is a sign of living knowledge of human and environmental interactions. It is now up to the young generation to continue the tradition of timekeeping in the framework of globalization.

Similar to the language of ecology such as growing seasons, precipitation, or climate, the villagers used local terminologies to understand their environment. For example, the Arabic word *tajriba* was used specifically to refer to the experience and practice of ecological calendars. For example, monitoring the time of hibernation and emergence of marmots, and to mark the arrival of spring, was a *tajriba* local practice. The word *tajriba* shared similar meaning with the word *jooruu* (mentioned earlier) because both terms engaged human's ability to make sense of environmental changes and events observed in ecological habitats. In other instances, villagers use other synonyms such as *Munazara* ancient practice, or *baikoo jurguzuu* careful observation were used in making sense of events from the ecological calendars. It was rather apparent that Kyrgyz ecological calendars contained such language to empower the human capability of comprehending the ecological changes.

Moving beyond the language of the ecological setting, the language diversity used in ecological calendars suggested the flexibility of adapting and practicing concepts. Villagers in the Alai Valley, for instance, adopted a Persian spring festivity called *Nav'ruz*. For instance, when the vernal equinox occurred on 21st of March, people in Sary Mogul celebrated *Nav'ruz*, a new year, and a sign of spring. This celebration goes back to the Zoroastrian faith. Today, this event is officially recognized and celebrated in countries like Kyrgyzstan, Tajikistan, and Kazakhstan as both New Year as well as the seasonal festival. While the date of *Nav'ruz* was fixed in contemporary times with the Gregorian calendar being on the 21st of March, historically this was not the case with people in Central Asia (especially among the Turco-Mongolic tribes). In the past, the time of *Nav'ruz* was flexible, especially among some of the agropastoral tribes of current Kyrgyzstan and Kazakhstan. Because the arrival of spring significantly differed across micro-climatic zones, different tribes celebrated at different times. In the past, the tribes migrated from winter pasturelands to spring pasturelands when *Navruz* arrived. Some tribes in Kazakhstan used to start plowing and planting crops, depending on the arrival of *Nooruz*. For instance, in the case of *Argyn Kara Kesek* tribe in the region of Kazakhstan, the arrival of *Navruz* was celebrated on the 15, 16, and 17 of March. Among the *Nugai* tribes of Kazakhstan, the arrival of *Navruz* was recorded between 18 March to 18 April (Фиельструп, 2002, p.203-227; Басилов, 1986, p.55). The arrival of spring in Sary Mogul also begins in April, similar to that of *Nugai* tribes, which means the *Navruz* can be celebrated later depending on when spring begins. While the knowledge of ecological calendars could well be tribal-specific in Central Asia, it can also be flexible.

Although the tribes in Sary Mogul speak Kyrgyz (Altaic language family), they have adopted specific Persian *concepts* relating to seasonality, but the meaning of these adapted concepts was not outside of a specific ecological context. For example, farmers in Sary Mogul use the term *baar* to mean spring (April to May). Although there is a Kyrgyz word for spring (*jaz)*, the term *bahor* or *baar* from Persian language is often used. The coldest period of the season or winter is known as *childe* in Sary Mogul (November to April). This term comes from the Persian language and it means forty. This word is used from Caucasus mountain through the Tien-Shan mountains, but it reflected context-specific ecological meanings (Фиельструп, 2002, p.203-227). Although Persian influence among Kyrgyz exists (Valikhanov, 1904, p.23; Shahrani, 1979, p.157), the direct meaning of adopted concepts often contradicted the ecological context. The conceptual meanings of the words used in Kyrgyz calendars differed from how they were defined and applied in the context of ecological calendars. Therefore, any tribe from the Caucuses to Central Asia may use similar Arabic or Persian terms in their ecological calendar, but their meanings could vary depending on the social-cultural and ecological contexts.

The forces of the ecological language function as a working language behind the human language used in Central Asia. It allowed me to better comprehend the language diversities that existed in the Alai Valley and how they were flexibly linked to ecological calendars based on context. The farmers in Alai integrated some of the Arabic words into their daily life, but each word had a context-specific meaning. While the Arabic language has a long history in the region, since the 7th - 8th century (Масальский, 1913, Middleton, 2008, p.281), words such as *saratan*, *amal*, and *tajriba* were often used in daily conversations. The word *Saratan* from Arabic refers to Cancer, the name of the Zodiac signs in Arabic (Schuyler, 1877a, p.329). In the context of the Alai Valley, *Saratan* means a summer season (June - August), and was also affiliated with breeding birds. The summer in Alai begins when breeding birds (listed in the second chapter) were nesting as mentioned above. Similarly, a land-use period was locally called *amal aiy* (a month of plowing and planting) in Sary Mogul (April-May). In Arabic, the word *hamal* means Aries, the name of the Zodiac sign (Schuyler, 1877a, p. 329), all of which reveal context-specificity of the language itself to the ecological calendars. Briefly Central Asians, especially Kazakh and Kyrgyz, had applied the terms like *saratan*, *amal*, and *childe* in their ecological calendars, but they all reflected contextual meanings related to the ecological calendar and natural forces. Therefore, while the language of the ecological calendar was diverse, it retained its ecologically-grounded meanings.

The Cosmology of Ecological Calendars

To develop an analytical interpretation of the cosmologies (movements of celestial bodies) embodied within the traditional calendars was both a challenge and an opportunity. What makes our ethnographic findings on the presence of celestial bodies difficult was testing the co-occurrence of celestial events with terrestrial events. The ecological calendars involved cosmologies, which meant they were universal. However, any cosmological data revealed a subject or event associated with terrestrial event. Therefore, any cosmology may be artistically included as part of the local calendars (Makuritofe and Castro, 2008; Londono et al., 2016). In the study of the ecological calendars from the Western Pamirs of Tajikistan, the Kassam also acknowledged that celestial bodies were part of the community knowledge system (Kassam et al., 2011b, p.161). Similarly, the Kyrgyz tribes had a sophisticated celestial knowledge of heavenly events (Valikhanov, 1904, p.19). Some scholars suggested that the sun, moon, and stars were associated with a pre-Islamic cult of nomadic people from Central Asia (Fihl, 2002, p. 167). In short, I acknowledge the celestial aspect of ecological calendars, which are terrestrial.

The moon played a central role in the cosmology of people in Central Asia, especially among Kyrgyz people. While I did not directly assess Kyrgyz cosmology, I was interested in where cosmology was linked to ecological calendars. When listening to people, celestial bodies in the Kyrgyz traditional calendar were associated with earthly events and activities, which helped to construct an ecological calendar. According to Schuyler (1877), "…Three calendars are in habitual use – the ordinary Musulman religious calendar, with its lunar year; an agricultural solar year; and the Kirghiz calendar; and there has now been added a fourth, the Julian in the Russian form with a new series of festivals" (p.329). While it was not easy to separate celestial knowledge from ecological calendars, according to Schuyler (1877):

> …The Kirghiz year, like that of the settle inhabitants, begins with the feast of Nauruz at the vernal equinox, and is divided into twelve solar months, which are known by the zodiacal names I have just mentioned. A solar month is called *Yulduz,*or constellation, while a lunar month is called Ai, new moon, and *Iski-ai*, old moon. The winter months are frequently called after a complicated system very difficult to apply. The first month of winter is that when on the eleventh day of the month the moon is equal with Pleiades, *Ur-kar*, and is therefore called *On-bir-tugush*, that is, the eleventh conjunction. The second month of winter, when the moon and the Pleiades are together on the ninth day, is called *Tokuz-togush* (ninth conjunction); in the third month, *Yedi-togush*, they are together on the seventh day; in the fourth month, *Bish-*

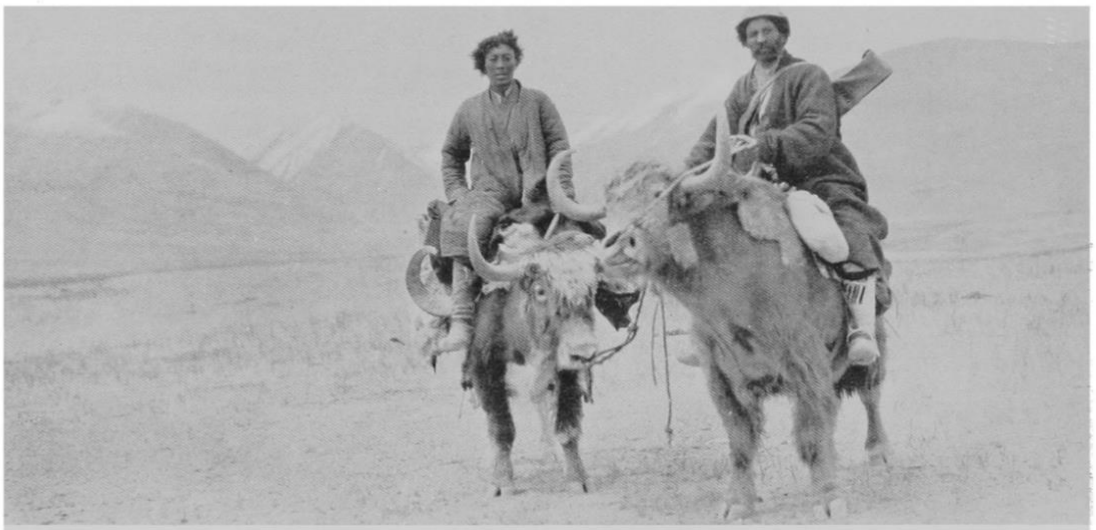
> *togush*, they are together on the fifth day; *Uch-togush*, on the third day, and in the sixth month, *Bir-togush*, on the first day. Besides these simple folk, instead of months, give names to certain times of the year, chiefly according to various events of steppe life, as the lambing season; the mare-milking season; May, the rainy times, which last for about a fortnight about the end of May and the beginning of June; *Tchilde*, the subsequent forty days (of heat); the sheep shearing season; and the slaughtering season (p. 334).

Schuyler's report from the Fergana Valley of Kyrgyzstan recorded in 1873 was quite similar to my ethnographic findings. Schuyler's reports do not ignore the co-existence of celestial events with terrestrial events. What was important in his findings (other than Moon, Pleiades or weather events) was the idea that cosmological evens were linked to terrestrial (place-based) events rather than an abstract entity. The presence of lambing season, milking season, rainy season, and heat seasons, all of these findings showed how celestial knowledge was not separated from the context-specific earthly social-ecological events. The local cosmology allowed us to navigate ecological events (earthly organism and activities) through cosmological events.

Moreover, Schuyler's report also shed light on our perception of change in the study of ecological calendars. Russian ethnographic sources also provided a similar, valuable, and historical example of ecological calendars having cosmologies. In 1924 -1925, a Russian ethnographer, Fedor Arturovich Fjelstrup, visited Central Asia and collected various ethnographic reports among many tribes, beginning from Crimea to the plains of Kazakhstan and mountains of Tian-Shan, Kyrgyzstan. According to him, the notion of *tokol* was mentioned as *togush*, *tokolai* or *tokis* (in other instances). As Fjelstrup himself put it (2002) "…when the Pleiades approaches the moon and distances, it is referred to *tokis*" (p.215). From his findings, I learned that the collisions of the Pleiades with the Moon served as a flexible time marker for certain seasons, livelihood activities, and ecological indicators (Ibid). In the past, Kyrgyz herders and farmers may have relied on the movement of stars or moon phases to mark their seasons and guide livelihood activities. That is how people created their earthly cycles. In the Alai Valley, I learned that local people relied on a lunar calendar, which was widely used by many people in Central Asia, but the lunar calendar was not fixed. Since the heavenly events were not stable, like the different phases of the moon and the motion of the stars, repetitive weather events were also not stable and in constant change. Considering that heavenly events, as well as weather events, as dynamic processes of change allowed me to learn how repetitive events during the seasons had to be understood as dynamic, flexible, and relational.

Hunting, Trapping, Foraging along the Silk Road of Pamir-Alai

Although the history of colonization was terrifying, many missionaries, travelers, and scientists, made contributions in documenting local people's lives and their relationship with their ecological habitat. In other words, cartographers, botanists, zoologists, ethnographers and sportsman, while supporting and being supported by colonizing powers, have also helped to advance science in the region (Middleton, 2012, p.299- 331). During the colonial times (1870-1920), there were a number of expeditions to the Pamir-Alai Mountain from Russia, Denmark, Britain, Sweden, and the United States of America. Every expedition to Pamir-Alai region was supported by local fieldwork assistants. The foreigners hired caravans and local tribes to guide them through Pamir-Alai Mountains (Littledale, 1892, p.6; Fihl, 2002, p.199-200; Cobbold, 1900, p.87). The guests were guided along the Silk Road cities such as Kashqar, Yarkand, Osh, and Tashkent through the Alai Valley. These cities were the main markets for hunters, trappers, and foragers of the region. During their travels, the wildlife explorers had documented local peoples' interaction with nature in respect to hunting, foraging, trapping and trading, all of which provided a foundation of knowledge related to ecological calendars as well.



BRINGING IN AN *OVIS POLI.*
(Nadir with rifle.)

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Figure 12. Kyrgyz Hunters, 1915 (Skyes and Sykes, 1920; p.331.334).

The key ecological indicators that I documented from the Alai Valley have historical roots, and were developed through engaging in activities like hunting (Figure 12), trapping, and trading. The people of the Pamir Alai Mountains have a rich knowledge of hunting, trapping, and foraging, which reflected their human-ecological relationships. The local tribes hunted Marco Polo Sheep (*Ovis ammon poli*), and Ibex (*Capra sibirica*) (Bliss, 2006, p.34). Mountain goats and sheep have always provided an alternative meat source, and people have hunted them. Therefore, the tribes of the region have developed a rich knowledge about *Ovis ammon poli* and *Capra sibirica* (Jumabaev, 2009, p. 59; Shahrani, 1979). People of the region hunted with matchlock rifles and special bows made in India (Bliss, 2006, p.174). The Pamiri people were also great falconers, as illustrated by British travelers (Cobbold, 1900, p.13). Similar to Kyrgyz tribes, and Kunjut people in northern Pakistan also used trained dogs in hunting (Littledale, 1891, p.28). Various local people in the Pamirs walked on snowshoes in winter while hunting (Olufsen, 1904, p.126-127). The Kirghiz and Wakhi made shoes, leather boots, and coats out of animal skins, especially from *Ovis ammon poli*. According to Danish officer Oli Olufsen, "Man's robe, consisting of a linen shirt, wide silk embroidered trousers of yellow skin, high-roped leather boots, and an overcoat made from large wild sheep, *Ovis poli*, which lives in the mountains of Pamir. The head is covered with a multi-colored velvet cap, lined with fur. Costumes of this kind are worn in winter" (Fihl, 2002, p. 178). These products were available in the *bazar* – markets (Ibid). Similarly, British explorers documented the relationship between hunting, foraging, and markets in 1915. According to Sykes and Sykes (1920, p.143), "Just below the fort there was a squalid little village of mud and stone shanties inhabited by Kirghiz, and here were collected bundles of wild sheep horns ready to be sent to Tashkent, where they are used to decorate native saddles or to make knife-less than three shillings-for the horns and skin." Thus, historical records of collaborative hunting wild animals and foraging activities must be acknowledged as part of seasonal calendars.

The knowledge, documented in the ecological calendars, speaks to the historically established hunting, foraging, and trapping cultures. Many explorers hunted around the Alai Mountains during colonial times. On his way from Naryn region (Kyrgyzstan) to the Pamir Mountains, Ralf Cobbold, a British traveler hunted with local tribes. As he notes, "I halted a day near the Kokui Bel Pass which leads to the Alai Valley and had some shooting and succeeded in getting some photographs of live *Ovis poli*" (Cobbold, 1900, p.152). Many local hunters released specially trained hunting dogs to capture the animals (Littledale, 1891, p.10: Skyes and Sykes, 1920; p.331.334). After a successful hunt, the hunter would take the head and the chest for himself and shared the rest of game. The hunters in the Pamirs have a significant social status. Community members would expect *shyralga* – a share of the meat. In other words, a hunter's ethic provided communities with an additional meat source. A Danish expedition to the Pamirs had noticed and reported on this food-sharing culture (Fihl, 2002, p. 204).

The stories of European and North American sportsmen in the Alai Valley revealed more than hunting or food sharing. The knowledge of ecological indicators developed through hunting, were sometimes reported by the sportsman. Ella and Percy Sykes, British travelers, noticed a very interesting conversation about Golden or long-tailed Marmot (*Marmota caudata)*. According to Sykes and Sykes (1920, p.144), "They hibernate during the long winter, and the Kirghiz affirm that when they emerge from their seclusion, they have no hair on their bodies." In summary, foreign travelers during the colonial times documented human relations with ecological habitats along the Silk Road of Pamir-Alai Mountains, all of which contributed to the historical knowledge of ecological calendars.

The tribes of Alai valley during the Soviet Union (1916-1990)

Human displacement, especially during early establishment of the Soviet power in the Alai Valley, impacted the socio-cultural and economic lives of the local tribes (Taipov, 2002; Kreutzmann, 2003, p.223; Kreutzmann, 2009, p.105; Sonntag, 2016, p.156). In the years around 1916, many Central Asian local tribes fought against Tsarist Russian colonial suppression and the early Soviet establishment in the Alai Valley. According to Taipov (2002), the anti- Soviet resistant movements in the Alai Valley were known as *Eldik Musulman Armia*, the People's Muslim Army. The tribes declared war against the Soviet establishment. Unfortunately, the local resistance movement was not successful, and the Soviet Army exterminated many tribes (Taipov, 2002, p. 47). However, the local resistance against Tsarist Russian colonization in Central Asia was more complex and complicated, especially during the transition period from Russian colonial administration to Soviet administration. During this time, many people holding traditional knowledge were lost.

As the Soviet administration was established, the local tribes were influenced to give up their traditional ways of life though nomadic life was not easy. They were assimilated into the Soviet planned economy. This further influenced their traditional knowledge systems. From 1932-1945, the Soviet administration began to re-organize its economy and integrate the herders into the Soviet economic system (Taipov, 2002; Kreutzmann, 2002, p.77). The Soviets militarized the region, borders were created, and many military outposts were built across the Pamir-Alai Mountains (Kraudzun, 2012b; Kraudzun, 2017). During this process, herders whose seasonal pastures were in, or close to the Soviet and Chinese border, were forced to move inside the Soviet border. The Soviets confiscated herders' livestock, and created so-called *Kolkhoz,* collective Soviet farms (Kraudzun, 2012b, p.175; Kraudzun, 2012a, p. 93). By 1939, 130 collective farms were created throughout the eastern Pamir-Alai Mountains. From 1930 onwards, the Soviets began settling the pastoralists in villages, and employed them to work on farms (Taipov, 2002). Many of the elderly woman in Sary Mogul have told me that during the Soviet times, they worked as a *sakhmanchy* – milking livestock on the Soviet farms.

Facing the brutality of Soviet polices in the times of Joseph Stalin, the tribes of the Alai Valley scattered into the Pamir Mountains, while many were captured and sent to Gulag camps in Siberia. The confiscation of private property and settling of tribes created conflicts between locals and communist authorities. During this period, many herders fled from the Alai Valley and escaped to the Chinese side of the border, while others moved to Afghanistan (Taipov, 2002, p.64). However, escape was often not successful. The Red Army of the Soviet Union caught people and sent them to Gulags. During the period of Stalin's repression, many people who served in the local Soviet administration were directed to jail without any legitimate reason. Thus, people of the region had faced far-reaching processes of collectivization, forced settlement, and Stalin's repression before the period of World War II (Taipov, 2002). In sum, these social-ecological transformations significantly disrupted the local knowledge systems.

The Settlement of Soviet Sary Mogul: A Return of Tribes to the Alai Valley

The creation of the Soviet farms, especially in the Pamirs of Tajik SSR, was not successful because of fodder shortages in the easternmost Pamir Mountains. The eastern territories lacked fodder needed to sustain a high number of state-owned cattle. During 1941-1945, the number of cattle had dramatically increased in the Soviet Pamirs (Taipov, 2002). There were 2895 yaks, 12767 sheep and goat, 134 horse, and 73 donkeys registered in the farms of Eastern Pamirs of GBAO. To address this fodder crisis in 1939, the Pamir Biological Institute was established in Chechekti (3860 m.a.s.l.). One of the main tasks of the research institute under the leadership of Soviet biologists P.A. Baranov and A.I. Raikova, was to address the fodder crisis in the region. The Soviet scholars at the institute conducted many experiments. As part of this research, barley fields were created in many valleys of eastern Pamir such as Madian, Bun-Kul, Chechekti, and Pshart. However, this was not sufficient due to the challenges of growing fodder at high elevations in semi-arid ecological zones. Food crisis was a struggle even during the Soviet era. Therefore, there was not enough fodder to support the Soviet collective farms in the Pamirs (Taipov, 2002).

As a solution, the Soviet administration created a fodder reserve (enclave) within the Alai Valley in 1945. The settlement of Soviet Sary Mogul was considered as a return of tribes to the Alai Valley. On July 9, 1946, the Council of Ministers of the Soviet Union issued pastureland reform policy Number 1509. This policy reorganized the pastureland of the USSR and the collective farms of Uzbek, Kazakh, Kyrgyz, and Tajik Soviet Socialists Republics (SSR). Under this policy, the area of Sary Mogul area in Kyrgyz SSR was given to Tajik SSR for long-term rent. About 61583 hectares of land from the Alai Valley was given to Murghab, Shugnan, and Ishkashim regions (*rayon*) of Tajik SSR. Out of the total territory, 3932 hectares were for fodder production, 33228 hectares for pasture use, 4 hectares for house building, and the rest (24374 hectares) had no assigned use. From different parts of the Pamir Mountains, tribes were forced to re-settle to Sary Mogul (Taipov, 2012, p.78; Sonntag, 2016, p.257; Kurmushiev, 2016, p. 38). Although settlement of Soviet Sary Mogul was a systemic and structured Soviet project, the Alai Valley was not new to these local tribes.

It is commonly believed that Sary Mogul was a community of people from Tajikistan, who have recently re-settled in the Alai Valley, which made little sense in a broader discussion of understanding of Soviet history in the region. The Alai Valley had been pastureland for several tribes (Dor, 1993, p.9; Maanaev and Ploskikh, 1983, p.60), long before the colonization of the region by the Tsarist Russian Empire. As I demonstrated earlier, the tribes of Alai Valley were displaced as a result of colonization by Tsarist Russian Empire and the Soviet Union. The tribes fled from Alai to the Pamir Mountains with their livestock when the Tsarist Russian Empire arrived. For example, my interviews suggested that people in the village were aware of their homeland, especially place names and seasonal pastures (*Jetim Jukur, Daroot Korgon, Shive, Kok Suu, Kichi Alai, Chon Alai, Kulchu, Kara Kabak,* and *Ukos,* and *Chyk.*) The local knowledge of pasture names (*Tuiuk*, *Boke*, *Kyzyl Agyn*, *Achyk Tash*, *Taldy Suu*, *Kara Bulak,* and *Kosh Korgon*) was well preserved in local peoples' minds (Watanabe et al, 2014). In short, the anti-colonial resistant movements, anti-Soviet movements, the militarization in the region, the collectivization of livestock, and Stalin's Repression, have all significantly impacted local people's mobility and place-based knowledge. In short, the process of settlement in Sary Mogul was a return of tribes to their home, rather the arrival of new peoples.

After the resettlement process, people were forced to intensify harvesting barley, Common Sainfoin (*Onobrychis*), and potatoes in addition to fodder grasses (*Leymus secalinus, Aceae and Atipa orientalis*). I think that this provided an opportunity to experiment with crop production in a climatically sensitive place like Sary Mogul. The initial years of resettlement were not easy due to heavy snow in winter (Figure 13). With the Soviet settlement of tribes in particular areas, the tribes had to winter with yurts along the Sary Mogul River. During winter, the upper Alai Valley received heavy snowfall (see Hedin, 1889, p.40).

CAMELS TRAMPLING A PATH THROUGH THE SNOW

Figure 13. Snow Cover in Alai Valley in 1889, adopted from Swen Hadin, 1889, p. 138.

A few years after the re-settlement, some mud-brick houses had been built. As I mentioned earlier, the area was previously tribal summer pasture only, and no one wintered there. Due to deep snow in winter, high elevation, and short summers, farming activities were not common until the establishment of the Soviet fodder base. The Sary Mogul was established as *kormavaya baza*, a fodder base that supported farms in the Pamirs of Tajik SSR (Kurmushiev, 2016, p. 10). During Soviet times, about 50 tons of fodder were transported from Sary Mogul to the farms in Pamir Mountain of Tajikistan in order to support 450 yaks during the entire year (Kreutzmann, 2003, p. 224). Despite the brutal impact of the Soviet resettlement policies on local peoples, which separated local people from their lands, the settlement of diverse tribes in Sary Mogul during 1946 was an opportunity to continue experimenting with crop production utilizing local knowledge.

For many tribes, the Alai Valley was not an unfamiliar place. The return of tribes to the Alai Valley marked the further development of their local knowledge of livestock herding and crop management. Since the establishment of Sary Mogul, the population has grown (Sonntag 2016), suggesting the accumulation of tribes. According to some studies, “Gradually the village grew as ethnic Kyrgyz from Jergetal and Murghab in Tajikistan and other nearby Kyrgyz villages moved to Sary Mogul” (Ibraeva et al., 2016, p.8). During the past 20 years, Sary Mogul turned into the second largest community in the Alai Valley. In 2002, 541 household or 2975 people were recorded (Taipov, 2002, p.20). In 2016, the number of inhabitants reached 4600 people (Sonntag, 2016, p.160). In January 2018, the total population of the village reached 5165 people (Ayil Okumotu, Sary Mogul, 2018). The Jergetal was one of the places where Kyrgyz tribes developed an understanding of land-use activities by living together with the Tajik farmers, who had a rich knowledge of farming. Consequently, there was a concentration of diverse human knowledge as the community grew throughout the Soviet period.

During his travels to the Pamir Mountains and Fergana Valley in 1916, Nikolai Vavilov, a famous Russian food scientist, was stunned by the great variation of crops in the region, especially different species of early-ripening barley and wheat. He recorded about 800 varieties of one particular soft wheat (Ревенкова, 1962, p. 31-57). In the past, the people of Chon Alai Valley, especially the Kara Tegin area (less than 100 km from Sary Mogul) planted two types of barley *Yalanach* or *Kok Arpa*, both local names referred to naked-grain barley with green color. The second type of barley recorded was *Yngyk Arpa* or *Saman Arpa*, both terms referred to fodder barley with abundant stems (Karmysheva, 2009 p.60). This suggested that farming was not new for Kyrgyz tribes of the region, and contradicted the stereotypical imagination of Kyrgyz people as a nomadic culture in Central Asia. In summer 2018-19, my research collaborators doubled-checked the local varieties of barley in the village. This field study showed that *kok – arpa* (blue-barley). There was also a second types of "round" barley with an abundance of stems called *Sartyei* (Figure 14). I do not know if this term refers to *Yngyk Arpa* or *Saman Arpa* (Karmysheva, 2009. p.60).

Figure 14. Round Barley. Image by Isabell Haag 2017

Standardization and Institutionalization of Time

One crucial impact of the Soviet Union was the standardization or institutionalization of time, which profoundly changed the local perception of time. Under the command economy, the Soviet bureaucratic system and administrative machine brutally controlled time for the sake of achieving its production goals. In the context of Alai Valley, people were well aware of specific dates, such as March 8 (International Women's Day), May 1 (Solidarity Day), May 9 (World War Victory Day), May 24 (the last day of the school), September 1 (the first of the school), and October 25 and early November (October Revolution in 1917) that were deeply-rooted in the minds of local people. These dates allowed people to learn the timing of certain livelihood activities in the past, and how have they changed in contemporary times. The Soviet farms commanded when it was time for sheep breeding and lambing, or when to plant barley or fodder crops, and when to harvest. However, these times have currently changed following the collapse of the ideologically of the Soviet Empire. In that sense, people are now in search of new meaning for time in an age of uncertainty.

Although Soviet science had advanced heavy machinery and technology for agricultural production, they did not rely on the local perception of time, despite the fact that the Soviets had ethnographic data about phenological calendars. The pasture committee today has continued its decision-making role. I think that the development of an ecological calendar will fill gaps in knowledge loss and benefit the pasture committee. What is interesting was that the pasture committee made its decision based on seasonal cues, but they have not preserved or documented this knowledge on paper.

The Sary Mogul community, like many communities in the Pamirs, benefitted from the privileges that the Soviet Union offered, while returning to their local ways of life. Since the Pamirs-Alai Mountains were border zones of the USSR with Afghanistan and China, Moscow provided special attention and special provisioning (Kraudzun, 2012a, p.95; Mostowlansky, 2017). During Soviet times, potatoes were rarely planted, but rather were provisioned in shops. Even milk was supplied through shops, rather than consumed directly from livestock. Soviet modernity also provided public schools, health care centers, veterinary clinics, and cultural centers (Kurmushiev, 2016). The Soviet Union's effort to liberate women was a good project. While some people in the region may feel comfortable or even proud of their Soviet history, the end of the Soviet Union threatened the Sary Mogul community. Due to heavy reliance on state programs rather than self-sufficiency, villagers faced another phase of social-ecological crisis and difficult transformations.

The end of Soviet Union: A Curse and/or Blessing

The collapse of the Soviet Union and sudden instability in Tajikistan affected not only the social, economic, and environmental well-being of the Sary Mogul community, but also delayed the official administrative return of the enclave from Tajikistan to Kyrgyzstan (1990-2003). The end of the Soviet Union resulted in the creation of independent states in 1991. During this period, what happened in Tajikistan affected the community in the Alia Valley as well (Ibraeva et al., 2016, p.9). With the collapse of the Soviet Union, there was a Civil War (1992-1997) in Tajikistan, which caused severe poverty, energy crisis, and migration into the Pamirs of Tajikistan (Bliss, 2006, p.271-343). The post-Soviet trauma was a period of survival instead of fighting for land with oppressors.

A lack of food was one of the main challenges in the region. In April 1992, some representatives of Tajikistan, Uzbekistan, and Kyrgyzstan gathered in Osh City in Kyrgyzstan and attempted to reorganize land use, farming, and herding practices in the Alai Valley. The objective of the meeting was to address the food crisis in the region. However, this attempt was not successful due to a shortage of capital (salaries) to cover cost of crop production for the farmers of Alai Valley. However, the representatives developed an alternative solution. The mountain communities in Pamir-Alai transported their livestock to Osh City and exchanged it for wheat (Taipov,2002; p.116-122). This is how people in Pamir-Alai survived these difficult periods. The end of Soviet Union today is considered to be positive, for some farmers. The privatization of state farms benefited local communities. People were able to decide when to breed livestock, when to secure lambing, and they became flexible in their market decisions as well.

During the famine in the Pamir Mountains of Tajikistan, all people in the region received international humanitarian aid, including Sary Mogul Village as well. The famine was mitigated by international and development organizations such as the United States Agency for International Development (USAID), World Food Program (WFP) with the support of Aga Khan Development Network (AKDN) (Bliss, 2006, p.298). The Sary Mogul community also received humanitarian aid before the transition to Kyrgyzstan in 2004. From 1997 onwards, Aga Khan Development Network (AKDN) initiated a development program in the region called Mountain Societies Development Support Program (MSDSP). This program supported and encouraged the local communities to achieve self-sufficiency, especially with respect to food. Within the framework of the development program, the community received crop seeds. According to local newspaper archives, 4 hectares of potatoes were planted in the Sary Mogul region in 1998. As a result, people received 60-65 tons of yield. At that time, 250 farmers were working in crop production in the Sary Mogul (Murgab Communism, 1998). This historical event of food insecurity must be acknowledged when discussing the ecological calendars.

Since the breakup of the Soviet Union, communities in the Pamirs have faced food shortages, and this was first mitigated with the support of AKDN. For example, "Over the past ten years, Aga Khan Development Network (AKDN) provided support for the region. The main mission of the fund was to develop the region and improve the lives of people. Currently, 70% of the population in Murghab receives aid. For Sary Mogul Village, I have provided 1906 somoni (Tajik currency) so that local people could grow Espartset *(Onobrychis)* fodder grass. Also, 5083 kg of potatoes were planted in 1 hectare of land, and 40584 kg of potatoes were produced. This is about 16 tons of potatoes." (Sary-Kol, 2002). Furthermore, 2030 somoni Tajik money were provided for 41 farmers in order to promote agriculture in Sary Mogul (Sary-Kol, 2003). Given the local context, addressing food insecurity was vital.

The famine overlapped with the energy crisis in the Pamir Mountains of Tajikistan, resulting in a massive migration of people from neighboring Tajikistan. Many people moved into Sary Mogul. The firewood crisis in the Eastern Pamirs of Tajikistan was another reason why people immigrated to Sary Mogul. Until the end of the Soviet Union, mountain communities of Pamir-Alai had been heavily subsidized by the state. Coal, oil, and many other natural resources were provisioned to support energy needs. This kind of provisioning was called the "Moscow supply" (Kraudzun, 2012a, p. 95). After the end of the Soviet Union, the state subsidies of coal and oil stopped. Due to lack of coal and oil, many communities from the Eastern Pamirs moved to Sary Mogul in Kyrgyzstan. According to Taipov (2002), between 1992 and 1996, 400 families left from the Eastern Pamirs and moved to a different region of Kyrgyzstan (Taipov, 2002). Food insecurities coupled with migration also provided another layer of context that was exacerbated by post-Soviet transformations and uncertainties.

Since then, Sary Mogul Village has become one of the most advantageous, convenient, and prosperous places for livelihoods compared to neighboring villages. People preferred to settle in Sary Mogul because it was close to Osh City (about 230 km), which provided convenient access to markets and food provisions. Osh City was important for many villagers in Alai Valley in terms of provisions, transport, and basic food needs. However, the transportation of food from Osh to the Pamir Mountains of Tajikistan remained problematic for two main reasons, harsh and unmaintained road conditions of the Pamir Highway M41 (especially in winter), and the international borders of Tajikistan and Kyrgyzstan. In winter, due to heavy snowfall, there was a lack of maintenance along Pamir Highway. Transporting food such as wheat from Osh to Murghab through high mountain passes with heavy snow was not easy

(Mostowlanksy, 2017, p.45). People confronted the natural forces while maintaining their livelihoods, but Toyota Land Cruisers seems change these confrontations.

Another issue was that after the end of the Soviet Union, the border of Kyrgyzstan and Tajikistan became an international border. This international border has been challenging for borderless tribes. Herders still face difficulties and restrictions while crossing international state checkpoints (Kraudzun, 2017). On one hand, life in the Pamirs Mountains of Tajikistan was challenging because people were dependent not only on traditional livelihoods (herding and planting), but also on trade and access to unavailable products outside of the villages. For this reason, many people from the Pamirs prefer to live in Alai Valley for its convenient geographical location. This was why maintaining exchange between the people in the Pamirs Mountains of Tajikistan, and the people in the Alai Valley of Kyrgyzstan, was essential (Sonntag, 2016). On the other hand, people in the Pamirs have a strong self-determination and sense of homeland, which required maintaining a relationship with the land.

Although the social-economic transformations in Tajikistan delayed the administrative return of the Sary Mogul Reservation until 2004, the community finally gained its autonomy and became part of Kyrgyzstan. Due to these challenges in Tajikistan during 1990 to 2004, the transition of the Sary Mogul region from Tajikistan to Kyrgyzstan took place slowly during 1995 to 2004. In 1995, the Soviet names of the administrative regions in the Eastern Pamir of Tajikistan changed and the Sary Mogul become administrative region belonging to Kara-Kol *jamooat* (Tajik official name for the county). In 2000, the Ishkashim and Shugnan districts gave the land of Sary Mogul to Murgab district. Between 2003 and 2004, the land was returned from Tajikistan to Kyrgyzstan (Taipov, 2002). In 2004, people could acquire Kyrgyzstan citizenship (Kreutzmann, 2011, p.188), and the community gained its autonomy after colonialism.

Development Organizations in Alai Valley

While the quest for natural resources grew due to geopolitical transformations in the region, it was the natural resource base of the Alai Valley that shaped local pastoral livelihoods. Most importantly since 1996, the 'Oshprim,' or local coal mine, has been operating near the Village of Sary Mogul (Sonntag, 2016). From then onwards, coal has been supporting not only the villages in Alai Valley, but also villages in the Pamirs of Tajikistan, creating jobs and securing fuel. Despite the economic value of the coal mine, the local people said that pastures around the coal mine lost productivity, were covered with black dust, and were dry and deserted. Only a few people are currently utilizing the pastures near the coal mine. Most families have changed their pasture areas. Many villages are concerned about the negative impact of the coal mine on human health because the working conditions were terrible. Nonetheless, the Sary Mogul region was locally more valued and has attracted more people, increasing diversity. As locals say, "we are *bash koshkon el* – people of many." What made Sary Mogul different was the diversity of tribes and ethnicities living and applying their knowledge and building social relations while sharing space and resources to sustain life. Therefore, the population is growing rapidly. Because the Alai Valley was not only rich in natural resources, but also for the natural beauty of Trance-Alai Rage, this place has already become a mecca for climbers.

Many communities in Kyrgyzstan or Tajikistan were considered at the edges economically. However, people in Sary Mogul engaged in various ecological niche activities that showed otherwise. Besides livestock keeping and farming, people worked in the coal mine, and there was a huge dependency on remittances (exodus). Although many Kyrgyz citizens were labor migrants outside of their country, the money they sent home was invested to build new houses, or rehabilitated old houses for their children and families (Nasritdinov and Schenkkan, 2012; Ibraeva et al., 2016, p.18). The region provided alternative and seasonal job opportunities locally. For example, during summer, some people in Sary Mogul engaged in various seasonal jobs. Seasonal construction activities, livestock management, small-scale farming, providing transportation services at the coal mine, and summer tourism services all provided alternative income sources (Ibraeva et al., 2016, p.7-16). The eco-tourism business, in addition to revenues from migration, has also become seasonally vital for the local people. Women sold locally-produced handicrafts during the short summer season. There were more than 10 organized women's *Uuz Apalar* in Sary Mogul which seasonally processed sheared wool in summer and produced carpet felt. They visited Osh and Bishkek cities to show their work in various exhibitions. Because the coal mining, eco-tourism, or migration activities are also part of their seasonal calendar, it is certainly up to local people to decide which additional activities to include in their calendar.

Figure 15. Summer Festival Organized by CBT. Image by Abdush Tashbekov 2017

Since 2004, there have been some collaborative development efforts in the Alai Valley. The Pamir-Alai Transboundary Conservation Area (PATCA) established potential development opportunities with respect to food systems, biological diversity, and eco-tourism (Gaunavinaka, 2010). In fact, many studies focused on addressing challenges and opportunities of eco-tourism in Alai Valley. In 2006, Community-Based Tourism (CBT) was established in Sary Mogul (Watanabe et al., 2010; Watanabe et al., 2014). A recent survey suggested that during the past 10 years, the number of guest houses was growing, woman and men were receiving special training in eco-tourism, and seasonal tourism has provided increased income (Ibraeva et al., 2016, p.41). The eco-tourism business became part of the short summer economy in the Alai Valley. Furthermore, every summer CBT, a partner of the ECCAP project, organized a seasonal summer festival in the pastureland, where woman, youth, and children actively participated (Figure 15). In Sary Mogul, this festival was organized only once during the hot days of the summer. Thus, ecological calendar contains seasonal economies shaped by the international development projects.

The Aga Khan Development Network (AKDN) and the Swiss Agency for Development and Cooperation (SDC), in affiliation with development program Helvetas (Swiss, Germany, and USA-based) and Community Development and Investment Agency ARIS, remained as necessary development organizations for addressing the livelihood challenges in the region. Although villagers collaborated with these agencies to gain support for livelihood improvement, poverty reduction and, many more local issues (access to fresh water, infrastructure for irrigation, medical care, ecological education for children), additional support for crop development and livestock health still needs to be taken into consideration. For example, villagers have complained about the black lung issue *kara – opko*, and the disease (*aphthae epizootica*) *yashur* in livestock. During summer, some crops were irrigated by glacial streams, but those fields outside of the village lacked irrigation channels. Especially during the dry seasons, there was a shortage of water for irrigation. Last year, Korean tourists invested money to provide safe water for the villagers. The people in Sary Mogul also complained about the long winter. Only during summer can they grow potatoes and barley. These crops, especially potatoes, have been threatened by early frost, and these food sources were crucial for personal consumption (Ibraeva et al., 2016, p.9). Thus, I noticed an urgency for addressing food insecurity in the face of uncertain of local seasons. Hence, these existing issues and inequalities were exacerbated by seasonal uncertainties. Therefore, both people and development agencies must take local knowledge and concerns seriously as mountain communities need more support.

Conclusion

The objective of Chapter 1 was to re-contextualize the Sary Mogul area based on the farmer's knowledge of ecological calendars. While this knowledge directly benefits their traditional livelihoods, such as livestock keeping as well as small-scale farming, the existing literature in this area provided little background data. This chapter further demonstrated that Sary Mogul was very well established long before the establishment of the Soviet Union.

The mountain communities in Central Asia had complex local histories, ethnic minorities, and geopolitical political context, all of which were exacerbated by the ongoing seasonal changes. The challenges and opportunities of their coping strategies in face of ongoing geopolitics added another layer of complexity to their adaption to changing climate while maintaining herding and copping livelihoods. Because the Alai Valley was a crossroad of civilizations in the Silk-Road trade, the context of local tribes was shaped by Persian, Arabic, Chinese, Russian, and English civilizations as they engaged in exchange and trade as well as conquests. Especially the colonization of Central Asia known as the 'Great Game' - the 19th-century geopolitical struggle between British, Russian, and Chinese in the Pamir Mountains of

Central Asia - disrupted the ability of local people to grow crops and continue their way of life in the region.

Despite these external interventions, I demonstrated how hunting, trapping, and foraging along the Silk Road was well established. The mountain communities in Central Asia had a long history developed throughout engaged relationships with their natural surroundings. However, it was heavily disrupted during the 19th-century colonization of the region. Past research demonstrated diverse knowledge produced during the colonial expeditions and explorations. However, these established and continued relationships were disrupted, especially following the forced assimilation of local people into the brutal system of the Soviet Union. Similar to the North American context of indigenous peoples, the Soviet Union created enclaves or reservations, and forced tribes to settle there to exploit community labor for fodder production in Sary Mogul. However, Sary Mogul also benefited from the Soviet projects.

That said, applying the notion of "Intellectual Pluralism," I argued that settlement of diverse tribes in Soviet Sary Mogul in 1946 must be perceived as the return of tribes to the Alai Valley. This return of people to the Alai Valley set the stage for new challenges, and the opportunity to adapt place-based knowledge of livestock herding and crop management in the region. It was very unfortunate, however, that the Soviet Union entirely changed the local perception of time by institutionalizing and standardizing time. The industrialization was inevitable.

Despite the history of Tsarist Russian conquest and forced settlement of tribes, the local history of Sary Mogul unfolded as they formed a plural community comprised of many people with diverse professions, all of which benefited their collective adaptive abilities. Later, Sary Mogul has witnessed social-economic and political transformations impacted as a result of the

Civil-War (1992-1997) and poverty in Tajikistan. This severely impacted food safety. Sary Mogul gained its sovereignty as a community and became officially part of Kyrgyzstan in 2004. Before becoming a sovereign community, the village received enormous support from the Aga-Khan Development Network, learning how to grow the right types of potatoes at high elevations. These pilot projects were implemented as a solution to address the famine in the Pamir Mountains of Central Asia after the end of the Soviet era. Today, Alai Valley, like many other rural regions, is part of global international development community.

CHAPTER 2

COMPREHENDING BIOPHYSICAL CHANGE: A SEASONAL CALENDAR OF THE UPPER ALAI VALLEY, KYRGYZSTAN

Introduction

Changes in climate were threatening the livelihoods of small-scale farmers whose survival directly depends on subsistence-economy such as farming, herding, hunting, and gathering practices that feed almost 70-80% of the world population (Lowder et al., 2016). Specifically, the communities in the Pamir Mountains of Central Asia were at the forefront of climate change (Kassam, 2009a, p.686; Kassam et al., 2011, p.148). Grazing grounds were less productive. Pastoralists are seeking pastures at higher elevations due to a change in snow. These annual weather fluctuations were causing uncertainty for sustaining livelihoods in mountain communities. Farmers need innovative research that focuses on their agriculture and herding challenges, and meaningfully guides them through year-to-year weather variations.

A team of international collaborative and transdisciplinary scientists developed an ecological calendar that fosters seasonal adaptation at the village level. Grounded on local knowledge from several locations in the Pamir Mountains of Central Asia, these calendars have been developed through a joint effort by a *community of inquiry* (scientists) and a *community of social practice* (farmers, fishers, hunters), through participatory action-based research (Kassam, et. al., 2018). The knowledge contained in the ecological calendars can help communities not only know how context-specific seasonal and weather-related changes occur in a particular area, but also show people how their knowledge systems can accommodate annual weather variability. Focusing on collaborative efforts to develop traditional ecological calendars in the Village of

Sary Mogul, in the Alai Valley, Kyrgyzstan, I showed how the key physical indicators inform particular livelihood decisions as seasonal transition from to another.

Changing climate is leading to local environmental shifts that impact farming and hoarding activities. The glaciers in the Pamir Mountains are retreating, avalanches are occurring, and earthquakes are happening. These glacial landscapes in Alai Valley are in dynamic movements due to tectonic activities (Reznichenko, et al., 2017). After interviewing villagers, I learned about their experiences with small-scale, year-to-year variability. This made it hard to predict weather fluctuations, especially in the spring and fall. For example, the Kyrgyz weather forecast from Osh City or Bishkek City, the capital of Kyrgyzstan, does not match with their local weather patterns. Due to weather instability, it was becoming difficult to predict seasonally occurring ecological events, such as the duration of snow cover, frost, and ground temperature. Strange weather events, including *kara-suuk* black cold (winters without snow), have occurred, especially in the winter of 2015-2016. A lack of precipitation during the winter and spring has decreased the productivity of fodder grass. Because farms relied on fodder grass to sustain livestock through the winter, the availability of fodder in spring has become an issue.

Moreover, too much snow in spring limits livestock access to grass, and the community faces a fodder shortage. Stored fodder was insufficient to sustain livestock in 2016-17, when the snow melted very late in spring. This variability in spring snowmelt made people uncertain, as livestock grazing depends on access to grasslands. For these and many other reasons, the villagers asked for solutions to address small-scale seasonal changes. The communities need anticipatory knowledge to make a critical decision, especially during the spring and fall. This knowledge can safeguard their livestock from food shortages, secure sheep lambing, and provide crops during planting and harvesting seasons.

My research focused on regional challenges of comprehending weather variability from the villager's point of view. I communicated how they are coping with changes in seasonal patterns, and focus on seasonal uncertainties like precipitation, lack of snow in winter, cold summers, and unexpected frost in autumn, all of which impact local livelihoods. My mapping of the ecological calendar allowed farmers to make decisions related to planting, harvesting, and managing livestock depending on the shifting physical, biological, and environmental variables. I focused on the practical application of the ecological calendars developed for the Sary Mogul community to address their context-specific livelihood challenges threatened by weather changes.

I examined how the local knowledge within ecological calendars from the Alai Valley fostered seasonal adaptation on small scale variations. Based on qualitative interviews, I hypothesized that comprehending specific interdependent relationships amongst the ecological events (physical changes, biological and other social variables) would inform villagers to anticipate local changes. I argued that the revitalized calendar benefits livestock and crop-related decisions. Therefore, revealing the presence and impact of local seasonal changes in the region required developing an easily interpretable calendar. The ecological calendar, thus, accommodated livelihood challenges related to the local climate. Mapping the repetitive cycle of events (physical, biological, and social activities) helped me to achieve understanding of climatic constraints and environmental changes in a given area.

Context

The ecological calendar reflected synchronized rhythms of the seasonal changes in Sary Mogul village. The villagers in Kyrgyzstan do pay attention to weather forecasts from various Kyrgyz TV channels and radio sources. However, there is often a mismatch between the weather forecast and the established seasonal patterns in the Alai Valley. Although weather was related to day-to-day events, and ecological calendars dealt with seasonality of multi-year changes, a lack of local information (data) remained an issue for the villagers. Instead, their understanding of yearly seasonal cycles were based on their orally preserved knowledge. When I began studying the calendar of Kyrgyz people, it was extremely hard to describe a Kyrgyz calendar known as *Kyrgyz Aye*. Kassam *et al.* (2011) described the calendars with respect to time as experience-based and relational, in which humans are able to harmonize with changes in their habitat, and "develop systems to understand temporal relationships between ecological events and synchronize their own activities with complex seasonal rhythms." In other words, it is a local system that this Chapter aims to describe.

The ecological calendar contained different dynamic seasons (e.g., quick, fast, slow, active, and inactive) of the year. Local sense of time unquestionably has changed since the collapse of the Soviet Union. There was a perception that time is going quicker and faster, which makes people worry about the rapid pace. I suspected that this may have to do with the transition to a free-market, global economy from a labor-intensive Soviet system. I do not know how people experienced time during the Soviet era. However, with the post-Soviet awakening into a neoliberal free market system, the perception of time was that it is going faster these days. During the replacement of the Soviet economic system with neoliberal globalization, a sense of seeking a new meaning of time became essential in these regions. In contrast, the sense of time in an ecological calendar is much slower depending on the seasonal productivity and human performance. This may not apply to all people, especially those villagers whose livelihoods are not depended on herding or cropping activities. Among those who engaged in more herding and farming livelihoods, the ecological experience of time was more likely to remain. It was known as "Oecological time" as mentioned by Evans-Pritchard and Even (1939).

Experiencing the herder's and farmer's sense of time might be ecologically peaceful, but local people expressed some nostalgia for the era of the glorious Soviet Union. The Soviet industrialization did change villager's lifestyles in terms of health care, education, and women's rights. The Soviet modernity and industrialization improved infrastructure and public services such as hospitals, but healthcare systems changed with the end of Soviet rule. Changes in pastoral sense of time to modern sense time remains vivid even today. People lived in the Village of Sary Mogul during fall, winter, and spring (September to April) with access to electricity, coal-heated mud-brick houses, which was considered a lifestyle change. It was much warmer to live in a coal-heated home in the Alai Valley during the cold times from September to April.

After the end of the Soviet era (especially with the privatization of livestock), the community transitioned into a self-governed entity. During Soviet times, collective farms strictly controlled decision-making, for example, when to move livestock to a summer pasture, or when to plant barley or potatoes. However, an ecological perception of time created bottom-up decision-making within the villages. In the past, the pasture committee, as the administrative body of collective farms, made the decision when to begin specific activities like planting crops, harvesting crops, and livestock-related decisions. With the end of Soviet system, local people benefitted from more flexible decision-making. Currently, the pasture committee maintains its role to inform the community when to begin land-use activities, and when to move livestock to summer pasture. However, I noticed a lack of communication between the pasture committee and individual people in the village.

Despite the presence of multiple sense of time, the Kyrgyz people do not have a revitalized ecological calendar. Even though local people miss the Soviet modernity, some farmers have expressed flexibility in their decision-making such as when to harvest and breed livestock. The pasture committee does observe changes in their ecological environment, they do not have documented knowledge about the seasonal weather patterns to monitor change. Considering the context of conflicting times, collective and individual decision-making challenges, a revitalized ecological calendar would aid not only the long-term sustainability through herding, and cropping, but also empower their seasonal decision-making in times of uncertainty, especially with climate change.

Methodology

The ECCAP was an international, collaborative, and transdisciplinary project. The participants of the project aimed to revitalize ecological calendars and co-generate knowledge in collaboration with a community of inquiry (scientists of from different disciplinary background) and a community of social practice (farmers, herders, hunters, and fishers) (Kassam et al., 2018). In recent years, we have conducted a Seasonal Round Workshop (2016), semi-structured interviews (2017), and a Poster Validation Workshop (2018). I focused my research on ecological events, retrieved from qualitative interview analysis, and we subsequently created a digital Seasonal Round. The purpose of the co-creative research project is that everyone benefits from the research process, especially farmers.

Seasonal Round Workshop - 2016

Within the broad, transdisciplinary framework described above, the initial process of developing ecological calendars began in July 2016 with the Seasonal Round Workshop (SRW).

The objectives were to build a relationship with the community, to explain the purpose of our research, and to foster communication between the scientists and local people in order to understand how herders and farmers navigated their social-cultural and livelihood activities in a site-specific place. Before the workshop, special preparatory instructions were provided for those who were new to the place and the project objectives. Dr. Karim-Aly Kassam (Principal Investigator) provided us not only an informative presentation about the ECCAP project, but also how I was planning to develop Seasonal Calendars (Figure 16). Responsibilities such as asking questions, leading the discussion, translating, taking notes, and filling the blank Seasonal Round (SR) were assigned and agreed upon by the scientists (Figure 16).

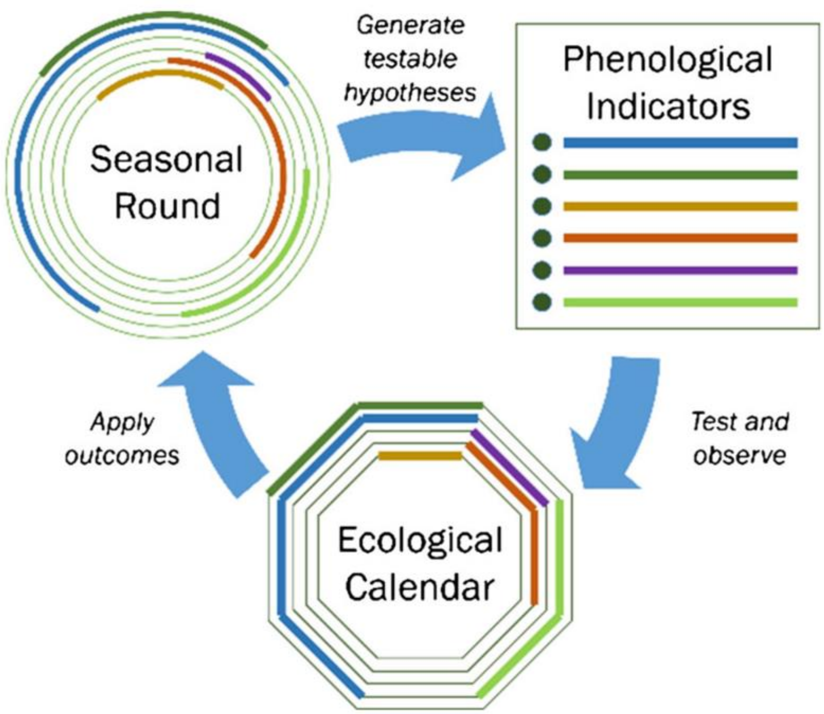


Figure 16. Methodology of Seasonal Calendar. Adapted from (Kassam et al., 2018).

Because some of the scientists had many years of working experience in the region, relationship building had long been established. Nonetheless, we re-established a strong connection with the spiritual leader of the village, and with youth from the Community-Based

Tourism (CBT) in Sary Mogul. The youth greatly helped us organize the workshop, considering local values by inviting *aksakals* - elders (the knowledge holders). Out of 34 invited people, 24 participated in the workshop. A special meal was prepared, and the workshop was completed.

During the workshop, Dr. Kassam introduced and explained the project objectives. In 2017, I translated while another graduate student carried out interviews (Scheimreif and Kassam, 2018). Dr. Kassam asked key guiding questions to understand how the community engaged local seasons, livelihood activities, land-use practices, festivals, social-cultural events, phenological indicators, and how participants experienced these seasonal changes. Prompting questions included: How many seasons do you have? How do you know when seasons end or begin? What kind of animals do you have? How do you know when to change seasonal pastures? What type of crops do you plant? How do you know when to till or harvest certain crops? Have you noticed any changes in the weather (unusual events) and many more? Throughout the workshop, the research team actively recorded the discussion by taking notes. After the workshop, we collaboratively updated and double-checked the findings.

Participants provided us with valuable insights about the operation of livelihood activities associated with the placed-based seasons. The start and the end of certain local seasons were marked by the arrival of migratory birds, ice freeze, melt of ground frost, the expectation of the last snow, emergence of vegetation, emergence of mammals, mating season of domestic and wild animals, color changes in grasslands, and the hibernation of animals. Quite often people reflected on celestial movements in order to explain earthly events in their environment. The informants also expressed uncertainties as to how the seasons became unpredictable, why they are receiving less snow in winter, and how potato crops were vulnerable to unexpected weather events, such as frost in early autumn. Despite these climate concerns, the participants documented ecological indicators, such as frost being related to the departure of migratory birds, or hibernation of individual animals. Moreover, the development of the Seasonal Round (SR) revealed more and less critical times of the year, like food shortages in Spring, and times of abundance after summer.

The Seasonal Round Workshop (SRW) in 2016 was the first phase of the co-generation of knowledge. It was a meeting of local farmers with international scientists to exchange knowledge about the climate and local weather fluctuations. Initially, it did not provide a full picture of the complex relationships between livelihood activities and the changing seasons. Due to the presence of multiple languages, understanding the local seasons became confusing for scientists. Later it was challenging to interpret the complexity of human languages and local terms. In the process of interpretation, new cues emerged. For example, potatoes were collected when the cold arrives (dropping of leaves), when pasturelands start to turn yellow, and when breeding birds begin to depart. Otherwise, frost may destroy the potatoes. Moreover, after the arrival of heavy snowfalls in mid-November, animals were kept in the village (due to lack of access to grazing pasturelands) during November to April, until the snow disappears. Hence, herding practices shifted depending on the arrival and disappearance of snow. These seasonal indicators established a path for further research.

Semi-Structured Interviews - 2017

Before carrying out the second phase of the fieldwork in July 2017, the Cornell University IRB approved semi-structured interviews which had been developed based on the Seasonal Round Workshop (SRW). The semi-structured questions were designed considering the social-cultural context, particularly addressing the traditional Kyrgyz calendars. The questions included diverse subjects such as personal experiences of seasonal and weather changes (unusual weather events like snowfall, frost, or shifting seasons), ecological indicators (behavior of birds, plants, mammals, and herbivores), traditional celestial calendar (lunar calendar), and community livelihood (seasonal holidays, land use, herding activities). The questions were prioritized into 21 main guiding themes. We started the questions by asking the informant's awareness of traditional Kyrgyz calendars. The following questions were then asked: How do you know when a particular season ends or begins? What kind of plants or animals informs the arrival or end of certain seasons? How do you know it is time to plant barley or potatoes? How do you know when to move livestock to summer pasture? How do you know when to harvest hay, barley, and potatoes? These questions were not strictly structured but rather were based on the free flow of conversation.

Thus, in July 2017, we carried out semi-structured interviews with 39 people, 19 men and 20 women. It was all caried out in a single village. we applied snowball sampling during the fieldwork (Bryman, 2008, p.459). As a local to the region, we followed all the IRB requirements such as proper introduction, informed consent, permission to use audio recording, and transcribing the interviews. The questionnaire asked about personal information, background, work occupation, and photos. The informants were mostly herders, pastoralists, hunters, drivers, teachers, gardeners, nurses, pasture managers, and local activists. We only interviewed adults 18 years of age or older. We walked from house-to-house in the village and interviewed people with permission. Sometimes, we approached people who were walking in the village, gathering in the market, or working in their crop lands.

Throughout 2017-2018, the interviews were transcribed, and key ecological indicators (local seasons, physical indicators, animal cues, plant cues, and livelihoods activities) were documented. Based on these data, we prepared a particular poster calendar. It contained

Gregorian month names, ecological indicators (physical changes, birds, plants, and mammals), special local seasons corresponding or correlating with weather events, and human activities (crop planting and livestock herding activities). The poster version of the ecological calendar was represented as a table. For example, the arrival of spring was late in March, informed by the arrival of White Wagtail (*Motacilla alba*), the snow disappearing, marmots emerging, the beginning of sheep lambing season, and livestock was taken to pasturelands. Alternatively, in mid-August, fodder changed colors, marmots hibernated, summer ended, harvesting of crops (e.g., hay, barley, and potato) began, pasture seasons ended, and people moved from pasture to the village.

Validation of the Poster Calendar – 2018

The third phase of my research was validation, which was conducted in July 2018. We crossed-checked the validity of the ethnographic information with community. We arranged a Validation Workshop (VW) in Kyrgyzstan. The youth from Community-Based Tourism assisted us with inviting 25 participants. In Sary Mogul, we had not used the SR calendar because it was still in development. However, we validated the poster (table) version of the calendar. During the workshop, we shared our climate data with the community. After the presentation, we asked the community if the key phenological cues were correct in relation to their livelihood activities. For example, we asked whether snow melts in April, rivers open, marmots emerge, certain species of birds arrive, and if people begin land-use activities according to the table calendar. It was extremely difficult to explain spatial and temporal co-occurring events in linear order. But our collaborative approach allowed us to introduce new information. Sometimes, I misinterpreted and misplaced specific cues, and the community members corrected them. Two of our team members actively kept notes during the validation workshop. A great deal of clarification, additions, and new knowledge emerged during the validation process. This is how the Kyrgyz calendar was co-generated and validated.

Revisiting the findings in Summer 2019

As a field assistant, we actively contributed to the development of the ecological calendar in the Alai Valley of Kyrgyzstan in 2016 - 2020. I participated in the first workshop (Kassam et al., 2018), co-conducted semi-structured interviews with students, validated the poster calendar, and joined several field trips from the start of the project. Yet, the creation of the Seasonal Round Calendar and its ethnographic interpretation was still discussed further. We had issues with translating Kyrgyz into English, which was not easy. Having accomplished three field seasons of collaborative fieldwork, in fall 2018, I become a full member of the ECAAP project and a (Graduate Research Assistant) in the Department of Natural Resources and the Environment (DNRE) at Cornell University. Having learned analytical skills (qualitative and quantitative) during four semesters of study at Cornell University, I focused my MS thesis on further contributions to revitalizing an ecological calendar for tribes in the Alai Valley.

I planned to double-check our findings in order to describe the Seasonal Calendar from the Alai Valley, and develop a digital version synthesizing the data. During the process of qualitative interview analysis (May to August 2019), I listened to every single audio file we gathered, both from the semi-structured interviews in 2018, as well as from follow up interviews. I translated and transcribed all of those interviews. After a month of listening, translating, and transcribing, I used ATLAS.ti software, which was developed in Berlin (Legewie, 2013), and carefully selected the key ecological indicators that informed farmers when to plant potatoes, when to harvest potatoes, or when to stop herding livestock with reference to physical changes and site-specific natural events. Based on these findings, I updated and validated the poster as well and gained more insights on seasonal changes.

Due to translation issues, new phenological indicators emerged, which were not previously revealed. For example, I did not know that *chychkan,* eastern mole voles (*Ellobius tancrei*) emerged in April and May. Thus, the poster calendar was updated with additional data. The poster calendar contained the followings data: local seasons with Kyrgyz names, Gregorian months and names, physical indicators (weather-related events such as snow and rain); temperature-related events (ice formation, ice melt, and soil-related changes), animal indicators (mammals and birds), plant indicators, livestock-related activities, and crop-related activities. The ATLAS.ti software selected ecological indicators, and I utilized the coding mechanism suggested in the qualitative research guidelines (Emmerson et al., 1995).

Co-Creating the Seasonal Round in Fall 2019

I began working on developing the digital Seasonal Round, synthesizing a large quantity of knowledge in one representable unit. During August to December 2019, the process of generating the Season Round involved several stages. When imagining how a context-specific ecological calendar is developed, it was essential to consider other possible models by which a similar calendar could be described. The calendar from the Alai Valley was developed from multiple models. The first model of inspiration was the Seasonal Round of subsistence harvest in Wainwright, Alaska (Kassam, 2009b, p.118-172). The second model was from the Wuitoto people in Columbia, South America (Makuritofe and Castro, 2008). The third model was from *Inuit Woman Artists: a voice from Cope Dorset* (Leroux et al., 1994). While the example from Wainwright provided essential input in terms of the seasons and icons, the calendar from the Wuitoto and Inuit peoples provided similar elements of cosmology, as well as the diversity of celestial bodies within ecological calendars. Thus, I have used what seemed relevant for the creation of a Seasonal Round for the Alai Valley.

Having created an image of how the calendar from tribes in the Alai Valley should look, I read through information from (ecological indicators) the poster and designed icons that condensed multiple ideas into a single icon (see Glossary). Using Adobe Illustrator, I then developed icons for community events, harvesting activities, livestock management, plant knowledge, animal knowledge, bird knowledge and physical events (changes in snow, ice, and soil), local seasons, and movements of the sun (day and night length), and finally cosmology (lunar calendar, movements of stars, and celestial bodies).

Having included these elements, I introduced the approximate duration of seasons, activities, and events (start, middle, and end). Because the knowledge contained in ecological calendars (indicators) was associated with different events (temperature changes, snow cover, ice melt, soil heats up, potatoes are planted), I tried multiple ways to show the relationships. I created both versions of calendars with linear and nonlinear relations between biophysical and farming activities. The Seasonal Round could be demonstrated mechanically with straight lines (dividing and linking) as well as non-linear (in terms of waves of lines connecting events). However, lines were not the best way to represent the relationships because it was really difficult to make a distinction, or even draw a line showing different scales, and how organisms move around in space and time (crossing scales). Instead, I used a curved line showing the relationships of ecological cues. When placing icons, the calendar looked dynamic and unstructured. This actually was a blessing, because when information from the poster calendar was transposed onto a Seasonal Round, the issue of logical order emerged. Thus, rearranging the logical order of icons became crucial.

Ecological calendars functioned as annually repeating patterns of ecological events. There were two ways of thinking, linear thinking of seasonality (associated with one particular activity), and thinking in terms of relationships (multiple events happening as I move through time). I followed each cycle, for example bird-related seasons, and logically re-arranged some of the icons. I said to myself, “let me follow the time (cycle) with ice only,” “let me follow the time (cycle) with soil only” or “let me follow the time (cycle) with animal-related indicators only” or “let me think with potatoes only”. In this manner, the ecological calendar became event-specific and organism-specific, whether users are thinking about the seasonality of bird life, plant life, animal-related activity, or the phenology of wildlife. The logical patterns and sequence of interrelated events, as well as relationships amongst ecological indicators, emerged visually. I could not place the emergence of grass before snow melt or spring temperature changes. I could not place the arrival of birds in January. I placed the icons (as variables) based on local ecological constraints. Seasonal patterns existed in the relationships within local environmental change (winter being long, snow cover being long, etc.). Creating layers of livestock-related, bird-related, plant-related, and land-use related cycles allowed me to visualize the patterns of seasonality.

While independent re-arrangement of physical events, wildlife cycles, or land-use patterns was necessary, transposing the data from the poster calendar into a Season Round explaining the co-occurrence of multiple events, was challenging. Imagine the Seasonal Round with an arm or the hand of a clock moving through annually repetitive ecological events. At a certain point, it may hit only one event (an ecological marker of seasonal transition), but at a different point, it may line up with multiple events (ecological indicators), which makes the ecological calendar challenging to develop and understand. Only when I established the independent pathways (ice-specific, snow-specific, and soil-specific), did the relationships become clearer. Therefore, rearranging icons linking with one particular cycle (e.g., crops; potatoes, barley) was useful for creating the Season Round. However, relationships may be established in multiple ways.

If relationships existed within broader categories (community events, crop management, livestock management, bird life, and plant life), connections could be demonstrated. If there were no relationships, events must be logically placed in appropriate seasons. I cannot put the emergence of *Mamakaimak*, dandelion (*Asteraceae*) in January, or in the middle of summer. I also cannot place the icon that represents the emergence of the golden marmot in February because there was still deep snow. Even the wild animals have their own average seasonal cycles. For example, mallards do not show up in January, so the Gregorian calendar can be very useful in comprehending the logical construction of ecological events. Therefore, I did not remove the Gregorian month names. Villagers suggested that after the *5th Tokol* (end of March), *kyn* weather becomes warmer, and that was when *childe* (winter) ended, and spring lambing of domestic sheep took place. There was an excellent relationship with temperature changes around the Vernal equinox. Sheep lambing occurred as temperature changed from cold to warm after the Vernal equinox. In this sense, people do make decisions by estimating the average temperature change in spring. Therefore, Gregorian month names were integrated into the Seasonal Round with other variables.

Ethnography and Seasonality

My work employed an ethnographic approach to understand how people accommodated the dynamics of local natural constraints, both as holders of various knowledge and professions, as well as a community living in a specific place. Ethnography is an approach for studying individuals or groups of people, their cultures, and their life from their point of view. This approach aimed to comprehend, describe, and interpret the social reality from the villagers' world view. Participant observations, unstructured interviews, structured interviews, semi-structured interviews, and life-histories included many of the data collection methods used in ethnographic fieldwork (Bryman, 2003; Bryman, 2008; Bryman, 2016). This work, hence, reflects the use of ethnography to understand seasonality. However, I have not personally spent an entire year in the Alai Valley. What is reflected in this Chapter was based on multiple interviews from villagers.

Ethnography has benefited many fields related to understanding human and patient interactions, understanding psychological trauma, and even understanding the role of ethnographic research in conflict areas. Depending on the purpose and research topic, an ethnographic approach can be used, applied, and may benefit many other scientific fields (Leunberger, 2015). I applied an ethnographic approach with mixed data collection methods to advance transdisciplinary and social-ecological research in the Alai Valley of Kyrgyzstan. This work focused on livelihoods that were linked to changes in the natural environment. During May to July, 2019, I coded files that I had transcribed, and categorized the codes according to specific thematic groups such as cosmology, celestial knowledge, traditional lunar calendar, research context, livestock management, crop management, and local seasonal changes. Ethnographically-generated knowledge was described in detail, thus revealing villager's contextual seasonality, relationships, and perceptions. Specifically, the idea of "Thick Description" in the book *The Interpretation of Cultures* by Geertz (1973) inspired this work. Anthropologists use the method of "Thick Description" to shed light on the social context. I applied this method in a social-ecological context of understanding the seasonal cycle in the Alai

Valley. Local seasonality can be “thickly” described, but it is hard to achieve. I provided an ethnarchic account for revitalizing ecological calendars and interpretations. In other words, the calendar was my abstraction of comprehending the seasonal changes in the Alai Valley.

Results and Discussion

Although it is very challenging to describe the yearly cycle of the upper Alai Valley as a text, the main result of my work is the digital two Seasonal Calendars for the Sary Mogul village. The difference between the two calendars is that one shows the relationship between environmental variables, and human practices (herding and planting) with non-linear relationships (Figure 17), whereas the other shows these with linear relationships (Figure 18). I have synthesized the outcomes of the interviews into a visual calendar. In other words, the non-linear calendar makes it easier for farmers to understand their own seasons, whereas the linear calendar can be useful for the academic community. Two seasonal calendars are also available in English and Kyrgyz languages. On the side page of each calendars, icons (environmental variables and human activities) with detailed explanations are available. In this thesis, I have made them available (see Glossary). In the following sections below, I break down seasonal calendars into seasons, biophysical events, animal, plant and social practices in order to describe their relationships in detail.

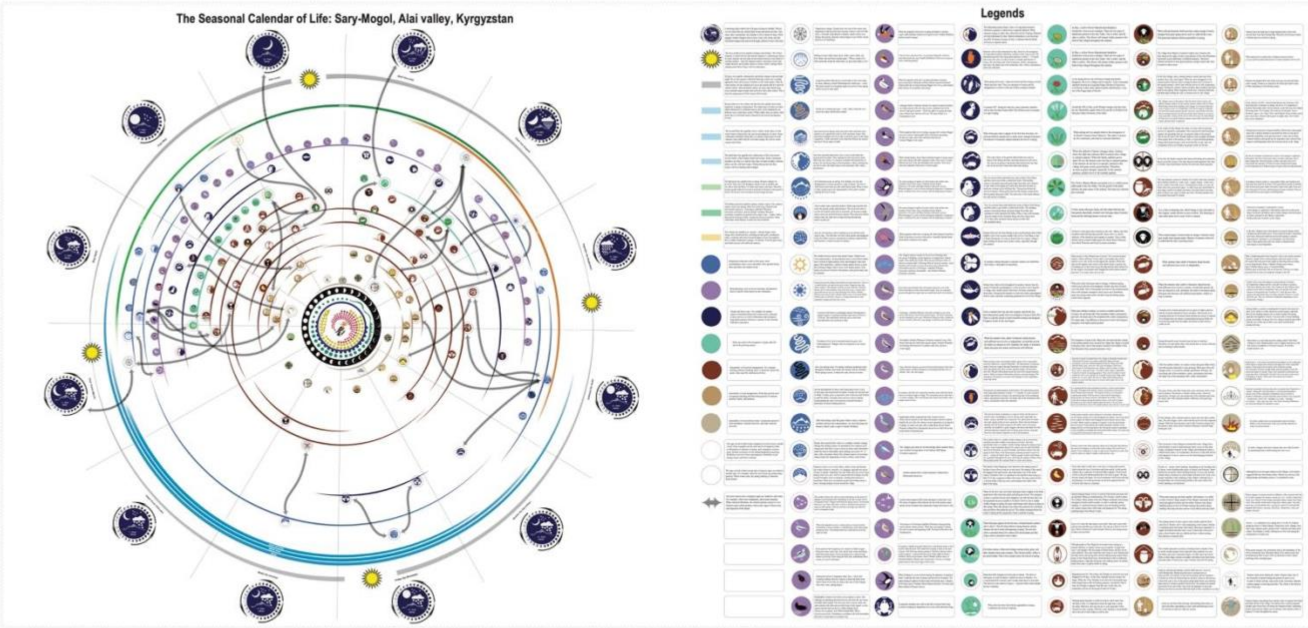


Figure 17. Non-Linear Seasonal Calendar, English Language

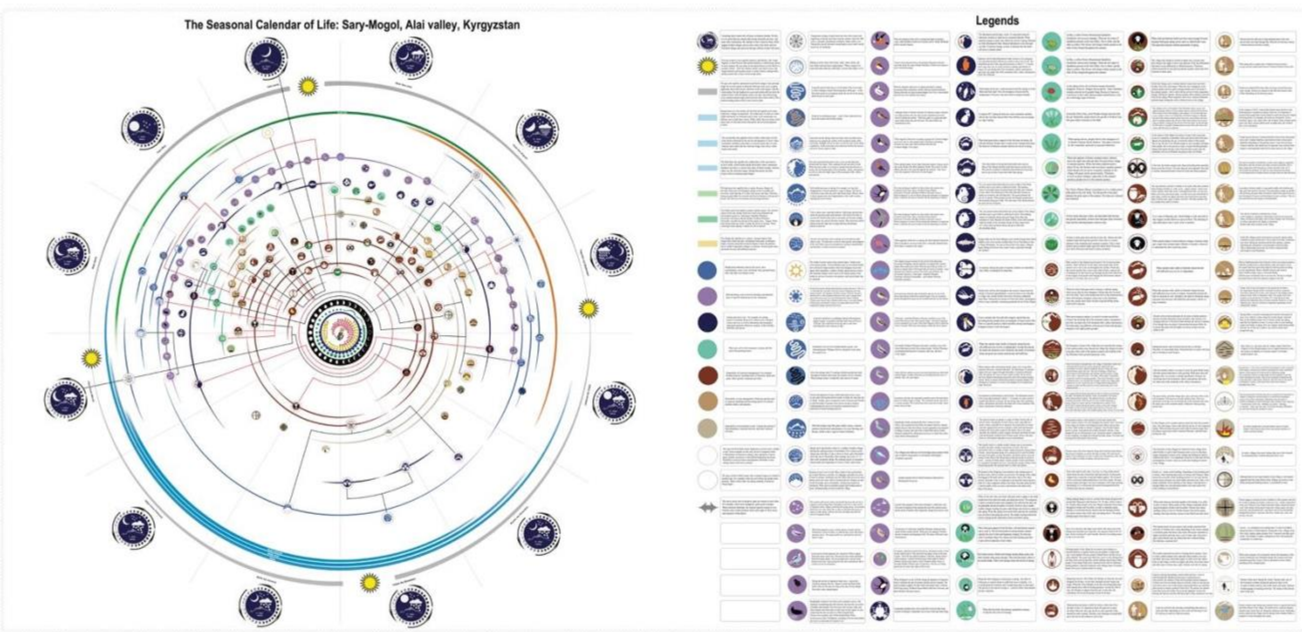


Figure 18. Linear Seasonal Calendar, English Language

Comprehending Local Seasons

From a local point of view, weather uncertainties have intensified since 1995, when the operation of the "Osh Prim" coal mine and other mining activities in the Alai Valley began. The villagers argued that the changes and uncertainties in Sary Mogul, such as human health-related issues, lack of grass in the pasturelands, and even strange weather events, were associated with mining companies in the valley. Their association of climate uncertainties with extractive mining activities can be reasonable. I do not mean that the local air pollution is driving the local climate conditions though it could be part it. Extractives industries emit CO2 gas causing global warming that, in turn, changes weather patterns globally. Warming has created unprecedented climate variations in snow, temperature, and rain in the region. Emissions and local climate variability can be generalized through global weather processes that may influence local weather, but I hope to communicate what I have learned.

I will now primarily focus on the local understanding of seasons, snow, temperature, and rainfall. I will then examine the four main seasons, with a greater focus on snow cover, as there are three distinct local winters. Furthermore, I will describe local seasonality, especially during the winter with reference to temperature, snow, and ice. Seasonal shifts are occurring, especially in spring. Spring and fall have become uncertain and unstable due to changes in temperature and variations in the time of arrival and departure of snow. These seasonal shifts and variations in snow fall, temperature, ice, and soil were associated with livelihood challenges. Temperature changes in spring and fall played essential roles in timing of planting and harvesting crops. Therefore, monitoring key ecological indicators during those seasons was vital.

Based on the Sary Mogul seasonal calendar, there were four main seasons in the Alai Valley of Kyrgyzstan. The winter was locally named *kysh*, the spring as *baar*, summer as *saratan*, and autumn as *kyz*. There were three types of winter, *kysh* overall winter, *tokson childe* mid-winter, and *kyrk childe* – mid-harsh winter. The winter in Sary Mogul was relatively long, lasting from mid-October to May (temperature changes). The mid-winter occurred from mid-November until the end of March (coldest period in winter). The harsh mid-winter took place from December until February, which are shown in the calendar (Figure 19). The remaining seasons were short; spring (April to May), summer (June, July, and August), and autumn (September to mid-October).

One might argue that the Gregorian calendar is not useful because the ecological events cannot be fixed in time. In the process of revitalizing the ecological calendar, the Gregorian calendar provides a basis for calibrating (approximating) the events. Because the Gregorian calendar is already in the minds of many people for years now, the Gregorian calendar has methodological relevance. Also, the environmental constraints work differently in different places. For example, March can be spring elsewhere, when March is winter in Sary Mogul. After the revitalization of the calendar, farmers may decide how to go by the Gregorian calendar. If ignored, it becomes difficult to estimate the year-to-year seasonal variations. I included the Gregorian calendar because it is also useful to approximate the evens during the final validation process, which is planned in 2021.

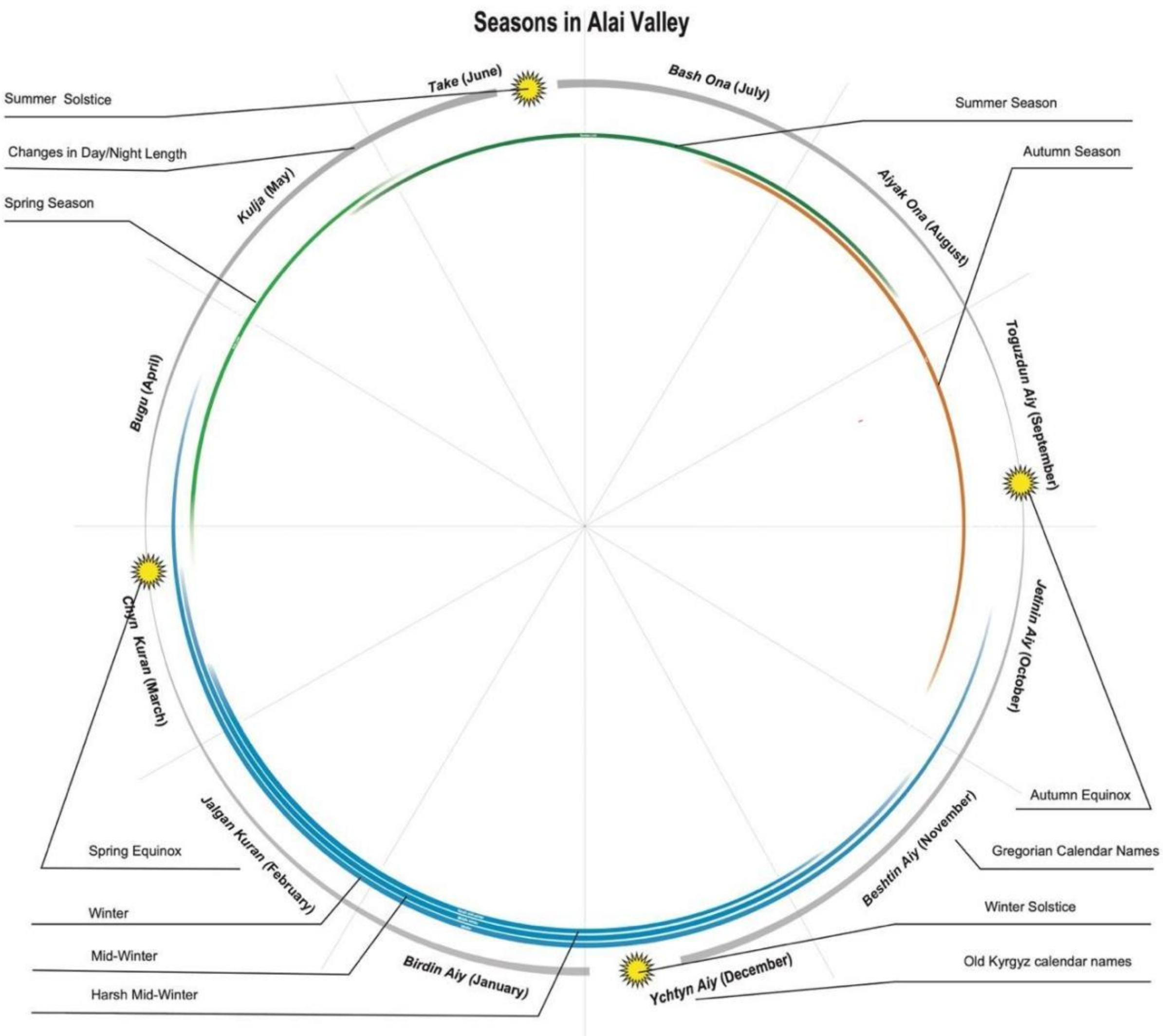


Figure 19. Local Seasons in Alai Valley

Physical events served as a seasonal marker when one season transition into another. While *kysh* generally referred to winter, *childe* could mean the cold period within winter. The community members claimed that 90 *childe* was exactly 90 days of a cold period within winter (December to early March). In contrast, the mid-harsh winter or 40 *childe* was locally defined as precisely 40 days of bitter cold within winter (January to early February). However, in the Alai Valley, each of these winter seasons, and other seasons, were informed through indicators. For example, how the community knows when winter begins might be dependent on indicators that were associated with winter. The arrival of winter may begin with the hibernation of marmots, or arrival of frost, or formation of ice. Sometimes winter arrived early with snow during September, but snow was complicated. Therefore, winters (e.g., 90 *childe* or 40 *childe*) may begin and end with the arrival and departure of snow. While winter can be marked with physical indicators, fall and spring cannot be determined by 90 or 40 days of cold. Some people measure seasonal changes through snow cover, others through temperature changes, and still others based on animal behaviors, like the marmots. The day-to-day approach to seasonality, however, allowed villagers to monitor the duration of snow cover. Therefore, physical indicators provided understanding of flexible seasonal markers (Figure 20).

Historically, different people have applied the notion of *childe* depending on their place-based season. For example, 90 *childe* can be found in the historical ecological calendar of Kazakh tribes. In the context of Kazakh ecological calendars, the term *childe tokson* referred to 90 days of a windy period. The term *childe* itself also referred to 40 days of heat, among other tribes (Фиельструп, 2002, p.212). It was fascinating that the language of ecological context has retained its local seasonal significance despite the layers of colonialism in Central Asia. Mountain peoples from the Alai Valley also appropriated this knowledge into their seasonality. This ecological language thus contributed to the revitalization of their seasonal calendar. Many tribes have applied the concept *childe* in different ways depending on their climatic, ecological, and geographical conditions. The idea behind the notion of *childe* refers to environmental stress. People from the Caucasus to Central Asia used the term *childe* in their calendars (Фиельструп, 2002, p.203-227) depending on variation of ecological context. In the Alai Valley, the term differed to mean winter, mid-winter, and harsh-winter informed through physical cues (Figure 20).

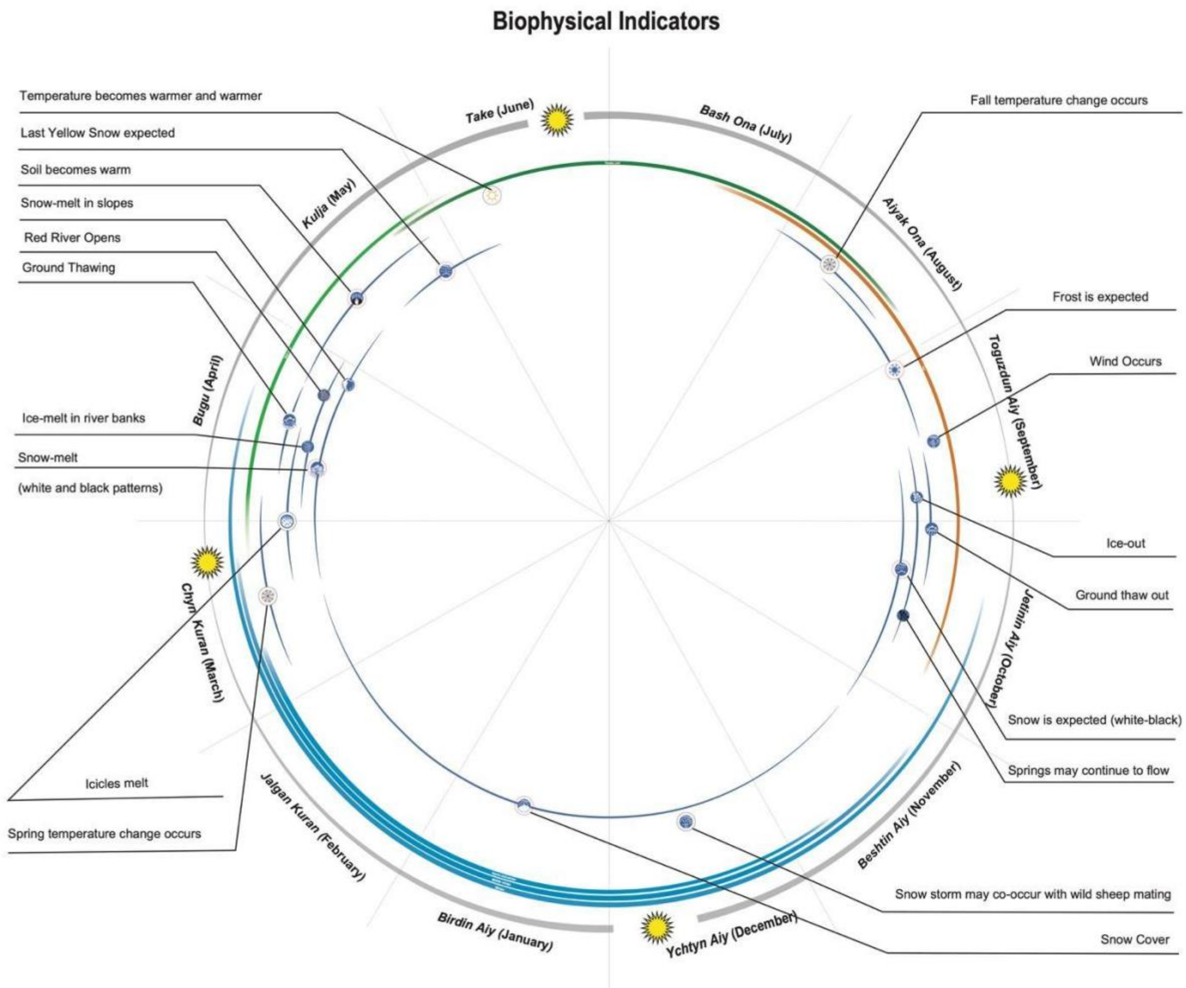


Figure 20. Biophysical Variables

It was now essential to identify those seasonal markers as winter in the Alai Valley, which lasted remarkably long. My findings showed that winter arrived in mid-October and extended to April (depending on seasonal markers). Temperatures below zero marked the overall winter period. The arrival of the first snow in mid-October marked the beginning of mid-winter. From mid-October to mid-November, snow arrived, it melted, and froze, creating *ala-telek* – white and black snow patterns in the field. This snow pattern against the dark surface of the fields (accumulation of snow) marked the arrival of the winter (Figure 21). From the time when snow arrived until it disappeared, it could also be called the *childe* period. Japanese farmers also observed white snow patterns against a dark background of the mountain slopes. In different seasons, white and black snow patterns emerged resembling various animal shapes such as a monkey or snake. This wisdom was called *yukigata*. The emergence of different *yukigata* or snow patterns was used by Japanese farmers to determine the right time to plant crops (Yasuaki et al., 2005; Kassam, 2021). The occurrence of white and black snow patterns was a unique way of studying snow melt. For example, snow patterns were used to understand seasonal changes in the Holy Cross Mountains in Colorado, and Nulato Hills in southwest Alaska of the USA (Strum and Wagner, 2010). Similarly, a community in the Alai Valley of Kyrgyzstan paid attention to the white and black snow patterns to determine the arrival of winter, and departure of mid-winter (at the beginning and end of snow cover).

Figure 21. White and Black Snow Patterns during Spring (Nulato Hills Alaska)

Source: Strum and Wagner, 2010, p. 4.

Upon the arrival of winter from mid-October to mid-November, another physical event co-occurred, the formation of ice along the rivers and streams called *guur-alat.* When *guur-alat* occurred, community members heard the sound of ice formation, which marked the arrival of overall winter. Then, in mid-November, people expected a heavy snowfall. That was when snow completely covers the fields, known as *bardalalait*, a snow accumulation. From then onwards, the Alai Valley was covered with snow until April when the snow melted. When fields were snow-covered, that was mid-harsh winter known as *40 childe* in the Alai Valley. The amount of snowfall, duration of snow cover, and accumulation/melting factors were less understood in upper Alai Valley.

Upon the end of winter and the beginning of spring, several physical indicators occurred. The mid-winter ended when icicles started to melt in late February and early March. In late March and throughout April, *guur-tyshty* – ice break occurred. It was when the ice melted and fell into the Kyzyl-Suu and Sary Mogul Rivers. People knew these changes in season by listening to the sound of ice-break. Snow started to disappear around this period, and white and black snow patterns occurred for the second time in spring. Usually in April, *sary-kar* - the last snow was also expected. Livestock grazing practices, which I discuss later, were linked to snowmelt as people cared about the first snow, the accumulation of snow, and the last day of snow. Long before this study, Swen Hadin (1889, p. 134) reported, "In the Alai Valley, on the other side of the mountains, the same month is the season of *sary-kar* or yellow-snow, the name given to the last of the snow." In mid-April, farmers observed *jerge tap kirdi* – when the surface snow has completely melted, the heat entered the ground, steam came out from the fields, and the soil became soft and dry. April and May were not stable, and snow anomalies were expected during the transition from winter to spring. Hence, such physical indicators facilitated the transition from winter to spring.

I will now briefly explain how seasons have shifted, especially during spring and fall. It was impossible to understand how seasons have shifted, especially in spring, without including the timing of historical events and livelihood activities. For example, people suggested that spring has shifted about a month, or harvesting times have shifted depending on biophysical changes. The farmers justify these shifts considering historically fixed dates with reference to currently changing conditions.

The Soviet solidarity events that were fixed in Gregorian calendars were now holding their meaning and people observe changes in the timing of their seasonal decisions. Farmers who experienced Soviet and post-Soviet transformations were well aware of Soviet events such as March 8 (International Women's Day), May 1 (Solidarity Day), May 9 (Word War Victory Day), May 24 (the last day of the school), September 1 (the first of the school) and October 25 and November 7 (October Revolution in 1917). In the past, planting sainfoin, barley, potatoes, and moving livestock to summer pasture occurred between International Women's Day and World War Victory Day. Today that was not the case. People said that planting crops and moving animals to summer pasture was now much later, at the end of May, and even into early July. There was a seasonal shift noticed in spring. During the Soviet era, people would harvest crops in October and return livestock to the village by November, except those who had to bring their kids to school on September 1. Based on interviews, I notice that seasons and livelihood activities have shifted, especially in spring and fall.

Snow, Temperature, and Rain

Despite the time conflict between Gregorian events and ecological events, people are attuned to biophysical changes in their environment. Seasons were becoming less stable and uncertain, especially changes in temperature (spring and fall), and the arrival and the departure of snow in addition to other indicators. In summer 2018, community members complained that snow departed early, but due to cold, crops did not grow well. The summer of 2017–2018 was cold, and summer has been getting colder in recent years. People complained that in some years, the grass did not grow as high as it used to be. Scientists suggested that snow depth in winter, and sunlight in summer, influenced the growing season and forage quality (Hjeljord et al., 1999). A combination of decreased temperature, rainfall, and soil quality limited plant growth influencing the biomass (Van der Wal et al., 2000). The main reason was that during winter, the Alai Valley did not receive enough snow. Locals have a particular term for it, *kara suuk*, a dark cold winter without snow. For the Alai Valley, not getting enough snow was an unusual event, and snow cover is changing.

Even when there were years with normal snow cover, the arrival and departure of snow was still unstable. According to local people, sometimes the arrival of snow in fall extended to January, which was unusual. Herding livestock longer than expected indicated that these relational events were tied to arrival of snow. Sometimes, snow covered the fields too early and the period of hand-feeding livestock were longer. The melting of snow in spring became unstable. People knew it by observing the times when livestock went to the fields, after which plowing, and planting begins. The community suggested that it can snow in the Alai Valley even in summer, which was an unexpected surprise.

The arrival and departure of snow were not the only unstable indicators of fall and spring. The temperature changes from warm to cold, and cold to warm, were also crucial cues of autumn and spring. The problem was that as the temperature increased, snowfall decreased. While the departure of snow may be beneficial for herders moving their livestock, early spring may not be the best time for planting crops, especially potatoes. Snow might depart early, and livestock might be out early, but I do not have data on the vanishing of frozen ground (thawing). Soil temperature and composition need to change for crops to be planted. At least the soil must become warm enough for potatoes to be planted, known as *jerge tap kirdi*. Although community members said that thawing varies between 5 to 15 days every year, it would still be essential to understand the relationship between the departure of snow, and changes in soil temperature during spring and fall.

The growing season (summer) in Alai Valley was short (e.g., May, June, and July). With such a short growing season, timing on planting and harvesting is critical to get a successful crop. Thus, accurately timing the seasonal changes and targeting as much of the viable growing season as possible while avoiding freeze and frost is a big challenge. Some village members argued that a cue of fall was temperature change, but others said that it was the arrival of snow. Autumn, however, was arriving too early for crop harvesting due to decreasing temperatures. Quick changes of color in grasslands informed the seasonal transition from spring to fall. Several variables can be highlighted here. Temperate changes from warm to cold, emergence of wind, the disappearance of insects, color changes in grasslands, the emergence of frost, the formation of ice in streams, the departure of certain birds, and escape behavior of sheep were all vital indicators of seasonal transitions. Changes in temperature were essential indicators for harvesting crops, especially potatoes. Early frost (locally known as *kyrgyek*) in autumn was a hazardous event, as it damaged potatoes. From mid-August to late September, temperature changes which affected several indicators, were monitored to complete potato harvest on time.

These underlying climate and ecological processes, especially in the fall and spring, define the growing season. The Gregorian calendar enables me to estimate the window of the possible events in spring and fall in order to track the growing season. Thus, the ecological calendar—an adaptable monitoring system built from components of the ecosystem directly reflects annual climatic and ecological dynamics.

Summer rains played a minimal role in the community because there was a limited impact of precipitation on livelihoods, such as livestock keeping and crop management. I have limited data concerning rain and how it has become unstable as well, especially in summer. In summer, there was a general tendency for increasing rainfall. However, some villagers argued that rain was declining. There was too much rain in spring and summer 2017. This was due to, what ecologists referred to as cloud cover in summer, which influenced vegetation growth and limited sunlight. Ecologists suggested that cloud cover and shade may affect the productivity, biomass, and forage quality of plants (Devendra, 1995). The first thunder is used as a sign of summer in Alai Valley. However, my study is limited to provide enough knowledge on the rainfall in spring, summer and fall. I elaborate on this more in the section on harvesting hay, irrigation of crops, and shearing sheep.

Anticipating Seasonal Changes

Temperature driven events were important during spring and fall. People observed the shifting seasons, the changes in arrival and departure times for snow (snow cover), and the changes in the amount of snowfall. It was essential to know specific issues that the community was facing with snow, temperature, and rain, but also to understand how collective knowledge contributed to changes in livestock and crop management. I shall first explain how seasonal shifts, changes in snowfall, temperature, ice, and soils impacted livelihoods. Physical seasonal indicators (Figure 20) were associated with planting, harvesting, and herding activities (Figure 22). In the Seasonal calendar below, I emphasized these relationships. Human livelihood activities were clearly associated with physical events.

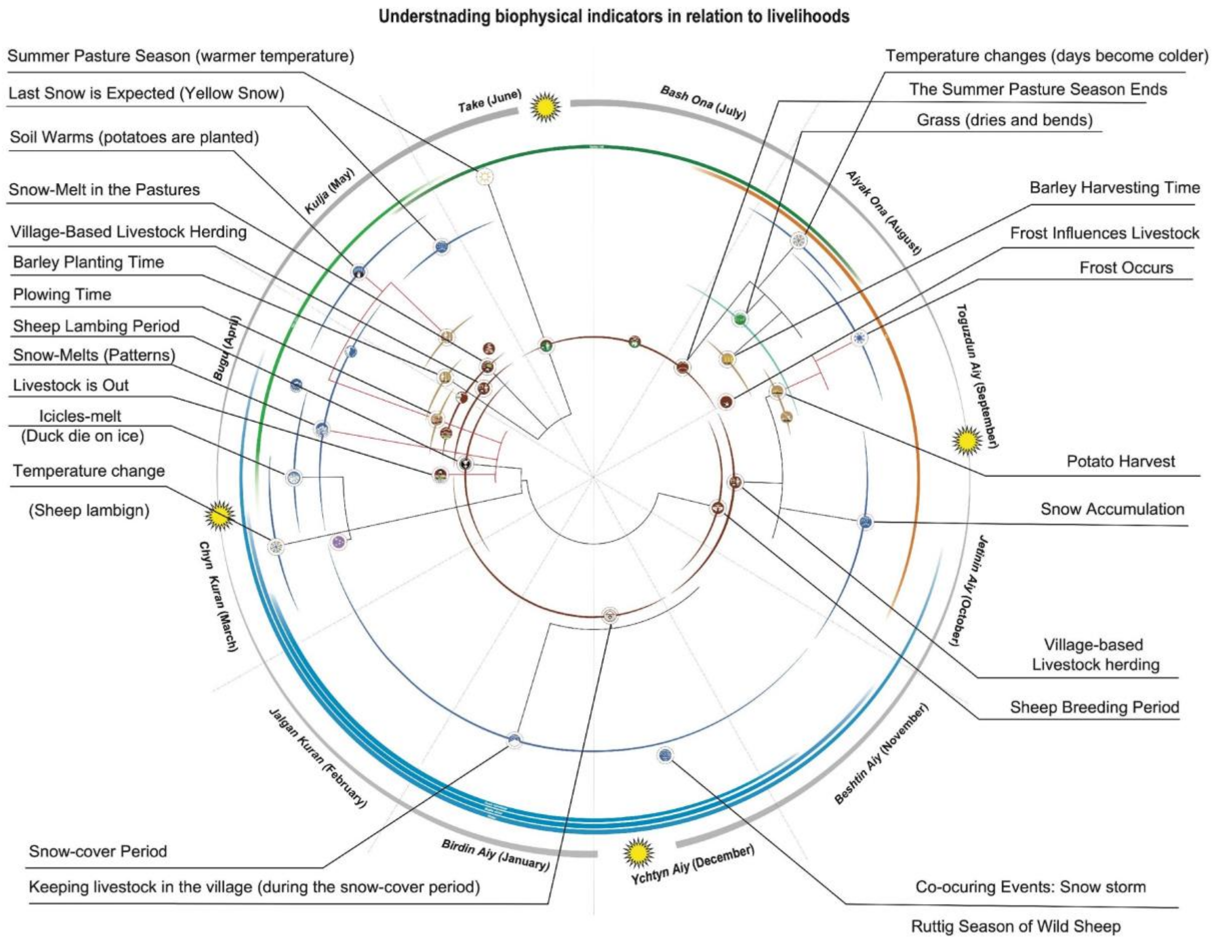


Figure 22. Understanding Biophysical Indicators (planting, harvesting and herding) in Sary Mogul

Herding activities were linked to both physical and biological indicators. Close to *tokson childe* season (mid-winter), people bred domestic sheep. However, sheep breeding was not necessarily dependent on the arrival of snow or conditioned on ecological constraints. While the average time of snow arrival was between mid-October to mid-November, this was no longer the case. Farmers know that sheep gestation was five and a half months. According to farmers, October was the best time to breed sheep, and March or April were best for lambing. Summer pasture season ended with temperature changes from warm to cold, which drove herders to the village. Livestock were removed from higher elevation pastures. Layers of ice formed in the streams and water buckets. Some farmers arrived in the village on the first of September (kids have to go to school), while others returned later, at the end of September or October. Some herders grazed livestock in the fields up to the point when the snow started accumulating. As people arrived from their summer pastures to the village, the herders bred domestic sheep. Sheep breeding sometimes corresponded with the arrival of snow. However, I did not know exactly when snow fall occurred in fall and melted in spring. Nonetheless, knowing the physical changes, such as snow fall in October and snow melt and late March, provided an approximate time for sheep breeding. The decision was made to ensure that spring lambing would begin when mid-winter ended, meaning when icicles began to melt (warmer temperatures).

Herding livestock near the village was tied to the arrival of snowmelt, snow arrival, and snow cover, and these were important variables that guided herder's practices, including moving livestock. Although the arrival of snow was variable ranging from October to January, in some years, snow arrived early in September. As farmers returned to the village from summer pasture in September, they began herding livestock around the village (village-based herding), also known as *novat* (Watanabe and Shirasaka, 2016). However, herding practice depended on the arrival and departure of snow. If snow falls less up to January, herders keep livestock in the fields, both near the village and in the pastures, but that is not the case every year. Usually, village-based herding lasted from September until mid-November, when snow supposedly covered the fields limiting access to grass. Then herders feed livestock at home until snowmelt occurred in spring. As soon as the snow melted in spring, livestock was put out in the fields. April and May were the only spring months when farmers herded near the village before summer pastures become accessible to livestock. The village-based herding was known as *kezuu* (Watanabe and Shirasaka, 2016). If the snow melted earlier in *jailoo* the summer pastures, farmers with many livestock rushed to those pastures. The key was to understand how the arrival and the departure of snow was anticipated through seasonal livestock herding practices.

Spring was one of the crucial seasons of the year as snow, temperate, and soil-related changes were vital for planting crops. The end of *tokson childe* (mid-winter) was essential for livestock to successfully give birth in spring, as well as for farmers moving livestock into the fields with the departure of snow. Temperature change, however, was also an essential sign for plowing, planting, and harvesting activities. Our teams need to clarify the changes in temperature, snowmelt, or soil thawing because my research is limited to estimate the time of snowmelt and soil temperature changes. Early snowmelt may be beneficial to livestock, but not for crop planting unless the ground temperature increased. Changes in snow depth and temperature occurred sequentially. For example, people started plowing and planting barley and common sainfoin when *tokson childe* ends, after snowmelt when the earth became dark, and *kerge tap kidi* soil warmed in April. Barley and common sainfoin were planted in late April, whereas potatoes were planted in early May, but soil temperature varied slightly year-to-year. Potatoes were planted much later, as the soil warmed enough in May. However, the first snowmelt may not necessarily mean the complete departure of snow. Topographic differences impacted snow melt (south-facing slopes melted first), especially when people prepared to move their livestock out to pasture.

As farmers continued into summer and fall, from the unstable spring in the Alai Valley, snow may fall until June. Sometimes if snow departed, planting occurred early. But if there was no *kyn,* enough sunlight and warmer temperature in April and May, crops did grow well, as happened in summer 2018. Potatoes flowered later the year, as I validated with villagers during the Seasonal Round. It is very common that some farmers mis-timed their activities due to many personal choices. The timing of crops was not equally distributed because families have different (personal) stations which influence the development of potatoes. The temperature changes from warm to cold played an essential role in harvesting crops, especially potatoes. For example, as frost emerges, potato leaves dropped and changed color. People said the departure of birds was related to the period of harvest, but it was difficult to determine if bird migration was associated with local temperature changes, or temperature changes elsewhere (see Chapter 3). The majority of villagers harvested potatoes before the end of September, as cold arrived and early signs of frost occurred. Farmers collected potatoes as soon as temperatures dropped, leaves fell, and people noticed frost on the grass and under the trees. Other indicators, such as the departure of migratory birds or hibernation of marmots, also possibly corresponded with the potato harvest.

Seasonal Livestock Management

Community knowledge reflected in the ecological calendar had a practical benefit for livestock-related decision making. Livestock, especially sheep and goats, were sensitive to changes in temperature and precipitation. For example, if there was frequent rain during the short summer in the Alai Valley, domestic livestock, especially sheep and goats, did not gain weight, or possibly died. Constant rain combined with colder temperatures during summer impacted livestock weight (fat accumulation) in recent years. Notably, early shearing of sheep and goats may have caused death during their transition from spring to summer if there was unexpected snow, rain, and temperature drops during the shearing season (May and June). During Soviet times, Uzbek farmers sheared sheep in the Fergana Valley (lowlands where spring comes earlier), and a few days after transporting the sheep to the Alai Valley, their livestock would often die due to rain and cold temperatures. Soviet farmers often faced weather surprises when allocating livestock within microclimatic zones. There was no doubt that changes in weather, especially in spring, have impacted livestock. Therefore, shearing may be scheduled a little later in summer, depending on the spring indicators.

The farmers in the Alai Valley experienced unstable weather during the transition from spring to summer (April and May). One of the main threats to livestock during spring was the *Jut* snow crisis. Due to sudden temperature changes, the snow converted into a thin layer of ice covering the grasslands. Any grazing animal faced food shortages and sometimes death. *Jut* (snow crisis) was a common event known by the pastoral tribes of Central Asia (Khazanov, 1994, p.73-74). A sudden temperature rise in winter melted the snow, and the water turned into ice in the pastures overnight when it freezes again. Bryant et al., (1983) calls this "icing" meaning, "Indeed cold weather following wet snow or rain, may lead to ice layers in the snow or "icing" on the ground surface, limiting access of herbivores to vegetation." Once vegetation was covered with ice or snow, there was no way that livestock would be able to access the grass. Long-lasting snowfalls in spring put pressure on the use of fodder reserves. The farmers often used up all available fodder, and livestock died from starvation. Fodder shortages were experienced by the herders of the Pamir Maintains (Callahan, 2013, p.135; Shahrani, 1979, 91). The people in Sary Mogul recalled several devastating icings during 1974, 1978, 1980, 1990, 1993, 2008-2009, 2012-2013, and 2015-2016 (Sary Mogul interviews). Although snow is linked to many human livelihoods, in my research I do not have a long-term trend for snow from the region as this work relies on semi-structured interviews with local people.

Although the occurrence of *jut* events was not frequent in the Alai Valley, the ecological calendar revealed daily, weekly, and sometimes monthly annual variations in spring. Physical indicators (e.g., snowmelt, thawing) in spring varied from 10 to 15 days, and sometimes even a month, due to shifting seasons. However, I did not have long-term data on the average snowmelt time in spring, and soil temperature changes in April and May. Some farmers argued that livestock was taken out to pasture 20 days later compared to the past. This situation was risky for several reasons. April and May were the lambing seasons. For secure lambing, people needed fodder. If the snow melted late, and too much snow remained longer in spring, the lambing season becomes problematic because of a lack of stored fodder. In spring 2016, villagers bought fodder from the City of Osh in order to save their livestock from *jut*. Therefore, understanding the thawing of snow in spring, especially late or early departure and arrival of snow, was crucial.

Events like *jut* could become more frequent, but farmers can only prepare for events like icing during Sprig time. It is locally known that icing occurs in springtime, estimated in May and June. None of the fall sign inform icing in spring because seasonal shifts in fall do not inform spring events. However, seasonal shifts in fall such as early snowfall or late snowfall constrains food availability in terms of harvesting. A crucial preparation for springtime is needed like storing enough fodder to secure livestock in case of icing. If I am a farmer, I would prepare for jut almost every year. Therefore, the community may store enough fodder to survive lambing during the delay of snowmelt in spring and *jut.*

Snow and Herding Practices

While climate change impacted livestock, ecological calendars helped not only to better prepare for the uncertain transition period from spring to summer, but also to know the right time to move livestock. Studies were conducted on the livestock management in the Alai Valley (Shirasaka et al., 2014; Liu and Watanabe, 2014; Watanabe and Shirasaka, 2016; Shirasaka et al., 2015). However, previous research did not focus on environmental constraints, especially the interdependent relationship of snow, temperature changes, and snow cover that drove the seasonal allocation of livestock. There were four distinct seasonal herding practices applied in Sary Mogul. Throughout the winter and early spring (from November to April), the animals were entirely dependent on herder care and stored fodder, which was the first practice. It was locally called *koldo-karoo*, which referred to hand feeding of livestock in the village when there was no access to field pastures due to too much snow. Second, as the snow disappeared in spring, the villagers herded their livestock, called *kezuu*, in nearby pasture grounds during April through May. Third during the summer season (June to August), the herders migrated from the village to *jailoo* summer pastures, where they herded livestock (Shirasaka et al. 2014, p.91). When the summer season ended in September, the herders returned to the village, and livestock herding again took place on pastures near the villages. This type of village-based herding system was called *novat* (Watanabe and Shirasaka, 2016), and the practice continued up to the point when snow arrived. While these seasonal herding practices were repetitive, the terms mentioned in different articles such as *kezuu* and *novat* were synonyms. What made these terms different was in *novat* practice, one person herds many peoples’ livestock around the village. In contrast, *kezuu* involved each household grazing their livestock independently scattered around the village. These herding practices, especially *kezuu or novad*, took place twice in a year, in autumn (September to November) and in spring (April to May). Thus, the tribes in Sary Mogul maintained the adaptive elements of pastoral practices (Figure 23). We need to ground the truth of my claims with data capturing technologies such as GPS tracking, camera traps, or drones.

The ecological implication of village-based herding, whether there is a limited carrying capacity of pastures or too much livestock in the village, is a complicated issue and the suitability of eco-calendar is a totally different topic. Even though previous research exists on the assessment of carrying capacity in various part of the Alai Valley, the carrying capacity of pastures needs more detailed analysis considering the changes in herding practices after the enclavement of Sary Mogul, which is particular to the village. The farmers struggle for territorial sovereignty even within their own country because of the enclavement history. Farmers cannot graze their livestock outside of the historically marked territory, which is the implications of enclavement history in the Alai Valley. With growing human population in the village, the notion of sustainable and inclusion needs to be further addressed.

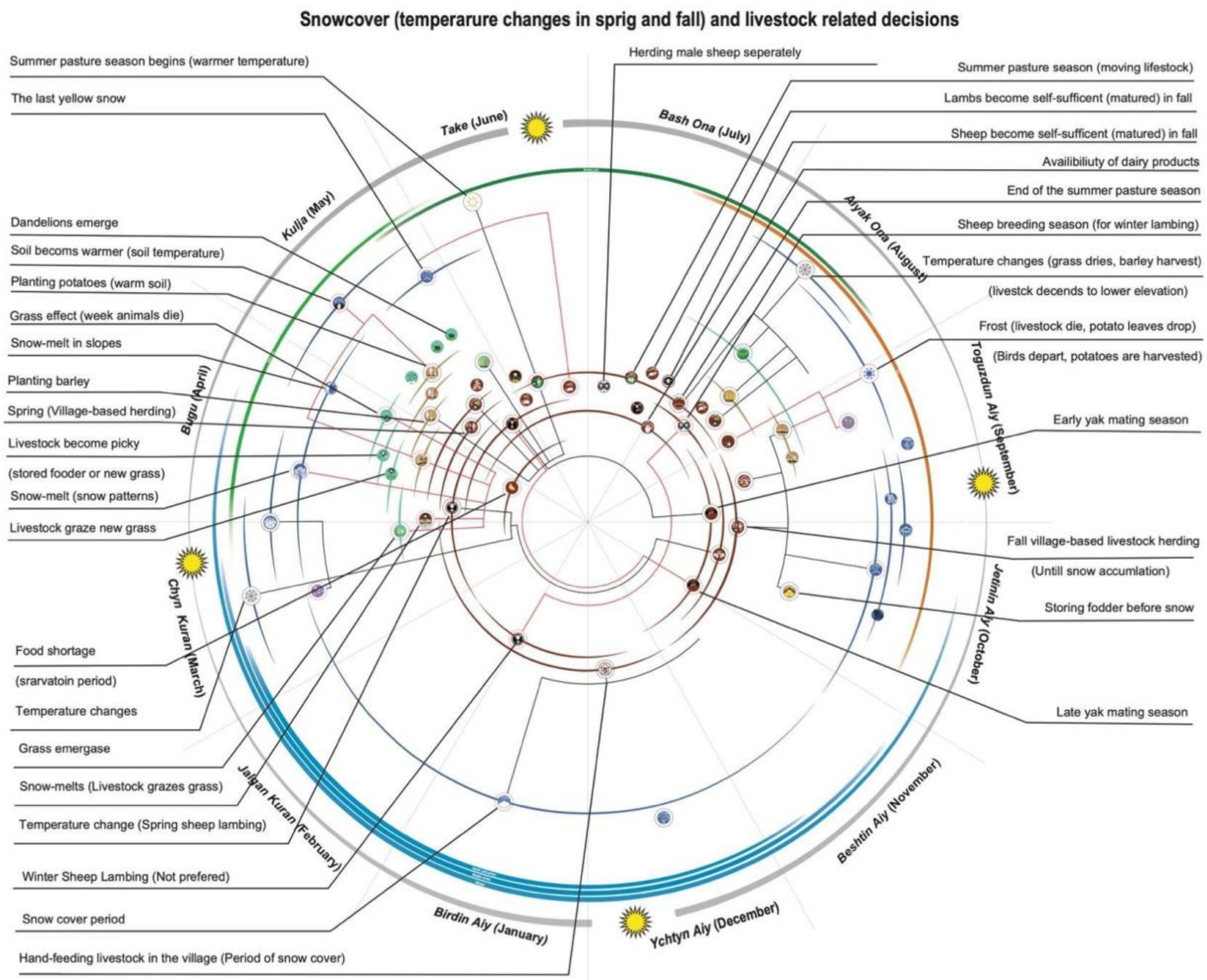


Figure 23. Seasonal Pasture Utilization in Sary Mogul Village

Maintaining livestock (sheep, goat and caw), near the village for almost seven months, a time known as *koldo-karoo* (hand-feeding period) throughout the winter and early spring, was a common practice in the Alai Valley (Figure 23). This was not the case in the past. From November until the end of April, the livestock was maintained at farms within the village. This period was strictly marked by snow cover. Farmers were experiencing *kara suuk* – a dark cold or winters with less snow. Seeing the Alai Valley without snow was a strange event, but it was very rare and unusual. In other words, people do pay attention to the variable changes in snow cover every year.

Nonetheless, from mid-October to April, snow cover remained in the upper Alai Valley. The arrival of snowfall in November prevented animals from grazing near the village, therefore, animals were sheltered and hand-fed in home shelters until the snow disappeared in April. Herders simply could not move livestock to different winter pasturelands with less snow and open grass fields. Given the current situation of village-based life during 6-7 months of snow cover, and limited access to pasture during snow cover, people decided to hand feed their livestock at home.

The practice of *koldo-karoo* began in the early Soviet period as local tribes were forced to settle in a place with long duration snow cover. Due to this forced settlement, the nomadic herders were no longer able to migrate and utilize seasonal pastures elsewhere following the traditional patterns, such as wintering *kyshtoo*, summering *jailoo*, and autumn *kyzdoo*. Historically, the pastures around Sary Mogul were only used during the summer *jailoo* period. George Littledale, a 19th -century British traveler, wrote that "Gulcha is situated in a grassy valley, a couple of miles wide with groves of timber. Up a valley to the north-west here is a beautiful view of some fine snowy peaks forming parts of the chains of the Little Alai Mountains; there were a great many Kirghiz encamped in the valley waiting until the snow should melt on the higher ground, then they would gradually push on to the Alai Plateau…" (Littledale, 1891, p.7-9). Even today, local herders move from 2500 m.a.s.l elevation up to 3500 m.a.s.l to the Alai Valley (Liu and Watanabe, 2015). As the tribes were forced to settle, especially in Alai Valley, herders were restricted in their mobility and utilization of seasonal pastures elsewhere, especially during the winter.

Second, when snow started to disappear in April (it varied year to year), farmers started herding their livestock, relying on the *kezuu or novad* practice (herding around the village). In other words, village-based herding began in April when icicles started to melt, snow disappeared, and the last snowfall arrived. Some descriptive terms characterized the snowmelt events such as *guur-tyshty* (ice melt along the rivers), *ala-telek* (appearance of white and black snow patterns in the fields), and *sary-kar* (the arrival of last the yellow snow). These were associated physical events observed by the community in April. Along with these changes, pastures turned green, known as *Kok Chykty* (emergence of green vegetation). A flower named *Mamakaimak*, dandelion (*Asteraceae*), emerged as well. Early vegetation period was a key marker of spring.

Furthermore, villagers observed behavior changes in animals and their reactions to the newly-emerged vegetation. As the fresh grass appeared, livestock began grazing the grass around the village. This behavior was locally known as *kok kubuu.* Some animals that were weak (unhealthy) died during this period known as *kok-suruu* (natural effect of fresh grass) or scours – diarrhea common among livestock. The herders in Sary Mogul did not worry about scours because they called this *ulgoo* (the naturally happening process). This period was also considered to be *arykchylyk* (lack of weight) as animals were undernourished after a long winter. Lambing season and lack of vegetation were the main reasons for the undernourishment. Transitioning from winter to spring reactivated village-based *kezuu or novad* temporal practices. From there onwards, this village-based herding system continued until the end of May and early July, when the farmers finally migrated from the village to the summer pastures, especially when the temperature became warmer and snow melted. People visited the Tuiuk pasture, which was about 50 km from the village, where snow can be observed all year round because of the glaciers of Zaalai Range.

Third, moving to the *jailoo* summer pasture began in late May and early June, depending on the arrival of spring and departure of snow (Figure 20). This literally meant that the departure of snow and emergence of grasses, which varied from year to year. According to a 2016 survey conducted by the Swiss Development Agency, 70% of villagers moved livestock to summer pastures (Ibraeva et al., 2016, p.7). The villagers knew the right time to move by observing the snowmelt, when the grass field opened up in the pastures that were located in the south (Zaalai Range) and north (Alai Range) ranges. Some people stated that the right time to move livestock to summer pastures was a month after the barley was planted, when it developed *maiza* spikelets (end of April to end May). Although there was a relationship between planting time for barley and moving livestock to pasture, both activities depended on the same physical process in spring. If plowing and planting began early, then pasture season began earlier as well. In other words, if the snow melted early, both land-use activities, as well as the allocation of livestock, took place early. If herders remained in the village, practicing village-based herding became impossible, as newly-emerged barley was under the risk of being eaten by animals. For this reason, after barley was planted, livestock needed to be moved to summer pasture.

Maize or ripening time of barley was not the only cue used to determine the summer season. Animal behavior changes were also used as climate sensors. During the summer *kok chykty* grass emerged, and *kok kubuu* livestock grazed the newly-emerged grass in higher pastures, gaining weight in spring. Community members observed that livestock became picky and refused to consume reserved fodder, especially when fresh grass emerged (Figure 23).

The ecological calendar also contributed to an understanding of the seasonal availability of dairy food products (growing season). As the spring lambing season began, the milking season began as well. This meant that people experienced *Ak-chykty* (availability of milk products) from April to October (Figure 23). For mobile herders, milking season may end in September, while some farmers could continue milking, especially cows, if they did not move. Dairy products were processed and stored in summer, and were consumed until the next spring, especially during April and May.

Dairy products were the main diet of the pastoral communities in the Pamirs (Shahrani, 1979, p. 93; Manaev and Ploskikh, 1983, p. 84; Dor, 1993, p.81-85; Khazanov, 1994, p.67; Jumabaev 2009, p.73-77; Callahan, 2013, p.125-29). Yogurt was preserved in solid form after several processes of drenching and boiling with other dairy ingredients. The thick layers of butter after milk was boiled was washed, boiled, and stored in the rumen of sheep or yaks. Food acquired from livestock, especially dairy products (*syt* - milk, *ayran* – yogurt, *kaimak* - cream, *kurut* cheese, *saamal*- horse milk, *kymyz*- fermented horse milk, *karyn mai* - butter, *sary mai* yak butter, and *syzmo,* processed yogurt) were produced, eaten, processed, and stored in cold places from March to October. This period was known as the long yellow *uzun sary* (starvation period). Thus, the availability of dairy products from April to September was essential, and farmers took advantage of the short summer growing season to produce dairy products used year-round (Figure 23).

Many scholars have written about food systems of tribes in the Pamirs, but few mentioned that dairy products were stored for the stressful seasons of the year (food shortage) known as *uzun sary* (period of day length change in spring). For example, yogurt "The staple milk products among Kirghiz during the milking season are *ayran* (sour milk). *Ayran*, a thin, curdled, sour milk that is reasonably palatable, is made from milk by adding a certain amount of water, bringing it to a boil, and after cooling, adding *oytuqi* or starter. For the starter, the Kirghiz use either fresh or dried *ayran*." (Shahrani, 1979, p.93; Callahan, 2013, p.125). During summer, milk was processed and converted to yogurt. Because the milk spoiled gradually in hot summer, yogurt was made to extend its long-term quality. *Kaimak* was a creamy butter processed and produced from milk. Once villagers moved livestock to summer pastures, they obtained creamy butter from yak, sheep, and goat milk. After the milk was boiled, it was left in a cool place overnight. As days passed, the top surface of the milk solidified into a creamy layer. The seasonal availability of creamy butter was from April to September. *Kaimak* was a typical food produced by pastoralists in the Pamir Mountains (Shahrani, 1979, p. 93; Callahan, 2013, p.125). All of these products were consumed during the most stressful time of the year (April and May).

Of course, many other types of food were stored for the most stressful period of the year in spring. I only referenced the crucial food sources of herders in the ecological calendars. I learned that yak butter was stored for spring. Because the spring is stressful season after winter, people store butter. It was known as *Karyn maim,* a solid stored butter rather than liquid butter. Throughout the summer and fall, the farmers produced butter and stored it in a shady place. The butter was formed to a duck shape, and then stored for winter and spring. It was often opened and consumed in May during a period with few food resources (Sary Mogul, interviews). *Syzmo* – was a dried form of yogurt in a handwoven string bag that was dried for several days. Once the water from yogurt evaporated, the herders kept it in their cooler houses, shade, and underground storage, and consumed it in winter and spring. *Syzmo* was commonly produced by mountain communities of the Pamirs Mountains (Callahan, 2013, p.126).

Herders were in their summer pastures, the *jailoo* during June to August (Figure 23). People were busy doing various seasonal livestock-related activities. Calving and foaling season began for large animals like yaks and horses. The calving season for yaks, known as *topoz tol,* continued from mid-May to June. In mid-June, farmers sheared sheep called *koi kyrkym.* In July, yaks were sheared known as *topoz kyrkym.* Weaving yak and sheep wool *jyn yiryy* allowed women in Sary Mogul to make various types of rugs (*taar, chadar, gajary, eki jyzdyy,* and *terme*). They also prepared belts (*boo, uug tizgich,* and *jel boo*) and specially-designed felts (*ak kyiyz*, *orgo kyiyz*, *kara kyiyz, choimo kyiyz, oimo,* and *shyrdak with jeek*) all made of wool (Akmataliev, 1996; Bliss, 2006, p.200). Yak and sheep shearing were seasonal activities upon which local productivity relied. During summer, male sheep were separated from the flocks, called *kochkor bolynot* in June, which was one of the most important decisions. A special herdsman called *kochkorchy* was hired to herd male sheep separately from June to October. By the end of August, the spring-born lambs became *kozu-torolot* (self-sufficient), and they were sheared as well, which marked the approach of autumn.

Figure 24. Drying Piled *Ganek* Manure in Summer.

During the short growing season, farmers did their best to carefully store enough traditional fuel (manure) to use during winter and spring (Figure 23). Villagers used animal manure as fuel (Figure 23). A recent study showed, “Consumed *kuik* (manure) originates mainly from livestock, as 62 percent of households used *kuik* as fuel” (Sonntag, 2016, p. 161). In late April, the farmers moved *kuik* (manure) outside of the farms to let it dry throughout the summer

(April to August). The farmers had special ways of preparing *kyk-kes*yy (cutting) and stockpiling the manure called *ganek* (piled manure, Figure 24). Drying the manure depended on the availability of sunlight, wind, and favorable weather in summer. Too much rain in summer could damage the fuel source, preventing drying. In August, people stored the dried *kyk* in a protected place for winter use. This traditional fuel source was widely used among the pastoralists of the Pamir Mountains (Shahrani, 1979, p.41; Callahan, 2013, p.129). Hence, the ecological calendar may even be useful for understanding the seasonality of traditional fuel sources and their relations to weather.

In early September when the *jailoo* season ended, the pastoralists returned to the village with their flocks to continue *kezuu or novad* practice, which was the fourth herding practice (Figure 23). As soon as cold arrived, the summer pasture season ended (late August to mid-September). The arrival of autumn was associated with the changing behaviors of livestock. In late August, livestock did not graze in the higher pasture lands, and they kept descending to lower elevation fields as a result of declining temperatures. The livestock started to leave higher pastures even if there was grass available. This livestock behavior was called *otko-kachat*. When summer ended, horses stop producing milk. An unexpected sudden frost could threaten lambs in late August to mid-September. However, not everybody returned to the village when these events occurred. In Sary Mogul, some farmers had houses near their summer pastures where they could stay year-round. When the majority of herders returned to the village, farmers without wintering shelters took shifts and herded the animals near Sary Mogul (September to October). Once again, people shifted to *novat* herding (Watanabe and Shirasaka, 2016). *Novat* herding was crucial because the herders grazed their livestock in the fields outside of the village as much as they could until *bardalalait* the heavy snow arrived in November. Even those who remained near the summer pasture utilized the same *Novat* practice until snow accumulated, and they shifted to hand-feeding practices. Some wealthy farmers, who grazed their livestock all year around at one location also practice handfeeding. When deep snowfall accumulated between October and November, herders shifted to *koldo-karoo* (feed by hand) practices, which continued until April and even May, when the snow melted later.

Timing of domestic sheep lambing

Understanding the changes in temperature and snow that drove seasonal herding practices was not the only use for an ecological calendar, as it also informed the timing of sheep and goat breeding. As the winter approached in October and November, the herders timed domestic sheep breeding to plan for *baargi tol kiret* (spring lambing) in March and April (Figure 23). Currently, October seemed to be the best time to breed sheep, because farmers had to be certain that lambing in spring took place when temperatures were warmer. Although some farmers undertook *kyshky tol* (winter lambing) during January and February, this was not commonly preferred. Cold temperatures during winter, the fear of exhausting fodder reserves, and uncertainty of shifting spring seasons, were the primary concerns. If the winter temperature was too cold, the young lambs might not survive during January. Furthermore, the winter lambing demanded farmers' attention and required much fodder. Having some fodder remaining for spring was crucial, because situations with snowmelt in spring were uncertain. The key, therefore, was to time livestock breeding to take advantage of warm temperatures during spring, especially in April.

The timing of sheep breeding was essential for the community, but it was hard to know when temperatures would change in spring. What I learned was that the villagers counted 5.5 and 6 months ahead when breeding sheep. When deep snowfall arrived during October or November, the farmers bred sheep and goats, known as *kochkor koshylat* (the male and female sheep are put together). Once the herders returned from their summer pastures, as temperatures dropped, sheep breeding began. I was told that the primary threat in autumn was *kyrgyek*, a sudden frost that could kill both small livestock as well as damage potatoes. While the notion *kyrgyek* referred to frost and the return of the migratory birds in the Alai Valley, among some pastoral tribes of Kazakhstan, *kyrgyek* related to protecting male sheep from mating in summer, and removing the apron in fall. Ethnographic sources suggest that *Kyr'giok (kiok)* was a period when male domestic sheep were ready to mate, but the herders applied an apron so that they could not mate during summer. The apron was removed in October (Фиельструп, 2002, p.211). However, in Sary Mogul, people herded male sheep separately from females during June to October. Unlike the pastoral tribes of the Alai Valley, Kazakh tribes did not herd male sheep separately from female sheep, but instead used a special apron to control livestock mating seasons. That apron was called *kyrgyek* in Kazakhstan. When to breed sheep in the Alai Valley corresponded with specific physical changes, such as *bardalalait*, the formation of ice and snow. Five months after breeding sheep *kochkor koshylat*, in October, *baargi tol kiret* (spring lambing) took place, around March or April.

Another ecological sign that informed seasonal shifts in the Alai Valley was *topoz jugurot* – mating season for yaks (*Bos grunniens*). Surprisingly, I learned that yak mating and calving seasons were monitored as a sign of seasonal shifts. Yak mating periods varied from July to November, and they bred at different times every year. According to herders, yaks were very clever and climate-sensitive animals. Yaks gave birth 256-257 days after mating, which was between 8.5 and 9 months (Sary Mogul, interviews). Similar to sheep lambing season, yak calving took place in spring when the temperature was warmer. If yaks mated early, then the spring would come early, and winter would be *jenil* – meaning not difficult. Summer would also arrive earlier, and *topoz tol* yak calving period may occur from May to mid-July, during the favorable summer season. On the other hand, if the yaks delayed their mating in fall, this was an indication of the *oor* – heavy winter extended to spring. Pastoralists in Sary Mogul suggested that the average yak mating time should be in early October. Because yaks were locally considered to be semi-wild animals, farmers actively noticed yak mating to mark the arrival of autumn or early winter. Moreover, farmers estimated summer considering the yak calving season (Figure 23).

The Yak mating season varies year-to-year, and the late mating of yaks was not desirable in the Alai Valley. It signifies a shifting of summer. In yak herding cultures, female yaks and their young were maintained near villages for milking purposes throughout the summer and autumn. However, males were left free in higher-elevation grazing pastures. The male yaks were often independent of the herders' attention throughout summer and autumn. During this period, male yaks would stay together and graze on their own, and the herders used binoculars to make sure they were safe from wolves. In contrast, female yaks and young were maintained close to human settlements because they needed to be milked regularly. When the yak mating period approached, male yaks returned to *jele* – the place where female yaks were milked. If yaks mated very late in November, local farmers argued that the winter might be too long, there might be too much snow in spring, and summer would arrive late. The local pastoralists noted that, "during yak mating period, sometimes male yaks come to *jele* – a place where female yaks were milked, and simply returned to the mountains without mating. This could be a cue of a long-lasting harsh winter, which may extend into spring" (Sary Mogul interview).

Livestock management in the Alai Valley was sensitive to temperature changes and has always been impacted by annual weather variability. Early shearing during the summer, or too much snowfall in late spring threatened livestock, especially during the lambing season. However, the community in the Alai Valley adapted to local weather changes and retained their capacities by utilizing their rich knowledge of pastoralism and herding practices. While there were several prior studies conducted about pastoral practices in the Alai Valley, I argue that herding practices were associated with temperature changes, snowfall, and snow cover. I also highlighted the vital contribution of the ecological calendar towards livelihoods security. The ecological calendar informed the pasture committee, and allowed herders to time livestock breeding, planting food, and store traditional fuel.

Seasonality of crop production

The ecological calendars may be valuable not only to livestock management, but also to crop production as well. Although the community was experimenting with various crops, predominantly potatoes, barley, common Sainfoin, and fodder grass, the impacts of local weather changes were noticed. Spring was unstable due to shifting seasons, and stressful due to food shortages. To maintain livestock during the lambing season, farmers needed enough barley, common Sainfoin, and fodder grass. However, late snowmelt can put pressure on the availability of fodder grass. If snow melts late (icing occurs), the community was at risk of using up all the stored fodder, which happened in 2016. Crop production in spring did not happen until specific physical indicators occurred in spring, such as the melting of ice and snow, thawing ground, and changes in soil composition. Potatoes were in the greatest danger, especially during the harvest season, as early frost in autumn may damage potatoes. The knowledge in the ecological calendar benefitted villagers to address these challenges. The community planted crops relying on physical events in spring and fall. To safely overcome the uncertain spring, the community stored enough fodder grass. Further, by observing ecological indicators of autumn, specifically temperature changes and the departure of migratory birds, harvesting of potatoes could be scheduled a little earlier. Hence, the knowledge in our ecological calendar further aided the seasonal coping strategies of farmers.

Small-scale crop harvesting, such as potatoes, barley, Espartset (*Onobrychis*), also known common Sainfoin, and various *talaa chop* fodder, was a vital source of livelihoods. What was an interesting positive change, is the possibility of growing potatoes as well as increasing willow trees in the village. Villagers from lower elevations with agrarian cultures knew that willows were used not only for aesthetic reasons, but they also used to protect crops from wind. Some people built walls to protect their crops from wind, whereas others used both methods. Ecologists suggested that controlling sunlight may actually benefit growth quality in certain plants, leading to early phenological outcomes (Bryant et al., 1983). The success, thus, not only depended on soil quality, irrigation and sunlight, but also possible wind damage as well. In addition to the main crops, people experimented with dill (*Anethum gravelens*), carrots, radish, garlic, and onions. Notably, growing *karagat* blackcurrant (*Ribes nigrum*) was locally perceived as a positive change. While these crops were new, barley, common Sainfoin, and fodder were vital to the harvest as they ensured livestock security. Common Sainfoin, was a productive plant that could provide 7-10 years of yield without re-planting. According to local people, barley was a top-quality fodder, after Sainfoin, and other grasses harvested for livestock. People were also familiar with *ak-bash godo* grass *(Stipa Orientalis), budai bashy* grass *(Poaceae) kara-bash* grass *(Poaceae),* and *kiyak* grass *(Leymus secalinus).* Currently, all of these crops, including barley, were not processed nor consumed by humans, except for potatoes. In the lower

Alai Valley, people still process barley while in the upper Alai Valley, barley does not reach full size to be consumed by humans. During the Soviet Union period, barley used to be processed and eaten. Today, unfortunately, many people in Sary Mogul, buy exported wheat from Kazakhstan, and do not process barley for human consumption. Thus, barley, common Sainfoin, and fodder were essential resources for livestock.

While crops were essential for livelihoods, crops were threatened by annual weather variations. In the Alai Valley, grass did not grow as high as it used to. In 2018, some farmers argued that their crops were better compared to their neighbors because they maintained soil with livestock manure. A decline in precipitation (less snow) during winter and favorable summer could also contribute to this process. Moreover, the grass was not as productive as it used to be, especially during the rainy season in summer (cloud cover). I refer to natural grasses that were not planted by Soviet collective farmers. However, I do not have data on summer rainfall levels, and this perception was based on qualitative research. People associated successful growth of grass with more snow in winter and favorable weather conditions (enough sunlight) in summer. While I cannot say much about rain increasing or decreasing, it was too wet during summer in 2017. It may also be related to cloud cover and late snowmelt in spring, which affected forage quality and growing season. That year, crops did not grow well. Favorable summer weather was essential for crop production. If farmers did not grow and store enough fodder for spring, the community may run out of fodder during years when there was a delay in snowmelt. If it rained too much during fodder harvesting in fall, collected grass may be molded (turn dark due to wet grass), which would reduce livestock survival, especially when pastures were inaccessible due to too deep snow. Therefore, storing enough fodder was vital to preparing for an uncertain spring.

Local people experimented with intensively growing potatoes since 1990, but without scientifically-proven, climate-resilient seed. Local variations of potatoes exist: *Germansky. Picaso, Kardinal, Agava, Jele, Super Elita,* and *Chelpek.* When the Aga Khan Development project addressed the food crisis in the Alai Valley region (1998-2000), the *Chelpek* seed was brought from Chelpek Village farm, near Yssyk Kul Lake of Kyrgyzstan. Chelpek Village was located at a similar elevation, and the hope was to find suitable seed potatoes that would grow in Sary Mogul. Some seed potatoes were brought from *Jar-Bashy* (western end of the Chon Alai Valley), Kyrgyzstan, and also from Suusamyr, a 3000-meter-high valley between Osh City and Bishkek City. Seeds were also brought from Ishakshim (Wakhan Valley) in Tajikistan and planted in Sary Mogul. Some of these crops matured in 60 days, whereas others matured in 90 days. Successful potato growth depended on sunlight, soil quality, and use of livestock manure. These local experiments with seed potato varieties suggested not only the complexity of local crop experiments, but also informed continuous adaptation strategies for the community.

By observing ecological indicators that were triggered by temperature changes (cold days, frost, and drying plants), villagers protected potatoes from frost in fall. Potatoes were important for the community because they provided food, income, and seed stock. In 2017, one family produced 3 metric tons of potato yield. The family kept 1 ton for personal consumption, and a half ton was stored as seed. The rest was sold in *kochmo* bazar, the Thursday market. In summer 2018, a kilogram of potatoes was sold for 25 som, barley was 25 som (equivalent $0.38 USD) Common Sainfoin was 60 som of Kyrgyz money (equivalent $0.88 USD; Sary Mogul, interviews). These food sources, especially potatoes, were stored in root cellars to be consumed during winter and spring. There was much uncertainty concerning potatoes harvest in early September. The longer that potatoes stayed in the ground, they developed bigger sizes and harder skins. This was not always possible because *kyrgyek* a great frost, may occur between mid-August to mid-Spring. If the potatoes were not collected before the frost, the plants might get killed, or potatoes may be collected half-developed. During 2008-2014, frost damaged potatoes several times, as documented by Swiss sponsored surveys (Ibraeva et al., 2016, p.9). These events occur from mid-August to mid-September, but it would be good to have historical data on this.

I will now explain the seasonality of crop management. Locally known as *amal-aiy* a month of plowing and planting, was expected after the 21 March, when the *Navruz* spring festival occurred. In Sary Mogul, crop planting began in April and extended into May. When spring arrived, people observed a list of biophysical processes known as *jerge tap kirdi*. Farmers in Sary Mogul knew the right time to plow and plant after the snow disappeared, and the ground thawed. Barley and common Sainfoin were planted in April, while potatoes were planted by mid-May. Local people stated that they could not plant unless the soil was thawed, as it was impossible to plant seeds into the frozen ground.

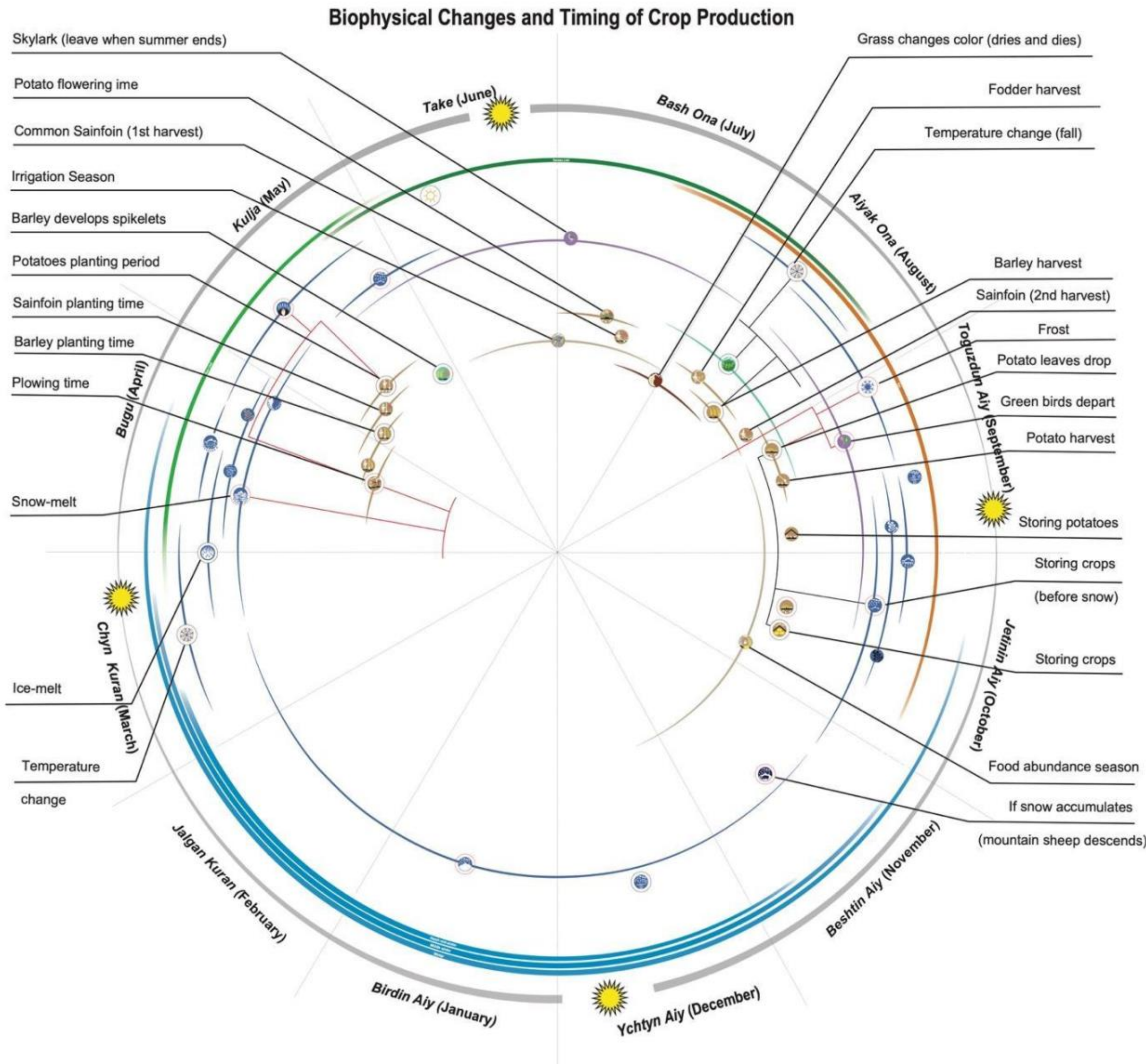


Figure 25. Biophysical Changes and Crop Harvesting

Due to limited results of our semi-structured survey, I was not able to quantify the timing of potato crops for spring of 2016 and 2017. Because it was a semi-structured interview asking farmers to recall the timing of their activities in 2016, and for the future in 2017, farmers did not provide exact dates. I asked if the time for barley and potato planting varied during spring 2016 - 2017, or harvest in 2016. I surveyed 40 informants (18 male, 18 female and two family members) during summer 2017. Local people stated that crop planting began at different times.

Some argued it was 5 -10 days later, whereas others argued it was 15-20 days earlier. The *jerge tap kirdi* varied year-to-year depending on the time when the soil temperature changed (Figure 25). Planting time for crops fluctuated every year in spring, depending on physical changes such as snowmelt, thawing, and soil temperature increases.

While it was difficult to observe variation in planting for 2016 and 2017, community members asserted that today's land-use activities were not beginning in April, but in May. As for the harvest, farmers usually collected potatoes starting after the second week in September. My interviews did not indicate extreme timing shifts during autumn. I learned to estimate crop timing periods during both spring and autumn. Generally, crops (Barley, Sainfoin, and Potatoes) were planted in April through May, and then were harvested in August through September (Figure 25). Because timing for potatoes was subject to soil temperature changes during planting, and frost in autumn, a week difference could occur in the time of potato planting. Only one respondent suggested that the more potatoes stayed in the ground the better it was. However, sudden temperature declines (frost and cold) did not allow farmers to keep potatoes in the soil until October.

Throughout the summer (June, July, and August), farmers irrigated crops, both inside and outside of the village. While many communities in the Alai Valley depended on surface water for drinking (Shirasaka et al., 2014, p.86; Ibraeva et al., 2016, p.9), crops also needed surface water from glacial streams, such as the Sary Mogul River. Outside of the village, crops were irrigated by small streams that flowed directly from the mountain ranges. The main river *Kyzyl-Suu* in the Alai Valley was not used for field irrigation in Sary Mogul Village. Depending on how much rain the village received during the short summer, barley was irrigated 3-4 times throughout the season. The first irrigation occurred about 40 days after planting. As soon as the barley heads turned dark, it was a cue to irrigate. Rainy summers reduced crop irrigation. However, too much rain also prevented successful crop growth. Similarly, potatoes were also irrigated three to four times, about 20-30 days after planting. Throughout the summer, villagers took turns in irrigating plots. Each section of the village received three-days of water flow administrated by the village organization. Farmers did pay attention to the flowering time for different potato varieties compared to the previous year. Throughout the summer, farmers tilled the soil, creating extra space for crops to grow well. They also remove extra grass that competed with the main crop.

When summer ended in early August, temperature changes drove harvesting seasons. The arrival of autumn was informed by *ot-kaity* (color change in vegetation), particularly when the *ak-bash godo (Stipa orientalis)* and barley started to bend, changing color from green to yellow. There was a morning wind called *galdurgan shamal*. People stated that this wind in particular informed the beginning of autumn season. Common Sainfoin was harvested two times, in July and in September. Crops such as barley, Common Sainfoin, and natural hay needed to be collected during August to late September before livestock returned to the village. Otherwise, barley and common Sainfoin were at risk of being eaten by the livestock.

The biggest problem facing crop management was not the timing for planting crops, but rather uncertainty during crop harvesting. Unexpected frost threatened potato harvest in autumn. People would like to harvest potatoes in October. However, farmers harvested the crop in September because of early frost. Compared to villages at lower elevations in the Alai Valley, farmers in Sary Mogul collected potatoes much earlier. Only a few people kept their potatoes in the ground to mid-October, the point when potatoes developed harder skins and were fully mature. Frost may occur three or four times during the transition period, informing the community to begin crop harvesting. Early signs of frost were vital indicators for crop harvest. Potatoes never grew to full size in this village due to the short growing season and early frost.

Knowledge in the ecological calendar informed people about when to plant and harvest crops. The farmers stated that they began land-use activities after snow melt, and then harvested crops before the arrival of snow. However, snow melt and arrival depended on temperature changes, especially between April and May, and then during August through October. Given the presence of multiple temperature indicators (e.g., insects, animals and plants), observing co-occurring temperature-related events provided growers with valuable data for decisions. Otherwise, villagers may lose potato crops if an unexpected frost arrives. For example, a family received about 1 ton of potatoes, which is equivalent to 5 – 10 bags (50 kg per bag) potatoes. With an increasing population over 5000 people, potatoes were an essential food source.

There was co-occurrence between bird migration and land-use activities, especially in the fall. People stated that crops were planted only after the arrival of migratory birds, especially *torgoi* (Skylarks). The frost that threatened potato crops, known as *kyrgyek,* was associated with the departure of migratory birds. However, I did not know what exact bird species were important. When small, thumb-sized green birds landed on the stem of grass, it signaled cold. Local knowledge for identifying species was limited, but I think that the birds could be either Humes Warbler (*Phylloscopus humei*), Greenish Warbler (*Phylloscopus trochiloides*), or Sykes's Warbler (*Inuna rama).* The departure or return of migratory birds informed the community about temperature changes, in particular, the arrival of cold in fall.

Plant Phenology

The ecological calendar provided a window into the short growing season in the Alai Valley. Some plants were used as cues to guide livestock herding, along with other indicators.

When fresh grass emerged, *baichechekei* snowdrops, *mamakaimak* dandelion (*Asteraceae*) and *kyzgaldak* poppies (*Papaveraceae)* indicated spring arrival. The farmers knew several plants that were essential seasonal markers. Markers such as grass and flower emergence, served as signs of seasonal changes from spring and summer. The plant cues informed livestock-related activities as mentioned above. Observing grass emergence, farmers knew when it was time to move livestock to summer pasture. Observing drying grass and color changes in pasturelands, herders knew that it was time to move livestock to the village (Figure 26).

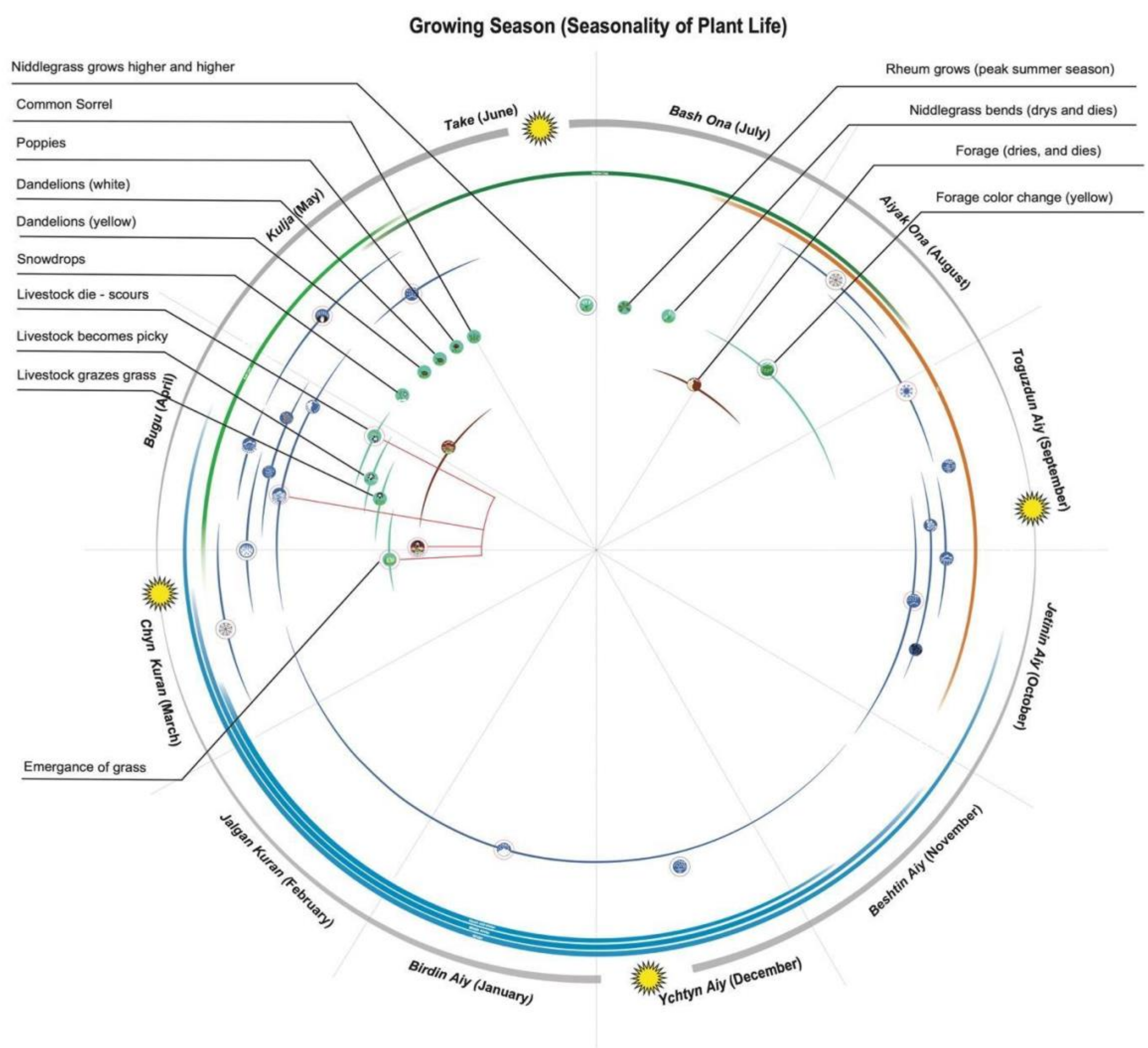


Figure 26. Seasonality of Plant Life in Sary Mogul

Seasonal changes also impacted plant communities in Sary Mogul. When spring arrived in April, *kok-chykty* grass emerged. Sometimes, grass emerged much earlier, called *jalgan jai,* a fake spring. People were familiar with *ak-bash godo* grass *(Stipa orientalis), budai bashy* grass *(Poaceae) kara-bash* grass *(Poaceae), kiyak* grass *(Leymus secalinus)* and *at-kulak* common sorrel *(Rumex acetosa).* Collectively these fodder plants were named *ot* – fodder grass. When autumn arrived in August, *ot-kaity* occurred, when fodder grass stopped growing and changed from green to yellow. I do not know why grasslands in the Alai Valley were drying too early, but this could indicate an early autumn. During the Soviet era, the grass height in the Alai Valley used to be much greater. Farmers told me that currently the grass does not grow as it used to before. This may mean that during winters, the Alai Valley is not getting enough snow. I do not have data to know whether Soviet farms used fertilizers or other chemical compounds in the fields outside of the village.

The Alai Valley had a short growing season. After late June, grass started to grow higher through a process called *jer kopty* and *ot koptu*, or enriched grasslands. When summer was at its peak, people observed *Chykyry* Rheum *(Rheum reticulatum Los)* in the valleys. The full growth of this plant indicated the peak of warmer days. There were few plant indicators for autumn arrival in August, *ot-kaity* (the return of the grass) referred to *ak-bash godo* grass (*Stipa orientalis*). These grasses changed color from green to yellow during mid-July to October. This color change took place earlier on *Kyngoi* (the sun-facing) slopes compared to *Teskei* (the shade facing) slopes. This knowledge about slope difference was valued and widely shared among pastoral communities in the Eastern Pamirs of Afghanistan (Shahrani 1979, p.14-116; Callahan, 2013, p.92-207; Soelberg and Jager, 2016, p.3). When *ot-kaity* occurred, common sainfoin started to lose its pink and purple flowers, which signaled the arrival of autumn. I learned that plant indicators informed farmers about the right time to harvest crops. Ecological indicators were used in relationship with one another. Farmers observed plant cues to navigate livestock management activities and crop-related decisions.

Animal indicators

Animal cycles and seasonal behaviors were used as seasonal markers, including Golden marmots (*Marmota caudata),* Marco Polo Sheep (*Ovis ammon poli*), and Ibex (*Capra sibirica*). Understanding their seasonal behaviors allowed villagers not only to know cycle of wildlife behaviors in the Alai Valley, but also mark the end observing seasons in spring and fall. Golden marmots were the most important animal indicators because their hibernation co-occurred with temperature changes during autumn (late August through late September) and snowmelt in spring (April through May). Some of the crop planting in spring, harvesting activities fall, and livestock practices co-occurred with hibernation of marmots. Therefore, I described animal cycle in the section below (Figure 27). Co-occurrence of events is hard to analyze.

People used the emergence of *Sugur Chykty* – the Golden marmot, as a sign of spring. Villagers perceived that the early emergence of marmots was a hazardous event. Sometimes marmots emerged too early while there was still too much snow, and then returned into hibernation. This behavior was a sign known as *jalgan-jai* – a fake spring. When marmots emerged too early and continued hibernation, villagers expected *jut* in April and May. People hunted, and trapped marmots to extract the fat and used it as traditional medicine. No other methods involved except using binoculars to observe the cycle of the marmots.

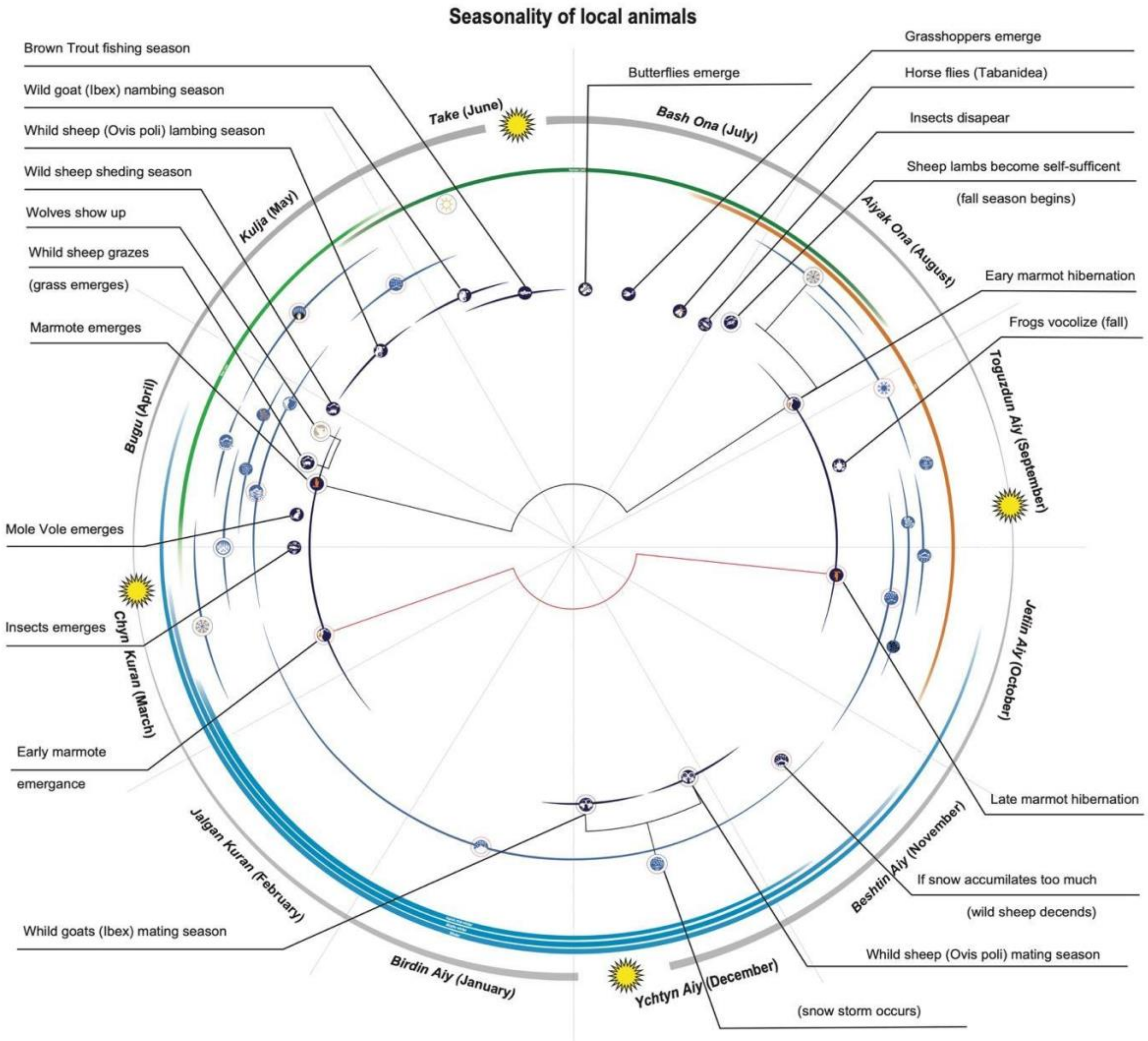


Figure 27. Seasonality of Local Animals

The anticipation of winter in the Alai Valley occurred by observing *Sugur Jatty* – hibernation of marmots in autumn, and *Sugur Chykty* marmot emergence in early spring. Marmot hibernation and emergence varied year-to-year. If marmots hibernated earlier, this indicated an early spring. If marmots delayed their hibernation, spring arrived later (see Chapter 3).

The seasonal behaviors of Marco Polo sheep and Ibex were important ecological indicators. Local people co-evolved and adapted to the natural environment by living together with these iconic animals of Pamir. Historically, these animals had both symbolic and economic values for people, hence, their behavior was known. From mid-November until late December, *kulja – burak*, the mating season of the Marco Polo Sheep, and *Teke-burak,* the mating season of Ibex, both occurred. I was told that when wild sheep and ibex mate, there will be a snowstorm. However, snow in the Alai Valley actually arrived sometime between September and in January. Snow arrival did not influence the mating season for mountain sheep and goats. Possibly this knowledge could be relevant in other parts of the Pamirs, especially Tajikistan, where snow usually occurred late in December. The central habitat of Marco Polo Sheep and Ibex was in the Pamir mountains of Tajikistan (Schaller and Kang 2008; Raul Valdez et al., 2016). This association of snow with the mating season of both animals might have developed in the places where average snow arrival was between late- November to mid- December. The mating season of these animals was a marker of *kyrk childe* – mid-harsh winter. I doubt that the mating season of these animals strictly corresponded with the arrival of snow in the Alai Valley, which I discussed further in Chapter 3.

Furthermore, *kulja – burak* the mating season for the Marco Polo sheep and *Teke-burak* the mating season of Ibex were important to comprehend the shifts in summer. This was determined by the lambing season of these animals, locally known as *Kyik toldoit.* Marco Polo Sheep gave birth by the end of May and early June, while Ibex lambing occurred a week later. Based on either early or late mating dates, villagers could know the early or later arrival of summer. According to local hunters, a 10 to 15 day difference occurred between mating and lambing of these two animals. Ibex both mated and lambed later than wild sheep (Figure 23).

Animal indicators were not separate from other or livelihood indicators. For example, marmots emerged around the time that migratory birds arrived. Marmot were expected to emerge around the time of snow melt, when the surface of the fields became dark. Moreover, with the departure of snow and the emergence of grass in spring, wild sheep descended to lower valleys grazing fresh grass. Later people noticed *kyiyk tyloit*, when wild sheep and goats shed hair, another sign of spring. Seasonal behaviors of wild sheep and goats was noticed by the local hunters and included in their seasonal calendar.

When spring arrived, *kurt-kumurska* insects and *chychkan* eastern mole voles (*Ellobius tancrei*) emerged during April and May. They were not used as a cue, but I included them for future research and reference. Especially impact of insects on food security in Central Asia. People also noticed the emergence of various insects such as *kogon* horse flies, especially close to fall. I do not have an exact species identification, but it could be horse flies (*Tabanidae*). In August through early September, insects, butterflies (I have no species identification), and horse flies disappeared, and frogs start vocalizing. In addition, when summer arrived, brown trout (*Salmo trutta*) were available, and villagers started fishing though September.

There were several essential animal signs that were correlated with one another and were also associated with human livelihoods. When the *kozu torolot* lambs of Marco Polo Sheep and Ibex become self-sufficient (maturity), people knew that it was fall. When the cold weather started in autumn, marmots began to hibernate. Herders knew that the end of the summer pasture season, and they needed to bring their livestock from summer pasture to the village. When there was too much snow at higher elevations, wild sheep and goats descended to lower valleys searching for grass, indicating winter arrival. Knowing the relationship of animal cues with other ecological indicators help villagers understand the beginning and end of local seasons.

Bird indicators

Community members had rich knowledge of migratory, breeding, and resident birds, and they noticed changes in bird migration patterns. The list of 48 birds observed in the Shamshal Lakes region of southern Xinjian Province (Khan, et al., 2012) were present throughout the Pamirs, including the Alai Valley. Birds such as *Chandyloch* white wagtail *(Motacilla alba), Kara-Chyiyrchyk* (*Sturnus vulgaris*), *Kashkalduk* Common Coot *(Fulica atra), Churok* Mallard (*Anas platyrthynchos*) and *Angyr* Ruddy Shelduck (*Tabdorna ferruginea*) were used as indicators of spring. Sometimes migratory birds arrived too early, while there was still ice around, and subsequently died. The breeding period for specific birds such *kara-kash torgoi* Horned Lark (*Eremophila alpestris*), *Chakchagai* Isabelline Wheatear (*Oenanthe isabellina*), *Kurchulduk* Northern Wheatear (*Oenanthe oenanthe*), and *torgoi* Eurasian Skylark (*Alauda arvensis*) served as indicators of summer. In fall, bird migration was strongly associated with frost (Figure 20). Clearly, local knowledge of ecological calendars provided insights about how seasonal changes altered bird migration patterns, especially in spring.

Local people are aware of certain seasonal changes, bird migration and their possible co-occurrence with human activities. Although it needs further research, co-occurring events, such as the relationship between migratory bird departure and crop harvesting, provided new insights on how farmers understood temperate changes. In Sary Mogul, there was a period called *kush-keldi* when migratory birds arrived, including *ordok* ducks, *kaaz* geese, and *karkyra* (*Gruiformes*), and *turna* (*Anthropoides*). When *Kush-keldi* occurred, villagers noticed that spring was about to arrive. According to villagers, the first bird to arrive in the Alai Valley was *Chandyloch* white wagtail *(Motacilla alba)*, followed by *Angyr* Ruddy Shelduck (*Tabdorna ferruginea*), *Kara-Chyiyrchyk* (*Sturnus vulgaris*), *Kashkalduk* Common Coot *(Fulica* *atra),* and *Churok* Mallard (*Anas platyrthynchos*). When migratory birds arrived in spring, *Ala partang* also appeared, but this term refers to both the Common Magpie (*Pica pica*), as well as Northern Shoveler (*Anas clypeata*). Some bird guides showed that it was a Smew (*Margellus albellus*) (Рябицев В. К. et al., 2019). According to Russian sources, the arrival of white wagtails was always observed by Kazakh and Kyrgyz people as a sign of spring (Басилов, 1986, p.55). These birds were also important in our research, but validity was extended in Chapter 3

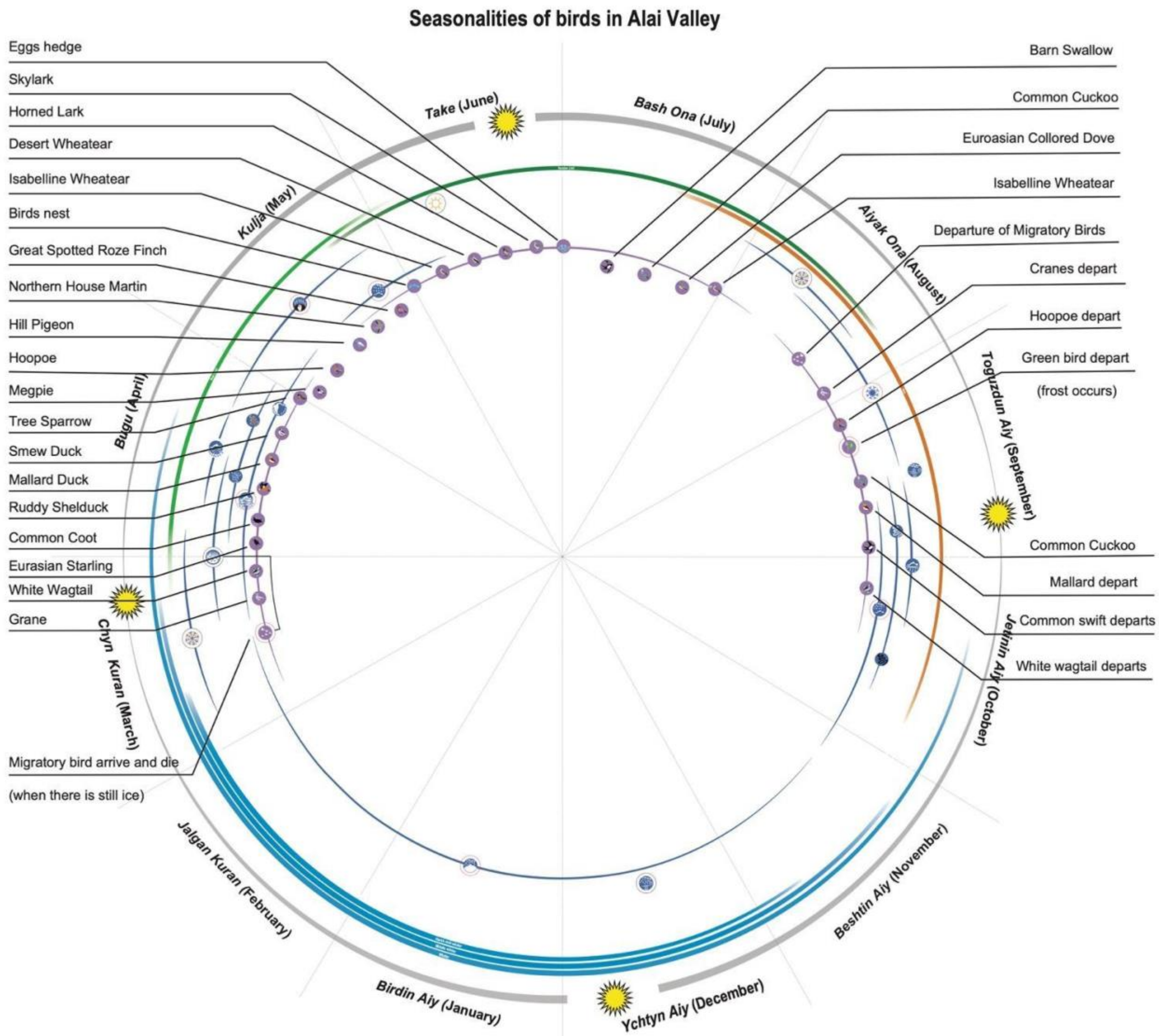


Figure 28. Seasonality of Birds in Alai Valley

As spring proceeded into summer, the arrival of breeding birds continued, including *Gijik* Eurasians Tree Sparrow, (*Passer montanus)*, *Ala partang* common magpie (*Pica pica*), *Sasyk-Ypup* Eurasian Hoopoe (*Upupa epops*), *Koguchkon* Hill Pigeon (*Columba rupestris*), *Bor-Bash* Spotted Great Rosefinch (*Carpodacus severtzovi*), and others like *Kaldugach*, which actually included three birds, Common Swift (*Apus apus*), Northern House Martin (*Delichon Ubricum*), and Barn Swallow (*Hirundo rustica*). While there were inconsistencies when identifying birds, these birds were marker of spring and summer (Figure 28).

Summer in the Alai Valley was known as *saratan*, occurred from May to August. People in Sary Mogul knew that summer began when *saratan-tuudu* – *saratan* birds laid eggs. In summer 2018, I clarified the term *saratan* with the community, and it referred to a species of small, gray and brown birds that were widely distributed in the plains of Alai Valley. They include *kara-kash torgoi* –Horned Larks (*Eremophila alpestris*), *Chakchagai* –Isabeline Wheatears (*Oenanthe isabellina*), and *Kurchulduk* – breading Northern Wheatears (*Oenanthe oenanthe*). It could also include *torgoi* Eurasian Skylark (*Alauda arvensis*) as well. In mid-July, eggs of these birds hatched and *balapan* - bird chicks emerged, which was the peak of summer in the Alai Valley. In the Kazakh calendar, there was a period called *Kyrgyiol* (*Kyrgyi*), meaning the Euro-Asian Sparrow hawk (*Accipiter nisus*). When their eggs hatched, this period was called *Kyrgyiol* (Фиельструп, 2002, p.211).

Migratory birds departed (known as *Kush- Kaity*) during mid-August to mid-September. *Kush- Kaity* was vital for the community because, with the departure of breeding and migratory birds, cold and frost known as *Kyrgyek* soon arrived. The term *Kyrgyek* referred not only to cold or frost, but was also associated with thumb-sized green birds. That *Kyrgyek* may have been

Humes Warbler (*Phylloscopus humei*), Greenish Warbler (*Phylloscopus trochiloides*), or Sykes's Warbler (*Inuna rama).* Local people believed that when these birds were seen along the River Kyzyl -Suu, cold and frost would soon arrive. Hence, the departure of these birds was associated with cold temperatures that occurred in early September.

The villagers also claimed that when *Chakchagai* Isabelline Wheatears, stopped singing, summer pasture season ended and autumn began. According to Ayé (2012), "…Calls include various whistles, hard chack and buzz chre…", which suggested that the community named *Chakchagai* after its call. This bird also had a symbiotic relationship with the long-tailed marmot. Throughout the short summer, these birds nested in marmot burrows. When migratory and breeding birds departed, especially birds that were known by the community, that event marked the end of summer and beginning of autumn. Bird emergence and disappearance indicated the short summer season in the Alai Valley.

I concluded that specific birds, such as *Chandyloch* white wagtail*, Kara-Chyiyrchyk*, *Kashkalduk* Common Coot, *Churok* Mallard, and *Angyr* Ruddy Shelduck were used as indicators of spring. As for summer, breeding birds such *kara-kash torgoi* –Horned Lark (*Eremophila alpestris*), *Chakchagai* –Isabelline Wheatear (*Oenanthe isabellina*), and *Kurchulduk* –Northern Wheatear (*Oenanthe oenanthe*) as well as *torgoi* Eurasian Skylark were used to indicate summer. Monitoring and observing birds played an essential role in understanding how local seasons were marked (Figure 28).

Community events

There were many community festivals that took place in Alai Valley, and most of them occurred during the period of abundance. With the end of harvest season, autumn was considered the period of *tokchylyk* plenty, or *byshykchylyk* abundance. Many community celebrations, such as *beshik toi* newborn celebration, *jeentek* food sharing after newborn, *bala oturguzuu* – circumcision, *chach ordy* - braiding, *kyz uzatuu* – marriage, *toi-tamasha* – feast, and *uigo bata aluu*- new house blessing all occurred during the abundance season. Only *bala oturguzuu* – circumcision sometimes occurred in spring. It usually took place in fall, which was locally preferred. Some of these seasonal feasts were also very common among the *Ichkilik* tribes in the Pamir Mountains of Afghanistan (Callahan, 2013, p. 112-119; Remi Dor, 1993, p.3-35; Shahrani 1979, p.99). It was fascinating to learn the seasonality of these events in the calendar.

Conclusion

I focused on the traditional ecological calendar of Sary Mogul, in the Alai Valley, Kyrgyzstan. I examined how people experience seasonal changes. Adaptation to the changing seasons was challenging. Precipitation and temperature-related changes impacted the sources of livelihood, be it livestock-related activities, seasonal land-use activities, or people's specific experiences with plants, animals, and social-cultural events. I emphasized how physical changes; changes in migration of birds; and changes in animals, plants, insects, or human livelihoods activities, were all influenced in one way or another by the changes in precipitation and temperature. I described the local seasonal patterns in relation to these physical changes and changes in the local ecology. I co-generated the first ecological calendar in collaboration with a *community of inquiry* (scientists of diverse backgrounds) and a *community of social practice* (farmers, herders, hunters, and fishers) for the village in the Alai Valley. Based on my qualitative interview analysis of herders and farmers in Sary Mogul Village during three field seasons, I designed a Seasonal Round, which provided anticipatory capacity at the village level.

The ecological calendar had a practical benefit for the herders, especially for the pasture committee, which served as a tribal council. Using ecological calendars required understanding the interdependent relationships between ecological indicators. Only by understanding relationships of key ecological indicators (local knowledge of livestock management), can villagers resolve the following issues. They can prevent livestock death during the shearing season, or schedule domestic sheep lambing during the transition from spring to summer. Villagers ensured enough fodder was stored to overcome unprecedented heavy snowfall in spring. Herders responding to early signs of seasonal changes with respect to seasonal herding practices. The community prepared enough food (dairy products and fodder) to overcome late spring. Herders time breeding of domestic sheep by relying on the ecological calendar, and also they monitor yak mating to anticipate shifts in spring. Finally, people focused on securing traditional fuel sources for long winters and late springs in the Alai Valley. The knowledge embedded in the ecological calendar, therefore, addressed specific issues in the community and supported their decision-making at the local scale.

I argued that the knowledge in the calendar benefitted specific seasonal decisions associated with livestock and crop-related activities. I learned how the ecological calendar may accommodate livelihood challenges and allowed farmers to make practical decisions in the face of annually changing seasons. These social-ecological practices were not outside of ecological systems, but rather an essential part of them. Knowing the specific interdependent relationships associated with several indicators, allowed me to conclude that villagers did utilize the knowledge revitalized in their established patterns within the ecological calendars, and anticipated year-to-year variations.

Traditional ecological knowledge embedded in the ecological calendar demonstrated the practical benefits of local knowledge for livestock-related decisions, and timing of crop-related activities in the Alai Valley. The revitalized ecological calendar was an example of building anticipatory capacity in response to annual seasonal changes at the village level. Therefore, in places like Kyrgyzstan, livelihood security should be the priority in adaptation to local weather changes. I concluded that similar calendars could be revitalized for other agropastoral peoples whose livelihoods depend on substance-based activities (herding, and cropping).

CHAPTER 3

FUTURE RESEARCH AND RECOMENDATIONS

Introduction

Ecological calendars have been studied as joint research projects between local communities and scientists to understand climatic variation and adaptation in different ecological settings (Prober et al., 2011; Makuritofe and Castro, 2008; Londono et al., 2016). Ecological calendars included a cycle of events essential for guiding seasonal human activities (Johnson et al., 2016). This has facilitated people in coping with climate variations, yet this field needs further research (Cochran et al., 2016). In the rural and mountainous regions of Central Asia, ecological calendars have helped people anticipate climate change and envision future possibilities in the context of uncertainties (Kassam, et al., 2018). Having revitalized a seasonal calendar from the Alai Valley of Kyrgyzstan in the context of an ECCAP project, my goal is to envision future research possibilities associated with the Seasonal Calendar in the Alai Valley.

I conducted a literature review concerning environmental variables in the seasonal calendar and expanded my understanding of the biophysical cycles from upper Alai Valley. Because snow accumulation (fall), snow cover (winter), snowmelt (spring), and snow-free (summer) were essential cues for human activities, herding of livestock, and cropping activities, long-term remote sensing of the snow cover changes could improve our understanding. Additionally, a critical aspect of the seasonal calendar was monitoring the growing season with a focus on seasonal markers during spring and fall. Remote sensing technologies such as the Normalized Difference Vegetation Index (NDVI) could be applied to understand changes in the growing season, snow-cover, and ice development in the region. While the villagers might not have access to remote sensing technologies, the researchers could think about how to measure growing season. Furthermore, the particular biophysical events occurring in spring and fall could also be monitored using locally-available digital technologies like camera traps and drones. Thawing of the soil in spring, and frozen ground in the fall, should be monitored, as the timing of the growing season is important for crop growth. Currently, not every village has soil data, but in the future, this could be an option for documenting cropping activities and ensure successful food production in Central Asia. Despite multiple ecological factors influencing the calendar events, the behavior of marmots, mountain sheep, goats, and yak should be monitored; the seasonal cycles of these local animals can reflect year-to-year seasonal shifts in climate-driven factors. Therefore, by viewing the local climate from a holistic and interconnected perspective, ecological calendars help anticipate year-to-year variations at the village level.

Methodology

Originating from Greek, the word *phaino* means to appear, or study repeating events in plants and animals' life cycles. They included the flowering of various plants, drying of plants in fall, birds' arrival, the emergence of insects, and ice forming. All of these phenological cycles can be studied (Dubé et al., 1984). The calendar I have revitalized is rich with phenological events. Ecological events in the calendar are associated with cosmology, climatology, hydrology, ornithology, etymology, biology, ecology, agronomy, and pedology. Therefore, results in this Chapter are based on phenological studies in high-altitude environments.

I conducted a literature review concerning the essential phenological events from the Alai Valley. My extensive literature review included common biophysical events such as snow cover, snowmelt, thawing seasons, growing seasons, plants, and animal cycles. I expanded on specific biophysical events other scholars have written about (e.g., snow cover, growing season, or thawing of soil in spring and fall) (Foster, 1989: Euskirchen et al., 2006: Evans and Fonda, 1990). I have also shared terminologies that could be useful for enhancing use of the ecological calendar. I have limited my scope of analysis by reading academic articles about certain with focus questions in mind, such as variations, responses, and future research possibilities. Consequently, I make specific recommendations for monitoring snow cover changes, growing seasons, and soil changes using locally-available and remote-sensing technologies. Finally, I point out how multiple ecological factors drive changes in the calendar, including the cycles of marmot hibernation, rutting of mountain sheep, and yak calving seasons. It is vital to consider the numerous environmental factors driving seasonal changes in plant and animal cycles. These insights will help farmers prioritize their seasonal decisions and activities found in the ecological calendar.

Priorities

Villagers should develop their own priorities, but I make the following suggestions. Because spring and fall were critical periods for seasonal transitions, local people might find it useful to carefully observe associated phenological events at those times. Temperature changes in spring informed snow cover, snowmelt, ice-break, and soil thawing. Animal and plant indicators co-occurred during these periods. With the emergence of vegetation, villagers were aware of the seasonal shifts in spring. This ultimately informed sheep lambing, taking livestock to pastures, and planting crops unless uncertainty threated their activities. Fluctuations in icing, spring temperatures, and precipitation might be expected. If the growing season is successful in summer, villagers might find it useful to monitor the end of the growing season in fall. Because temperatre driven events (snow cover, snowmelt, ice-break, and soil thawing) indicate the beginning and end of the growing season, which contributes to understanding of the food growing period. Many of the changes in fall were temperature driven. Grass dried, insects disappeared, frost occurred, birds left, soil thawed, and snow might be expected. These changes may occur from late July to mid-September. Thus, the ecological calendar allowed monitoring seasonal changes in spring and fall to sustain both livestock and cropping activities.

Snow Cover

Because the snow cover period was one of the essential seasonal cues for herders grazing livestock, snow cover changes in various ecological zones (e.g., climate, geography, and longitude and latitude) should be studied. Snow accumulation, snow cover, and snowmelt were common phenological events at high altitudes (Inouye et al., 2000). Snow cover in Eurasia, however, was complex and poorly understood. Atmospheric studies suggested that various oceanic weather patterns influenced snow cover in Eurasia, but global climate models were limited for predicting snow cover variability (Hardiman et al., 2008; Jeong et al., 2011; Cohen et al., 2012). Autumn, winter, and spring precipitation in the Pamirs were influenced by two air circulations: the westerlies and monsoons (Zech et al., 2005). Because there were many villages in the Pamirs, each receiving snow possibly from September to June, studying snowfall changes in the upper Alai Valley will be vital for future studies.

Using long-term, remotely-sensed images to study changes in snow cover may provide an understanding of snow cover trends in the Pamir Mountains of Central Asia. For example, the U.S. National Aeronautics and Space Administration (NASA) provided insight into the land-cover classification in the Pamir Mountains (Figure 29). The image of the snow cover was captured by Terra Moderate Resolution Imaging Spectroradiometer (MODIS) technology provided by the Land Rapid Response Team. However, it was only captured once on November 23, 2003. Mountainous areas require long-term study of snow-cover changes evaluated by remote-sensing technology with high image resolution and accurate color bands. Because snowfall was one of the main environmental variables in the calendar, remote-sensing technology could be applied to better assess annual changes in snow cover in the Pamirs.

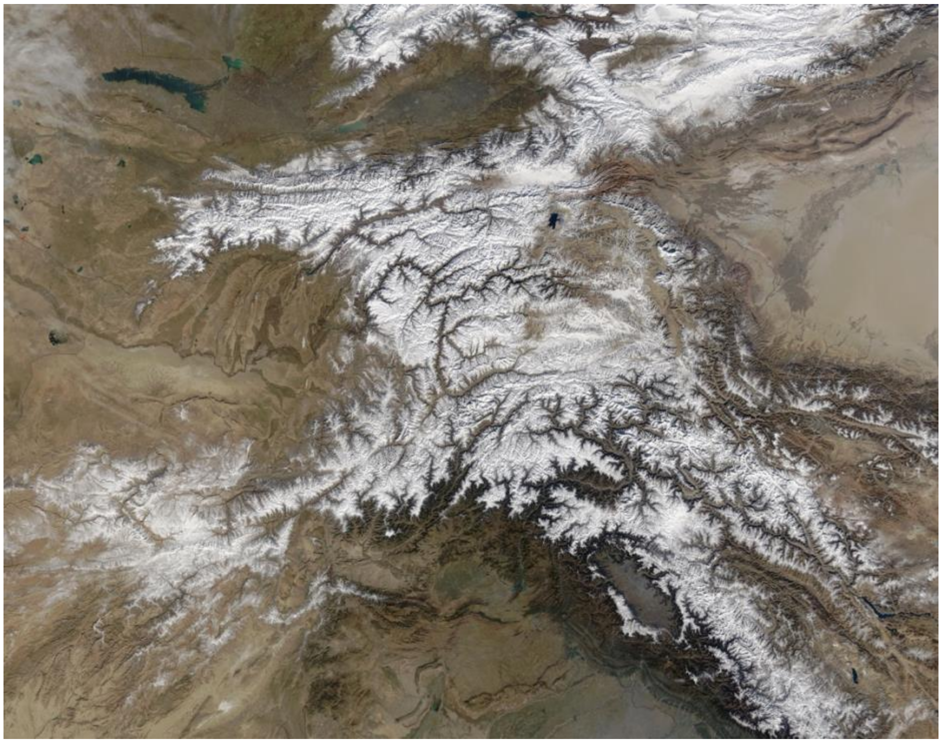


Figure 29. Snow Cover in Pamir Mountains (November 28, 2003)

(Image by Jeff Schmaltz).

Studies from Arctic tundra regions suggested that observing the timing of snow cover, melting of snow, and snow-free periods could provide vital indicators for climate-change studies (Foster, 1989). Shifts in the snow cover cycle in the Northern Hemisphere were studied during 1972 to 2000. Common biophysical variables from high-altitude areas can be understood through specific terms such as WLS (week of last observed snow) and WFS (week of first observed snow) (McDonald, 2004). Snow is melting earlier, and snow-free time is lengthening (Dye, 2002). Therefore, remote-sensing technologies such as Normalized Difference Vegetation Index (NDVI) combined with technologies like Conventional- and Multispectral Digital Camera Images (CDCI and MDCI) can be applied to better understand the changes in snow cover in a site-specific area (Buus-Hinkler et al., 2006). A similar study could inform the mountain communities in Central Asia and elsewhere. Scholars could build on these reccomendations.

The lack of historical data on the average timing of snowfall and snowmelt is a key challenge. How snow cover has changed in the Alai Valley needs more research. During 2001 to 2018, remote-sensing techniques were applied to understand climate variables in the Pamir Mountains of Central Asia (Zandler et al., 2020). This study used the Normalized Difference Vegetation Index (NDVI), Moderate Resolution Imaging Spectroradiometer (MODIS), and a more specific snow product called MOD10A1. Results from this study could be relevant to farmers in Band-e-Amir (National Park in Afghanistan) and Wakhan Corridor. Villagers in the Bartang Valley and the Alai Valley need a similar study to support local decisions.

Image. 30. Flowering time of potatoes, (July 31, 2017). Image by Murzakarim.

Alternatively, farmers from the Pamir Mountains might find it useful to apply locally-available technologies, such as digital cameras and drones, to assess snow cover and vegetation changes. Today, smart phones are available in many rural regions of Central Asia. For example in 2017, I collaborated with Professor Antonio Trabucco, a researcher at the center of the Euro-Mediterranean Center on Climate Change in Italy. As a part of the ECCAP project, we asked local farmers to photograph the vegetation growth, including the flowering times of potatoes during the summer of 2017 (Figure 30). Using cell phones, farmers provided essential data for understanding changes in vegetation phenology during spring 2017. We also placed camera traps near the village to monitor snow cover changes in Sary Mogul Village. The camera traps allowed auto-image capture (daily, weekly, and monthly). One of the challenges of using camera traps was their quality. If high-quality camera traps and batteries are used, they can provide a far better images of snow cover and vegetation changes in the Alai Valley. However, not many villages have drones. But with decreasing drone prices, I am sure drones will soon be available in every village in Central Asia. Meanwhile, farmers from the Pamir Mountains might find it useful to utilize smart-phones that are currently available.

Thawing and ground freeze

Spring and fall were the most important periods, as people maximized their food production during the short growing season. Soil-temperatures changes need further studied in the Alai Valley as the planting of crops depends on the soil-thawing period in spring. Harvesting is constrained by ground freeze in the fall. Variability in these biophysical events, such as soil thawing, freezing, and length of the growing season is likely to increase due to climate change (Euskirchen et al., 2006). Euskirchen et al. (2006) stated that “The growing season begins in the spring with increasing temperatures and light availability, the melting of snow, thawing of the soil organic horizons, and the onset of photosynthesis. In the fall, the growing season terminates as temperatures and light availability, the melting snow, thawing of the soil organic horizons, and the onset of photosynthesis cease." Therefore, in two periods (April and May) and (August to October) villagers could find valuable monitoring the biophysical events mentioned above.

One of the main challenges in predicting the soil-related environmental variables was the timing of thawing and ground freeze spring and fall. Geomorphology of the Alai Valley was complex, which obscured my ability to suggest anything about the changes in ground temperature. Our colleagues from Germany and Italy have collected data applying soil moisture loggers (The Xtreem soil moisture designed by Odyssay company) and temperature loggers (Humalog by "HOBO" company). My research does not focus on the results of this data. How soil temperature shifted during seasonal changes in the spring and fall needs further elaboration. Much of the agriculture in the Alai Valley occurred on the valley plain or "alluvial fan." Geological characteristics such as the valley floor, hummocky terrain, glacier valleys, mountains valleys, and glaciers formed unique micro-climates in the Alai Valley (Oliva and Ruiz-Fermandez, 2018). Given these multiple geomorphological distributions in the region, further study of ground thawing and freezing is needed. The significance of the soil studies in the region is that the variation in soil temperure is essential to food production.

Farmers in these mountain regions may find it valuable to anticipate ground thawing and growing season length in their village. The study of soil freeze and thaw is not new, but my expertise is limited to provide comrehensive suggestions on how to measrure them. Nonetheless, scholars refer to the seasonal soil temperature changes as freezing-thawing cycle (Koponen and Martikainen, 2004). Studying freezing-thawing cycle in local villages is essential. According to the ecological calendar, the spring thaw occurred during April to May, while the ground froze in September or October in fall. Studying the freezing-thawing cycle, and monitoring growing season length, may improve crop production and food systems in villages like Sary Mogul.

Because ecological calendars contain so much data, I think developing a model or innovative tool to measure freezing-thawing cycle can help to study the window of food production in spesific places.

Growing Season Length

The ecological calendar from the Alai Valley revealed the importance of studying growing season length (snow-free periods) in the mountains of Central Asia. Snowmelt was the primary point of reference in spring to determine growing season length. In the Northern Hemisphere, the lengthening of snow-free time has been commonly observed (Dye, 2002). In the field of phenology, changes in growing seasons, the emergence of plants, advances in flowering times, vegetation seasons, and frost dates for plants have been studied (Ahas et al., 2000). Changes in phenology were associated with changes in snowmelt, especially the advance of flowering times in a semi-arid environment (Crimmins et al., 2010; Walker et al., 2001). Snowmelt played an important role in flowering, seeding, and ripening plants (Bliss, 1971; Molau, 1996), especially in artic or high-elevation areas where late snowmelt influenced both the early and late development of plant communities (Cooper et al., 2011). A rich literature existed for studying plant life and vegetation in the Pamirs of Central Asia (Nowak et al., 2014; Nowak et al., 2016a; Vanselow, 2016). However, we do not have data concerning trends in growing season length in the Alai Valley, an important topic for future study.

Understanding these changes in growing season length was complex because plant development depended on several ecological factors (Miller, 1982). There was a complex relationship between how much snow was received, how long it lasted, and how this influenced soil temperatures and growing season length (Evans and Fonda, 1990). For example, some plants (e.g., birch) could develop under the snow if soil temperatures were warm enough. A delay in the growing season was influenced by low temperatures and deep-frozen soils, a slow rate of snowmelt, and heavy snow in winter (Shutova et al., 2006). Some flowers (e.g., *Saxifraga oppositifolia*) may grow and flower quickly after the thaw, based on its previous summer development (Larl and Wagner, 2006; Crawford, 2008). Therefore, multiple environmental factors influenced the responsive abilities of plants (Kudo, 1991). Seasonal temperatures, elevation differences, environmental conditions, species-specificity, reproductive success, vegetation zones, slope, soil-temperature, and other environmental cues (Odland, 2011) complicated the understanding of vegetative indicators in spring.

Long-term remote-sensing data could provide potential information to understand the changes in plant phenology (Jaagus and Ahas, 2000; Stow et al., 2003). Elsewhere, scientists have applied the seasonally-integrated, normalized difference vegetation index (SINDVI) to visualize vegetation cover changes in the North Slope of Alaska (Stow et al., 2003). Similar studies were carried out in Central Asia to understand growing season trends and vegetation changes (Propastin *et al*., 2008). This practical study applied a Normalized Difference Vegetation Index (NDVI) to assess the vegetation response to climate change. According to Propastin, et al. (2008), "The results of our study revealed a general significant increase of vegetation activity across the most part of the Central Asia's territory. The results indicated an 11.35% increase in growing season NDVI in Central Asia between 1982 and 2003." Unfortunately, data documenting changes in growing seasons and shifts in vegetation phenology are limited in the Ali Valley. During 1990-2013, Liu and Watanabe (2016) evaluated vegetation changes in the Alai Valley. They concluded, "Of note, vegetation cover remained unchanged in over 70% of the entire study area from 1990 to 2013, which indicates that most of the area is in a relatively steady condition. Only 13% of vegetation cover decreased in the entire area during 23 years." The ecological calendar from Alai Valley revealed future possibilities for integrating remote-sensing technologies to assess growing season length.

The ecological calendar from Alai Valley revealed that the growing season could be estimated from 90 to 122 days, during May to September (depending on snowmelt and vegetation development). Varying growing-season lengths were seen in different high-elevation regions of the world. The growing season was around 100 days in Norway. The snow-free season can be less than 120 days in Fennoscandia (Wielgolaski, et al., 2013). In the southern part of Europe, growing seasons may last 200 to 220 days. In other parts of Europe, seasons could last from 180 to 200 days. In Scandinavia, the growing season was around 180 days, and in the northern regions of the Arctic Circle, it was less than 150 days. Studies suggested that the growing season lengths corresponded to the estimated mean duration of the snow cover (between 180 to 222 days; Chmielewski, 2013). In the Colorado Rocky Mountains of the United States, the average snow cover period may be 199 days, varying from mid-October to mid-April (Wielgaloski, et al., 2013). While considering the variations of days in snow cover in different regions, snow periods could vary greatly depending on the elevation and annual temperature changes. Although day light and day length played essential roles in understanding how growing seasons and snow periods changed, similar measurements may enhance future research on estimating growing season length in the Alai Valley.

Ice-out and Ice-break

Fish behaviors were not used as biological indicators of change in the Alai Valley, but temperature changes in the water systems could be studied in the future. We learned that in the Alai Valley, farmers paid attention to water species (e.g., fish) that were connected with biophysical events (e.g., ice-free, ice-out, ice-break). This was mentioned in connection with the ice-free, ice-out, and ice-break times for the Red River in the Alai Valley. Kyrgyzstan and Tajikistan were landlocked countries with several lakes and rivers (Figure 31). According to Petr (1999), there were 846 lakes in the Pamirs. They had tectonic origins, and the largest lakes and rivers were Karakul, Zorkul, Yashilkul, Turumtaikul, Bulunkkul, and Sarez. According to Petr (1999), False osman (*Schizopygopsis stoliczkai*), snow trout or *marinka* (*Schizothorax intermedius*), Tibet stone loach (*Noemacheilus stoliczkai*), and karakul stone loach (*Noemacheilus lacusnigri*) were local native fish species. Introduced species included giebel carp (*Carassius auratus gibelio*) and northern whitefish (*Coregonus peled*) (Petr, 1999, p.180). Similar fish studies in high altitudes confirmed the presence of brown trout (*Salmo trutta oxianus*) in the rivers of the Alai Valley (Schöffmann, 2001). Temperature changes could be documented by observing lake icing dates, but there were limited historical data. Understanding annual temperature changes in rivers and lakes provided an alternative perspective for estimating when waters were ice-free and ice melted. Temperature change impacts on lakes and rivers in Central Asia could provide valuable data for the villagers to anticipate trends and make decisions concerning seasonal changes.

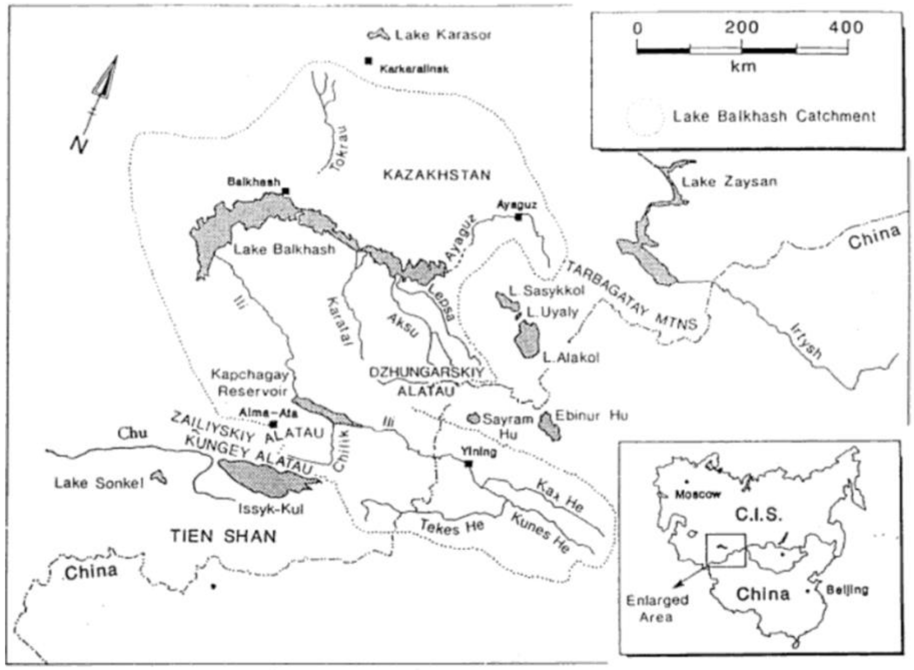


Figure 31. Major Lakes and Rivers of Central Asia. Image from (Petr, 1999)

May was the predicted month for ice-out and ice-melt in the region, which requires further investigation and local observations. Multiple factors influenced hydrological systems in the region (e.g., elevation, temperature, latitudes, and longitudes, and chemical water composition), and hydro-scientists (Meier et al., 2013) admitted that “With regard to the current climatic change, we need further research to understand the influence of glacier meltwater versus snowmelt and groundwater, to the total streamflow assessing future water resources for the Amu Darya basin. Currently, it is still an open question as to how glacier melt influences the water budget in the Pamir Mountains, and consequently, in the Central Asian lowlands.” According to Petr (1999), “In November the lakes start to ice over, and in winter, the ice may reach 2 m depth. Only a small area near hot springs groundwater sources remain free of ice. Ice melts in May.” Because the Pamir Mountains of Central Asia were a mountainous area, snow and ice melted some time during April through August, especially in glacier zones (Pohl et al., 2014). Thus, biophysical changes such as ice-break and ice-out could provide vital localized data for farmers to anticipate seasonal changes.

Villages near rivers like Sary Mogul, could benefit by monitoring the ice-out and ice-break events on their ecological calendar. Such locality-specific, temperature-related events reveal important data to estimate warmer temperatures. For example in Canada, government agencies work with non-profit organizations to provide and encourage citizen-science programs (Futter, 2003). Although citizen-science platforms are still in development in Kyrgyzstan, the government and non-profit organizations could provide platforms to submit data and monitor climate-sensitive events. It also gives local people ownership of the data. Villagers could also gather data to monitor the river changes by using digital cameras. In the study of ice-break and ice-outs, scholars use specific terms such as break-up start (BUS), break-up end (BUE), freeze-up start (FUS), and freeze-up end (FUE) (Šmejkalová, et al., 2016). These data may predict future climate change in mountain regions.

Seasonality of wild sheep and goats

The variability in breeding and lambing seasons for wild sheep and goats were little understood. These animals were distributed in various ecological zones, from Spain to California through Siberia and Alaska, as revealed in the book, *The Great Arc of the Wild Sheep* (Clark, 1974). Considering the differences in climate-specific localities, studies suggested that both photoperiod and harsh climate influenced mating and lambing time in wild sheep and goats. According to Shackleton and Shank (1984), “In general, the harsher the climate, the shorter the breeding season, and the longer the sexual segregation.” Photoperiod and climate influence the onset of lambing. Few data, however, were available for Central Asia, and previous studies on wild sheep and goats highlighted the importance of international transboundary conservation in the region (Schaller, and Kang, 2008; Valdez, et al., 2016). If there were enough forage and a longer growing season, the lambing period would be expected to be longer. With a shorter growing season (harsh climate), the lambing period was expected to be shorter in the mountains of North America (Bunnell, 1982). This holistic and interconnected thinking about climate and its influence on the annual breeding cycles of animals extends our understanding of possible changes in rutting and lambing season for wild sheep and goats in the Asia high mountains. We do not know much about the lambing season of sheep in relations to climate change.

Argali rutting and lambing times may be variable, but there were multiple factors influencing these differences. Wang, et al., (2019) acknowledged that elevation influenced the argali rutting and lambing period. For example, in the lower elevations with favorable climatic conditions, lambing occurred in early spring (end of March - April), and mating was in September and October. In higher elevations with harsher climates, lambing occurred much later, during the end of May and June (Fedosenko and Blank, 2005). Elsewhere, understanding plant phenology (growing seasons) and winter weather played a vital role that influenced Dall sheep population levels and mortality (Rachlow and Bowyer, 1991). Other studies suggested that animals like caribou (*Rangifer tarandus*) were affected by winter snowfall (Adams and Dale, 1998). Other studies focused on body mass (Hjeljord and Histol, 1999) and animal maturity associations with winter snowfall. Early or delayed maturity can be studied, especially regarding winter snowfall and rutting of ungulates (Jorgenson, et al., 1993; Saether et al., 1996). Given the fast habitat distribution of sheep, and many factors influence the onset of the rutting season, we do not know the role of climate and other factors.

Precipitation (snowfall, snow cover, and snowmelt) was important for studying the annual variation in rutting and lambing times for argali. Previous research provided limited data for understanding differences in rutting times for sheep and goats. Climate change, however, influenced species distribution and habitats (Salas, et al., 2018). Experts suggested that argali and ibex were sensitive to annual mean temperatures (Khan et al., 2016). Interestingly, these studies used biophysical factors (e.g., snow cover and snowmelt) related to growing season and vegetation when assessing ungulates cycles (Namgail, 2014). Precipitation in dry seasons, seasonal vegetation cover, seasonal vegetation availability, and quality of grasses, also influenced habitat selection by argali (Salas, et al., 2018). Therefore, we currently know very little about variation in breeding and lambing times of wild sheep under changing climate conditions in the Pamir Mountains. Scholars should compare climate data with a long-term observation of the onset of sheep rutting to evaluate the impact of change. This type of research should also include considering other ecological factors (e.g., vegetation, growing season, body size) before reaching any conclusions.

Seasonality of Yaks

Another potential ecological indicator of climate variability is the rutting and calving season for yaks. Studies provided various dates for calving from different places, ranging from March through July (Wiener et al., 2003). Why is there such a wide variation? Many direct and indirect ecological factors contribute to the variations in yak rutting and calving seasons. Like other animals, yaks may regulate their body temperature in response to temperate changes. The direct impact of climate on yaks includes sudden fluctuations in temperature, precipitation, and icing events. Icing is an excellent example of the direct effects of climate on yak mortality and population. The mating season of yaks is also influenced by indirect climate factors, including vegetation, elevation, geography, and growing season (Haynes et al., 2014). Such indirect changes are responsible for animal health, weight, body size, mating, and mortality. Krishnan et al., (2016) considered other indirect factors of climate change on habitat, temperate changes in different altitudinal gradients, changes in grazing pastures, seasonal changes in body weight, and energy regulation. Although yaks adapt to harsh climates, the increasing impact of climate change (e.g., heat stress), was a concern (Krishnan et al., 2016). Growing seasons for a particular year may shape the health and seasonal behavior of yaks. Thus, monitoring the growing seaso is vital for their survival and annual breeding, especially during winter (Wiener et al, 2003). This knowledge contributes to the awareness of the year-to-year, climatic-driven changes and their impacts on organisms for the ecological calendar in a particular place.

Seasonality of golden marmots

I started expanding my understanding of marmots because their activity corresponded to human activities in spring and fall. The seasonal behavior of marmots is also influenced by multiple ecological factors. Long-tailed marmots were widely distributed in the Pamir Mountains in different mountain zones (Kryštufek and Vohrolík, 2013). Elsewhere, multiple factors such as geography (e.g., elevation, altitude, latitude, slope, and stony areas), biotic (e.g., food, soil, moisture, and river systems), biophysical (e.g., duration of snow cover in days), and ecological habitat (e.g., rocky areas, meadows, hills, screes) influenced marmots generalist traits and mobility (López et al., 2010). Because marmots were generalists, their adaption strategies were complex, and ecologists considered these strategies as plastic (Dubson and Murie, 1987; Vuren and Armitage, 1991). Their generalist traits suggested the flexibility of the biological cycles of animals in the seasonal calendar.

Although there was no long term-study that examined the golden marmot's adaptive response from the region, the hibernation period of long-tailed marmots was about 7- 7.5 months (Davydov et al., 1991; Blumstein, et al., 1998; Mezhzherin et al., 1999). The hibernation of marmots depended on many factors. In lower elevations they emerged earlier than in higher elevations (Blumstain et al., 2004), depending on temperature changes (Inouye et al., 2000). It also depended on metabolic function (thermoregulation) during hot and cold climates (Barash, 1989). My study provided useful date estimates for marmot emergence, births, and hibernation in the Pamirs (Table 7). According to the estimates in my seasonal calendar, spring emergence was expected from April 15 to 30, and fall hibernation was expected from September 16 to 27.

Life event	Pamirs (4,000 m)	Gissar Mtns (3,000–3,500 m)	Turkestan (1,500–2,000 m)
Emergence	April 15–30	March 21–31	March 1–15
Birth	June 27–July 7	May 22–June 9	no data
Hibernation	September 16–27	August 25–28	July 25–August 7

Table 7. Estimated marmot emergence, birth, and hibernation. (Barash, 1989).

Villagers might find monitoring the marmot hibernation useful because marmot activities might co-occur during critical spring and fall transitions. Snow cover time may correspond with the marmot's hibernation period (Svendsen, 1974). It will be essential to study biophysical changes in fall, winter, and spring (snow accumulation, snow cover, and snowmelt). Snow affected changes in growing season length (e.g., foraging grass, fat accumulation, and breeding) in the marmot's adaptive responses (Vuren and Armitage, 1991). Studies from alpine marmots

(*Marmota marmota*) in the southern Pyrenees (French Alps) suggested that mean spring temperature (March) influenced marmot emergence at a larger scale (macro-scale) (López et al., 2010). Variation in snow cover, which used to be an indicator of marmot hibernation, may have impacted the survival of the marmot population (Vuren and Armitage, 1991). Population-level impacts on marmots, through direct (energy demand for winter hibernation) and indirect factors (fat accumulation during the growing season), were influenced by climate change (Tafani, et al, 2013; Rézouki, et al., 2016). Ecologists continue to acknowledge biophysical (e.g., snow cover, winter temperatures) and biological (growing season) factors as environmental stressors that influenced marmot abundance and survival (Vuren and Armitage, 1991; López et al., 2009; Tafani, et al., 2013; Rezouki, et al., 2016). While phenological networks and citizen science programs are under development, villagers could use the calendar developed by us and observe the changes of the biological cycles.

Remote-sensing technologies can be used to understand changes in local habitats, especially changes in growing season length. In my literature review, I found a few disease studies that focused on mole voles (*Ellobius tancrei*) and (*Microtus gregalis*) in Sary Mogul Village (Afenso et al., 2015; Marston and Giraudoux, 2 019; Giraudoux, et al., 2013). The Eastern mole voles were analyzed using trapping transects around Sary Mogul in 2012 and 2014. GIS inventory analysis by Marston and Giraudoux (2019) was valuable for showing dry grassland and steppe landscapes. Their land classification highlighted the ecological landscape of the Alai Valley. There was minimal agricultural lands where the area was classified as dry grassland, steppe, and dry-bare land. Marmots and other ground animals were influenced by habitat suitability. Similar maps described the ecological habitats that were vital for understanding the ecology of place (Marston and Giraudoux, 2019). Habitat classification added another layer of geographical differences (e.g., dry grassland, steppe, and dry-bare land) should be considered when observing marmot cycles.

Because marmot survival depended on growing season length and duration of vegetative cover, remote-sensing data may inform changes in the growing season. Marston and Giraudoux (2019) acknowledged that remote sensing could improve the study of vegetation phenology. According to Marston and Giraudoux (2019), "This again indicates that biomass levels at certain periods of the year are key and illustrates the importance of incorporating multi-temporal data capturing phenological variability, rather than just single-date imagery, for small mammal-landscape modeling." Multiple images were needed to capture the changes in one area over an extended period. Such studies could provide valuable land-classification changes and shed light on the possibilities of applying GIS technologies for understanding the changes in growing season length in the ecological calendars.

Seasonality of Birds

Because the ecological calendar contains data about birds and their seasonal movements, I attempted to expand my understanding of birds. There is no doubt that local and global climate change is impacting the seasonal behavior of birds. Especially with warming temperatures, birds may lay eggs earlier (Walther et al., 2002). The early arrival of breeding, singing, and migratory birds was also associated with early behavior of butterflies, insects, and amphibians (Walther et al., 2002). As an indirect impact of climate change, early breeding was speculatively assumed to be associated with insect availability, which could be controlled by weather (Tryjanowski, et al., 2006). Climate change may impact many elements that contribute to species survival, such as appropriate temperature for reproduction, availability of food sources, changes in bird populations, shifts in bird breeding dates, and changes in species phenology (McCarty, 2001).

The idea of rhythmicity (biological clock that triggers seasonal migration) remains poorly understood, as the patterns of bird phenology and seasonal migration are complex. Migratory bird behaviors are influenced by their biological clock, known as circadian rhythms, which are influenced by environmental variables (Gwinner, 1996). Other studies considered the plasticity of avian species to adjust their phenology responding to environmental variables (Gwinner, 1996). However, there was a knowledge gap in understanding the evolutionary responses of birds to changing seasons (Charmantier and Gienapp, 2014). Because climate change is occurring more rapidly than typical evolutionary timescapes, we do not know how rhythmicity informs their migration.

While understanding behavioral plasticity is important to the phenological response of birds, studying seasonal ecological constraints at breeding grounds is critical for understanding how birds were impacted by climate changes (Ockendon et al., 2013). Long-distance migratory bird arrival was driven by temperature changes in different places (Sparks, et al., 2013). Short-distance migration correlated with the context-specific temperature changes (Cotton, 2003). Studies suggested that birds need food availability (insects) when they arrive at a particular place. Food availability (emergence of inserts in a different location at different times) was associated with spring temperature changes and the timing of bird reproduction (Visser and Gienapp, 2006). Therefore, it was vital to study changes in the growing season length, flowering of plants, availability of insects, continental weather variability, and changes in the distribution of species, breeding, migration, and populations when evaluating bird phenology (Cotton, 2003).

Therefore, I am not certain if birds can be used as reliable signs for planting crops or harvesting activities, even if their seasonal migrations may correspond with human activities. Compared to wild sheep, marmots, or yaks, the birds are not fixed in a particular habitat (depending on what birds), which makes the arrival or breeding dates less reliable. Multiple ecological factors influenced the response of birds and their seasonal migration, which complicated their adaptation strategies. Local temperature changes, direct and indirect effects of climate, food variability, reproductive performance, life history, photoperiod, species diversity, and body size contributed to our understanding (Dunn, 2004). For example, changes in vegetation, shifting spring seasons, and plant phenology should be examined as well. Birds may also be sensitive to stress factors such as temperature, genetic factors, photoperiod, population, and food availability. Geographic differences between long-distance and short-distance migratory birds also influenced bird migration and seasonal behaviors (Dunn, 2004). Depending on specific birds and their breeding sites, scholars observed the recent early arrival of short-distance migratory birds in Poland (Tryjanowski, et al., 2002). Understanding how birds responded to climate change is difficult. Some birds overwintered in different places, which was not context-specific to the Alai Valley. They traveled long or short distances depending on migratory patterns. Migration also depended on how seasons elsewhere triggered movements. Because of these differences, climate change could favor short-distance migratory birds and negatively impact the long-distance migratory birds (Jenni et al., 2003).

Monitoring birds in Central Asia could still contribute to phenological data collection, but the citizen-science infrastructure is under development. A possible solution then is long-term data collection on the cycle of animal events, both locally and globally. Large-scale, citizen-science projects could also enhance our understanding of how birds respond to global climate trends. Many phenological networks, organizations, and data collection methods are emerging in the United States of America. Established by the Cornell Lab of Ornithology and National Audubon Society, eBird is one of many phenological data sets that allows citizens to submit observational bird data online (Schwartz, et al., 2013). Currently, not many people use eBird in Central Asia because they do not have regular access to electricity and internet. Large-scale data collection will be required to understand seasonal bird behaviors better. In Eurasian continents, seasonal bird migration followed north and south patterns, and vice versa. In Central Asia, villagers could, thus, use citizen-science programs like eBird. The biggest challenge would be mapping the habitat of spesific birds.

Conclusion

While there was a long history of studying phenological events as an integrated science (Schwartz, 2013), ecological calendars provided a holistic and interconnected perspective on local climate-change impacts. Local people decide their priorities within their annual ecological cycles. The calendar revealed essential data for understanding climatic constraints and seasonal changes in a place like Sary Mogul. For example in the Alia Valley, first snowfall occurred during September or October, and snow melted after April. Based on my literature review and experiences, I concluded that multiple environmental factors influenced all the events in the ecological calendar. Because snow cover was one of the main indicators of growing season length at higher elevations, remote sensing of snow cover could provide useful future monitoring for seasonal changes. While variation in soil temperatures remained unclear in spring and fall, future research should focus on soil temperature changes in alpine villages like Sary Mogul. Warm soils were imperative for producing both crops and livestock. Because many environmental factors influence growing season length, local people could collect data using available technologies like camera traps, digital cameras, and drones. Because the ecological calendar does not exclude plants and animals, seasonal changes could still be monitored to anticipate year-to-year shifts. Hence, environmental variables revealed greater understanding about the annual changes in high-altitude areas and future research perspectives.

CONCLUSION

This thesis was written as part of a transdisciplinary and international project, Ecological Calendars and Climate Adaptation in the Pamirs (ECCAP). Farmers and herders in the rural and mountain regions of Central Asia have long used ecological calendars to anticipate year-to-year local variations in seasons. However, considering Central Asia's long history of ethnic complexities and colonization, industrialization, and globalization, villagers have lost their written and documented ecological calendars. Since 2006, the revitalization of ecological calendars has been vital, as farmers and herders from different villages were experiencing direct and indirect impacts of a changing climate. Climate variations and seasonal uncertainties were impacting their seasonal decisions, making it difficult to time their herding and cropping schedules. A collaborative *community of inquiry* (scientists), and a *community of social practice* (farmers, fishers, hunters), have been committed to the revitalization of the ecological calendars by means of building anticipatory capacity for climate change at the village level.

Within the framework of the ECCAP project, my thesis focused on the revitalization of the ecological calendar for Sary Mogul Village, in the Alai Valley of Kyrgyzstan. Like many other research projects, it would be impossible to develop the ecological calendar without considering the contextual (social, cultural, ecological, and geopolitical) background. Because the existing literature associated with the Alai Valley provides little contextual knowledge about the people and place and ecological calendars, Chapter 1 recontextualized the social, historical, and environmental context of the Alai Valley its people. I learned that the increasing population of more than 5,151 people relied primarily on livestock, barley, and potatoes in Sary Mogul. People grow crops on the alluvial floor (in permafrost zones) at an elevation between 2,900 – 3,100 meters high and maximize their activities during the short growing season. People retained a close relationship with the land and were informed about local flora and fauna. The revitalized ecological calendar provided context and listed seasonal priorities for the community.

Studying historical ecological calendars of people from the Alai Valley was challenging because the region has been a crossroad of civilizations (Persian, Chinese, Arabs, Mongol, Turks, Russians, and English). Despite a long history of dispossession and possession that have influenced their ecological calendars, I provided evidence that human presence in the Alai Valley dated back to the Paleolithic period (Bernshtam, 1950; p.187-188). Humans have long been hunters, gatherers, farmers, and herders in the region. When we think about ecological calendars, we must consider the history of the Silk Road, where Persians, Chinese, Arabs, Mongols, Turks, Russians, and English have significantly impacted the local calendars. Although traditional lifestyles, including farming and herding, remain in the Alai Valley today, 19th-century colonization and industrialization of Central Asia influenced local hunting, farming, and herding practices. The creation of collective farms and reserves, and enclaving (especially in Sary Mogul) local people, significantly transformed livelihoods, including pastoral and cropping practices.

Kyrgyz peoples included both nomads and settled communities. Therefore, understanding their ecological and geographical context is vital when studying the calendars. The return of dispossessed tribes to the Alai Valley in 1947 marked the further adaptation of local knowledge of livestock herding and crop management in response to colonialism. The Alai Valley was not a new land to many tribes of the region. Deep snows during winter constrained human survival. Tribes moved seasonally before they were intentionally settled. After 1947, settlement provided an opportunity for people to experiment with crop production in a climatically-sensitive place like the Alai Valley.

Despite the disruption of the local knowledge by the colonization and industrialization, most local people remained herders and farmers, even today. Many ethnographers have documented the presence of an ecological calendar in the region, especially among Kazakh and Kyrgyz tribes (Фиельструп, 2002, p.205). A scholar from Ithaca, New York, well documented the presence of agriculture in the region (Schuyler, 1877, p.334; Фиельструп, 2002, p. 167). When looking at the ethnic affiliations and impact of the local language by neighbors, my research revealed that ecological calendars were impacted by Persian and Arabic languages. However, some uses of language would not be applicable in different places due its context-specific ecological meaning. The notion of *childe*, for example, is shared by tribes from Crimea to Kazakhstan, but its meaning varied because of different ecological contexts where people lived. In that way, the ecological calendar was sustained throughout history as people continued engaging in herding and farming.

Despite the brutal history of colonization and forced settlement of the tribes, the local history of Sary Mogul unfolded pluralistically. The community was comprised of many tribes with diverse professions, all of which benefited their adaptative abilities. The farmer’s ability to produce livestock and crops was essential, but climate often constrained them. In addition to climate, the food insecurity in Sary Mogul was closely related social-economic and political transformations impacted as a result of the Civil-War (1992-1997) and poverty in Tajikistan. The village gained its sovereignty as a community and became officially part of Kyrgyzstan in 2004. Before becoming a part of Kyrgyzstan, the community received enormous support from the Aga-Khan Development Network, utilizing how to grow the right types of potatoes at the elevation of 3,000 meters. To address the famine in the Pamir Mountains of Central Asia after the end of the Soviet Union, international organizations ran pilot projects experimenting with various potatoes and barley seeds. Food production remains vital for the survival of the communities in the region. Therefore, developing ecological calendars has been, and will be, urgent to address fragile livelihoods in Central Asia's mountain regions.

Having argued that the historical, geopolitical, and ecological context of the Alai Valley is important, Chapter 2 focused on the developing and interpreting the calendar. In the summer of 2016, I helped conduct an initial Season Round Workshop with 24 elders in Sary Mogul. The workshop established a partnership, and initiated a way to map the local understanding of ecological events in the calendar, and seasonal decisions (planting, harvesting, and livestock). In summer 2017, I prepared and conducted semi-structured interviews with 39 participants (n= 19 males and 20 females). The interviews were analyzed, and the key biophysical, and social practices were revealed. Based on these variables, a table version of the calendar was created and was validated with the community in summer 2018. Using ATLAS.ti, analytical software, key biophysical, and social variables were reviewed in summer 2019. Using Adobe Illustrator, all the biophysical, and social variables were integrated and digitized into a Seasonal Calendar. Two calendars were developed, one in English, and the other in Kyrgyz language.

I described the entire seasonality and socio-ecological cycle in Sary Mogul, which was not easy. Throughout the chapter 2, I argued that people understood the ecological events in relation to one another. Given the year-to-year climate variations, especially in the spring and fall, farmers were experiencing shifting decisions in cropping, harvesting, and herding of livestock. Therefore, developing ecological calendars may reveal complex relationships between biophysical characteristics and associated key local decisions related to planting, harvesting crops (mainly barley and potatoes), and seasonal livestock herding and breeding. The calendar I developed showed both environmental constraints and environmental variables within annually repeating events in mountain regions like the Alai Valley.

Having revitalized the local ecological calendar from the Alai Valley of Kyrgyzstan, Chapter 3 focused on envisioning future research steps. After describing the main ecological events in the calendar, I aimed to make specific recommendations for future research. I have identified the following key events to monitor in the future. I recommended monitoring snow accumulation (fall), snow cover duration (winter), snowmelt (spring), and growing seaason (summer), as they are related to herding and cropping practices. I have also prioritized monitoring soil temperature changes in spring and fall. Thawing and freezing of soil, ice-break, and ice-out, all are essential indictors of temperature changes in fall and spring. They reveal important data for monitoring the growing season. As a specific recommendation for the future research, I suggest using remote-sensing technologies to monitor snow cover and growing season length. Since there were scholars, non-governmential organizations, and other development organizations working in the region, an investment on technologies like loggers, and camera traps and drones could be made. While tourism prompoters use drones in Kyrgyzstan, in the Alai Valley drones might be problamic due to border control reasons. Only by identifying farmers' priorty decisions in fall and spring (lambig, herding, and cropping), respective or related biophysical events could be monitored. Ecological calendar provides that sepsific data. Monitoring biophysical events, mentioned in this chapter, will help foster adaptation to climate change at the village level, but we must consider farmers' multiple priorities. This Chapter could help farmers to test the seasonal calendar. Only after we test or use the calendar, the challanes and opportutnies would be vivid to developed spesific action plan.

GLOSSARY

SEASONS

The gray color signified photoperiod, specifically changes in day and night length. In the cycle of the four seasonsthe following events occurred: with the coming of spring, there will be *navruz*, referred to as the vernal equinox. After the vernal equinox, the day lengthens *kyn uzarat* and extends until *kyn toktoit* the summer solstice. After the summer solstice, *kyn-kaity*, days shorten *kyzgy taraza* autumnal equinox begins until *kyshta kyn toktoi* winter solstice. That was when the mating season for Ibex (*Capra sibirica*) started.

Because there were different winters, the first blue line signified *kysh* winter marked by a change in temperature. The coldest days of winter were called *childe,* informed by ice formation and ice melt. Local communities used different cues to mark these winters. Within *childe*, there was *tokson childe* ninety days of cold (mid-winter) informed by the arrival and departure of snow.

The second blue line signified *tokson childe*, ninety days of cold (mid-winter) informed by the arrival and departure of snow. Some community members claimed that it was exactly ninety days of cold, whereas some admitted that the cold lasts longer, but *tokson childe* meant mid-winter.

The third blue line signified the coldest days of the year, known as *kyrk childe,* which meant harsh-mid-winter.å Some community members said that it was exactly forty days of harsh weather, whereas others say the cold lasted longer. During this period, the Ibex (*Capra sibirica*) mating season began.

The light green line signified *baar or* spring. Because villagers did not know when snow would disappear, spring in Alai was unstable and very short; April and May. It was often cold, snowy, and rainy. Therefore, storing enough fodder for livestock and food for humans in this period was crucial. The activity level increased as food storage decreased.

The darker green line signified *saratan,* summer season. The warmest season of the year, during which *kara-kash torgoi* Horned Lark (*Eremophila alpestris*), *chakchagai*, Isabelline Wheatear (*Oenanthe isabellina*), and *kurchulduk*, Northern Wheatear (*Oenanthe oenanthe*) were present in the region; June – August. When these brown birds laid eggs, it marks the arrival of summer. When the *chakchagai* stops singing, it marks the end of summer.

The orange line signified *kyz,* autumn. Autumn began when forage dried, bended, and died, including *ak bash godo,* needlegrass (*Stipa orientalis*), and when livestock began to leave the pastures due to sudden temperature changes. In autumn, livestock gained mass, and lambs became self-sufficient (mature).

SYMBOLS

Physical indicators such as first snow, snow accumulation, snow cover, snowmelt, frost, ground freeze, thaw, and other soil-related events.

Bird phenology, such as arrival, breeding, and departure times of specific birds known by the community.

Animal and insect cues. For example, the mating season of mountain sheep (*Ovis ammon poli*), wild goat (*Capra sibir*ica), as well as hibernation and emergence of long-tailed marmots (*Marmota caudata*). It also included butterflies and insects.

Plant cues such as the emergence of grass until the end of the growing season.

Seasonality of livestock management. For example, herding seasons, breeding times of domestic sheep and goats, other specific relational activities.

Seasonality of crop management. Particular periods such as sequential planting and harvesting period for common sainfoin, barley, and potatoes.

Seasonality of sociocultural events. A particular period of food abundance, seasonal festivals, and other seasonal activities.

BIOPHYSICAL INDICATORS

Temperature changes. People knew the end of the winter and the beginning of spring when days became warmer. After the fifth *tokol*, a celestial constellation in March, *childe* was over. During this period, domestic sheep began to give birth, locally known as *tol* (lambing).

Melting of icicles when winter (*kysh*, *childe*, *tokson childe*, and *kyrk childe*) ended and (*baar*) spring began. “When a chunk of ice melts and breaks inside the cattle barns, we know that *childe* is over.”

A specific period when the ice on the bank of the rivers started to crack, making a sound (Onomatopoeia) called *guur - tyshty*. This hard sound of ice breaking marks the arrival of the spring, which occurred in early April.

Period of ice melting also *guur – tyshty*. That was when the river Kyzyl-Suu opened and became muddy.

Snowmelt period, during which *ala-telek* white and black snow patterns occurred against the surface of the mountain slopes, hills, and fields. Sunlight was not able to completely melt the snow on the fields. A little snowmelt occurred in the afternoon (before the sunset), and snow froze again at night.

Ala-telek, snowmelt takes place twice a year, in mid-April and around mid-November, thus marking the start and end of *childe*. When the snow melted, it was crucial to consider both specificities of *kyngoi*, the sun-facing slopes of the mountains, valleys, and pastures, as well as *teskei*, the shady slopes of the mountains, hills, valleys, and pastures.

Soil-related processes in spring. For example, *ton ketet* the disappearance of frozen ground was a sign of spring. The soil in the Alai Valley froze more than 1.5 meters deep. When it started to thaw, people noticed the fragmentation of the earth's surface, marking the end of winter.

Time to plant crops, especially potatoes. When *jerge tap kirdi* heat enters the ground, people plant potatoes. This local term refers to several soil-related events such as snowmelt, the soil becomes muddy, steam comes out, and the soil becomes warmer. These processes informed farmers about the right time to begin plowing and planting, known as *amal aiy.*

Sary-kar, the last heavy snow in spring could occur from early April to June. The half rainy, wet snow melted quickly and disappeared. In the Alai Valley, however, precipitation in spring was unpredictable, and therefore, it could even snow in summer.

The weather becomes warmer when summer begins. Herders moved livestock to the summer pastures. Several indicators must co-occur before herders move livestock to higher pastures. Snow must disappear. Grass must appear. Most importantly, a spikelet of barley appeared known as *maize*, thus informing villagers when to move to the summer pasture. If the herders did not move livestock to the pastures, newly-grown barley may be consumed.

In autumn, the days are getting colder. With temperature changes, people noticed livestock descending to lower pastures due to the cold. The grass stopped growing and turned yellow, known as *ot kaity*. The long-tailed marmots (*Marmota caudata*) hibernated. These signs all indicated fall.

Kyrgyek frost period, during which thumb-size green birds depart. They are so small that they can land on the stem of grass. Dangerous frost may destroy potatoes. The departure of birds co-occurs with frost. Therefore, farmers rushed to collect potatoes when early frost occurred. I assumed these green birds may be any one of the following: Hume's Warbler (*Phylloscopus humei*), Syke's Warbler (*Iduna rama*), or Greenish Wabler (*Phylloscopus trochiloides*). The key was to begin potato harvest when temperatures dropped, and early frost occurred.

A special wind known as *galdurgan shamal* (Onomatopoei) signaled autumn. A morning wind that could start from 6:00 am to 12:00 pm. The wind often blew from the east to west from mid-September and continued to May.

Formation of ice on the river systems known as *guur- alat* (Onomatopoeia). Villagers who lived along the rivers noticed the sound of ice.

Kara Suu spring water. If a spring continued to produce water through autumn, that indicated autumn would be extended. When springs ceased flowing, it marked the early arrival of winter.

Arrival and departure of snow, which took place twice a year, in mid-April and around mid-November. It marked the start and end of *childe*. Usually, snow was expected to arrive from mid-October to mid-November. Currently, snow may arrive as late as January. Understanding the snow cover period was essential because it determined livestock herding practices.

After harvesting crops like grass, barley (*arpa)*, common sainfoin (*Onobrychis*), and potatoes, *Jer tonot* the deep soil froze, which was also a sign of winter (October).

Burak was a term specifically referring to a sudden weather change during the mating season of mountain (*Ovis ammon poli*) sheep and wild ibex (*Capra sibirica*), from early December until the end of the month. Ibex mating may occur 10 -15 days after mountain sheep. The mating season of mountain sheep marked the beginning of *tokson childe,* mid-winter.

The duration of snow cover in the Alai Valley was from mid-October up to April. However, it is changing, especially the arrival of snow in autumn. Sometimes, the Alai Valley did not receive snow during winter *kara suuk*, which was unusual and rare. Villagers said that in mid-November, snow accumulates, creating layers known as *bardalalait*. When the snow accumulated, people started feeding sheep at home and were limited to herding livestock around the village.

BIRD KNOWLEDGE

This symbol collectively referred to *kush-keldi* known as the arrival of migratory and breeding birds. Depending on the late or early arrival of migratory birds, villagers determined the spring season. Occasionally birds arrived too early when there was still ice, and ducks died. This was known as *jalgan jai* fake spring. Land use activities began only after the arrival of migratory birds.

When bird migration occurred, various species of cranes *karkyra* (*Gruiformes*), *turna* (*Gruidae,* or *Anthropoides virgo*), other ducks, and geese, arrived. The spring smells nice, and land use activities began in April.

In the period of bird migration, the *chandyloch* White wagtail *(Motacilla alba)* arrived first. This mixed-color (white and black), small bird marked spring. The local people had a special ritual related to this bird. Upon seeing the bird, they immediately threw a stone at it out of excitement.

During the arrival of migratory birds, *kara* - *chyiyrchyk* small, blackbirds followed. They did not stay long in the area of Sary Mogul. Once they arrived, spring began.

Kashkalduk Common Coot *(Fulica atra)* continued to arrive. One challenge in identifying this bird, however, was the notion of *kashka* white-headed. This term may refer to horses, birds, and other animals with white spots on their head. I assumed that this bird might also be a White-Headed Duck (*Oxyura leucocephala*) or a White-headed Ruby Throat *(Luscinia pectoralis).* Nonetheless, according to the local description, this term was a local name for the Common Coot.

When the migratory birds arrived in spring and departed in autumn, *angyr* ruddy shelduck (*Tabdorna ferruginea*) arrived. Ruddy Shelducks informed seasonal changes. *Churok* (*Anas platyrhynchos), ala-partang (Margellus albellus),* and other ducks like *Angyr* Ruddy Shelducks (*Tabdorna* ferruginea) arrived, indicating spring.

When the migratory birds arrived in spring and departed in autumn, *ala-partang* Smew (*Margellus albellus*) indicated seasonal transitions.

Various birds like *ala karga* Eurasian Magpie (*Pica Pica*), white-headed duck (*Oxyura leucocephala*), and Ala-Partang Smew would also arrive and depart.

Although *Gizhik* or *Taranchy* Eurasian Tree Sparrows (*Passer zarudnyi*) were widely present in the area, they were also considered cues for the arrival of spring and summer. When they gathered in a group and made noise, farmers knew that rain would occur. The name *Gizhik* is an Onomatopoeia word.

When migratory birds arrived in spring, *sagyzgan,* the Common Magpie (*Pica pica*), also arrived. Some people referred to this bird as *ala parting*, but there were many other white and blackbirds like the Common Magpie in the region.

When spring arrived, the *Sasyk-Ypup* Eurasian hoopoe *(Upupa epops)* also arrived with other migratory birds in early March. They stayed in the area throughout the summer and left in mid-August.

The name *kaldugach* applied to three birds with similar tail shapes: the Common Swift (*Apus apus*), Northern House Martin (*Delichon ubricum*), and Barn Swallow (*Hirundo rustica*). When *Kaldugach* was seen in flocks during the departure of migratory birds, it indicated the end of summer and the beginning of autumn.

The name *kaldugach* applied to three birds with similar tales: Common Swift (*Apus apus*), Northern House Martin (*Delichon ubricum*), and Barn Swallow (*Hirundo rustica*). When *Kaldugach* was seen in flocks during the departure of migratory birds, it indicated the end of summer and the arrival of autumn. All of these birds were forked-tailed. I have included possible variations of icons.

When migratory birds arrived in spring, the *Bor-Bash* Spotted Great Rosefinch (*Carpodacus severtzovi*) also arrived. The Spotted Great Rose finch was generally common in the region.

The villagers measured summer by the arrival of breeding birds, the laying of eggs, the hatching of fledglings, and the departure of singing birds. Summer began when *saratan* laid eggs, known as *saratan-tuudu.* The following birds were included as *saratan*: *torgoi* Eurasian Lark (*Alauda arvensis*), *kara-kash torgoi* Horned Lark (*Eremophila alpestris*), *chakchagai* –Isabelline Wheatear (*Oenanthe isabellina*), and *kurchulduk* – Northern Wheatear (*Oenanthe oenanthe*).

Kara-kash torgoi Horned Larks *(Eremophila alpestris)* was one of the brown birds that laid eggs when summer began. They were commonly present throughout the region as resident birds known by the farmers.

Chakchagai –Isabelline Wheatear (*Oenanthe isabelline*) was one of the brown birds that laid eggs when summer began. This bird was important for the community in two ways. When these birds laid eggs, it marked the arrival of summer. When they stop singing, it marked the end of summer.

Kurchulduk: Northern Wheatears (*Oenanthe oenanthe*) was another of the brown birds that laid eggs when summer began. Northern Wheatears were breeding birds that arrived in early June and left in late August.

Torgoi Skylarks (*Alauda arvensis*) were brown birds that laid eggs when summer began. Northern Wheatears were breeding birds that were present in June, July, and August.

In mid-July, the community members noticed that bird chicks known as *balapan* begin to fledge. The community knew then that it was *saratan* summer. The word *saratan* also comes from Arabic, and it means Cancer (Crab).

Surprisingly nobody mentioned the waterbird *Kyky* Common Cuckoo (*Cuculus canorus*) that was present in the Alai Valley all summer. However, farmers identified *Bai ulu* Little Owl (*Athene noctua*) generally as an indicator of spring. However, *kyky* may refer to many birds such as *Pahtek* Eurasian Collared-Dove (*Streptopelia decaocto*) or the Little Owl as they sound similar (Onomatopoeia).

Some farmers did acknowledge their general familiarity with *Koguchkon or kok kabutar* Hill Pigeon (*Columba rupestris)*, which is also included in their seasonal calendar.

Pahtek Eurasian Collared-Dove (*Streptopelia decaocto*) was also a summer bird.

The times when migratory birds returned and departed were called *kush- kaity*. The departure of migratory birds indicated the end of the summer season and the arrival of autumn when the temperature changed from warm to cold.

The presence of *Chakchagai* Isabelline Wheatears during the growing season informed farmers of the summer period. When these birds stopped singing, it determined the end of summer and the beginning of fall. The name of the bird is also Onomatopoeia.

In autumn, a thumb-size breeding green bird arrived, and farmers noticed a frost locally called *kyrgyek*. This small bird may hang or land on the stem of grass when they migrate to the south. This frost may destroy potatoes. Therefore, farmers rushed to collect potatoes. I assumed that these green birds may be Hume's Warbler (*Phylloscopus humei*), Syke's Warbler (*Iduna rama*), or Greenish Warbler (*Phylloscopus trochiloides*). The key was to begin potato harvest with the early signs of fall.

When *Kaldugach* was seen in flocks during the departure of migratory birds, it indicated the end of summer and the arrival of autumn. The name *kaldugach* applied to three birds with similar tail shapes: the Common Swift (*Apus apus*), Northern House Martin (*Delichon ubricum*), and Barn Swallow (*Hirundo rustica*).

ANIMAL PHENOLOGY

The hibernation period for *Sugur chykty* Long-tailed marmots *(Marmota caudata)* was observed as a seasonal indicator. The arrival of marmots in April marks the arrival of spring. Marmots fully left hibernation by May. Marmot hibernation was not fixed and may shift. If marmots emerged mid-April, it indicated that herders would move livestock to pasture earlier.

Marmots fully emerged by May. However, the emergence of Long-tailed marmots *(Marmota caudata)* varied year to year. The hibernation period of the long-tailed marmots was about 7- 7.5 months, but it varied. It was crucial to consider *kyngoi*, the sun-facing side of the mountains, valleys, and pastures where the snow melted first; and *teskei*, the shady side of the mountains, hills, valleys, and pastures.

When spring arrived *kurt - kumurska* insects and flies emerged in late March and early April. The emergence and the disappearance of insects was also part of the ecological calendar.

During interviews in summer 2017, some community members told me that *Chychkan* the Eastern Mole Vole (*Ellobius tancrei*) emergence was a sign of spring.

When fresh grass started to appear for the first-time *kok kubuu*, the wild and domestic animals started to graze upon newly-emerged fresh grass. This behavior of domestic animals indicated the arrival of spring.

The term *kyik tuloit* referred to the period when herbivores such as Marco Polo Sheep and Ibex shed their hair. The arrival of spring was informed when herbivores lost hair, but we did not know the exact time, other than spring.

The period when herbivores such as Marco Polo Sheep and Ibex started to give birth was called *kyik toldoit.* The word *kyik* can be used to refer to some herbivores. The lambing season for mountain sheep and goats began from May and continued to June. Marco Polo Sheep gave birth earlier than Ibex because their lambs were more resistant to the cold than Ibex. This period informed the arrival of summer. When people heard the first thunder, they knew that mountain sheep gave birth. The early mating of sheep in fall indicated an early arrival of summer.

The period when herbivores such as Marco Polo Sheep and Ibex started to give birth was called *kyik toldoit.* The lambing season for mountain sheep and goats began in May, and continued to June. Marco Polo Sheep gave birth earlier than Ibex because their lambs were more resistant to the cold than Ibex. This period informed the arrival of summer. The early mating of sheep in fall indicated an early arrival of summer. The Ibex sheep mated 10-15 days after mountain sheep and gave birth after the mountain sheep.

Kyrgyz tribes inhabited a rich river system whether they live in Tien-Shan, the Alai Valley, or the Pamir Mountains. As soon as Kuzyl Suu river opened up, villagers began fishing for native brown trout (*Salmo trutta*), especially through the summer.

Herders told me that throughout the summer, farmers heard the sounds of *Chegirtke* (grasshoppers). Locust invasion was not a big deal in the village, but a female farmer from lower elevations complained about them. During the hot summer in Chon Alai Valley, grasshoppers destroyed crops, especially consuming grasses, but not in Sary Mogul.

End of autumn (late July and early August), specifically during the hay harvesting period, people noticed an emergence of *kogoon* horse flies. There was a specific period during which horseflies emerged and disappeared in July and August.

When the summer ended, lambs of domestic sheep became self-sufficient *kozu-torolot* or independent. Around this period, the lambs were sheared as well. Similarly, the lambs from wild mountain sheep and goats also mature and become self-sufficient.

When the summer ended, and autumn began, *Sugur Jatty* Long-tailed marmots *(Marmota caudata)* hibernated. The hibernation of marmots occurred from late August through September. If marmots hibernated early, the spring would come on time, and the winter would be snowy and cold. Marmot hibernation indicated the end of the summer pasture season. Shifts in marmot hibernation indicated seasonal changes. The emergence of marmots co-occurred with changes in soil temperature *Jerge Tap Kridi.*

All marmots were hibernating by mid-October. The hibernation period of the long-tailed marmots lasts about 7- 7.5 months. It was also crucial to consider specificities of *kyngoi*, the sun-facing side of the mountains, valleys, and pastures; and *teskei*, the shady side of the mountains, hills, valleys, and pastures when they hibernate.

Community members told me that fall was noticed when frogs vocalized (croaked) in September, but we have little data about frogs.

The arrival of snow in autumn was a sign of winter, but the time of arrival varied. Nonetheless, if snow arrived early, a heavy snowfall *Jut* was expected. Too much snow in winter and early spring limited access to pastures. Both wild and domestic animals would not be able to graze in the fields. Because of deep snow, the inability to graze triggered starvation and death for both wild and domestic animals such as sheep, goats, horses, and yaks. However, this disaster depended on total snow accumulation.

This symbol referred to a sudden weather change, such as snowstorms, snowfall, and other weather events known as *burak*. This term specifically referred to a sudden weather change during the mating season of *kulja - burak* mountain sheep (*Ovis ammon poli*) in December. In early December, the hunters observed how groups of male Marco Polo Sheep began scattering around in search of (*uiur*) – a group of female sheep. Usually, groups of male and female sheep live separately throughout the year. Knowing the mating time for Marco Polo Sheep helped predict the seasonal shifts in winter and summer.

The hunters in Sary Mogul also paid close attention to the mating season of the Ibex (*Capra sibirica)*, known as *teke-burak.* The mating of Ibex marked the beginning of the harsh winter, and it took place close to the winter solstice, December 22nd. It was important to note that Ibex mated and gave birth 10-15 days later than Marco Polo sheep. The main reason for this was that the lambs of Ibex were not as cold-resistant as the lambs of the Marco Polo sheep.

PLANT PHENOLOGY

When *kok-chykty* fresh grass started to appear in the fields, people knew that winter had ended, and spring arrived. The emergence of grass was essential because snow disappeared, the earth became dark, and the grasslands were accessible to livestock. However, due to sudden weather changes in spring, the grass could emerge early, known as *jalgan jai* fake spring. When fake spring occurred earlier than expected, the community did not believe that spring had arrived. This sudden warming informed the expectation of heavy and late snowfall in spring.

When fresh grass appeared for the first-time, wild and domestic animals started to consume it. This *kok kubuu* behavior among domestic animals indicated the end of winter and beginning of spring. The term also referred to mountain sheep (*Ovis ammon poli*) and mountain goat Ibex (*Capra sibirica*) descending to lower valleys.

Kok kubuu indicated a behavioral change among sheep, goats, and other animals when grasses emerged. The livestock become picky, refusing to eat stored fodder. That was how people noticed the arrival of spring.

Sheep may die after foraging on too much fresh grass in spring. The effect of fresh grass on weak livestock was called *kok-suruu* or diarrhea (scours). It was a crucial period for livestock, and it usually took place in mid-April. This process was also known as *ulgoo* – a process where weakened animals die due to diarrhea.

When Baichechekei Snowdrops (*Galanthus spp.*) emerged, it indicated the arrival of spring.

In May, a yellow flower *Mamakaimak* dandelion *(Dadneline asteraceaee)* emerged. There were two types of dandelions present in the Alai Valley. One was white, and the other yellow. This flower remained widely present in the fields of Sary Mogul throughout the summer. For the purpose of showing two different color flowers from one family, I made two icons.

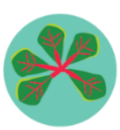
In May, a yellow flower *Mamakaimak* dandelion *(Dadneline asteraceaee)* emerged. There were two types of dandelions present in the Alai Valley. One was white, and the other yellow. This flower remained widely present in the fields of Sary Mogul throughout the summer.

As the spring arrived, the red poppy flowers emerged and quickly disappeared. However, villagers did not specify which species. Some community members showed me *Kyzgaldak* Poppy *(Roemeria papavera)*, a red flower in their yards. Based on photo identification, it was one type of poppy flower.

Around the 25th of June, as the Pleiades emerged and rose from the east, people observed the growth of *Ak-Bash Godo* Nail grass *(Stipa orientalis)* in the fields.

When spring arrived, people observed the emergence of *At-Kulak* Common Sorrel *(Rumex spp.)*. This plant was known by the community and used as a seasonal indicator.

When the spikelets of barley emerged as *maize*, farmers knew the right time to allocate their livestock from village to summer pastures. When the barley spikelets grew about 20 cm, the farmers started moving livestock to summer pasture. If the farmers did not move animals to pasture, they would graze newly-grown barley in the village. Therefore, as soon as grasses emerged, especially in the summer pastures, people moved livestock.



The *Chykyry* Rheum *(Rheum reticulatum Los)* was a widely-grown edible plant in the Alai Valley. The full height of this plant indicated the peak of the summer season. The stems were collected and consumed.

Ot-kaity indicated when grass, barley, and other plants bent and stopped their growth. This icon showed how *Ak-Bash Godo* Nail grass *(Stipa orientalis)* bent and died, informing farmers when to harvest their crops.

Ot-kaity was when grasses dried and died in late July. Barley and other meadows bent and stopped their growth. Grass color was a crucial indicator of the transition from summer to autumn. That was when farmers harvested natural fodder grasses like *Budai Bashy (Poaceae)*, *Kara-Bash (Poaceae),* and *Kiyak* (*Leymus secalinus*).

LIVESTOCK RELATED PRACTICES

When *kok-chykty* fresh grasses started to emerge, it indicated spring, which occurred after the snow disappeared. Herders took their livestock out to the fields. That was when people also moved to the summer pasture. Snowmelt and grass emergence varied year-to-year. Sometimes, grasses emerged much earlier, but then icing and shifting spring seasons could be expected.

When grasses emerged in spring, it was crucial to consider *kyngoi*, the sun-facing side of the mountains (valleys, and pastures); and *teskei*, the shady side of the mountains (hills, valleys and pastures). The slopes made a big difference in the process of snowmelt and grass emergence in the high pasture grounds.

The emergence of grasses in the village did not mean that they emerged in the summer pasture areas. Because the village of Sary Mogul was located in the valley, many of the pastures were situated in the foothills of the Alai Mountains, where ground temperatures varied.

Fresh grasses emerged, *kok-chykty* and snow disappeared in the summer pastures. Otherwise, farmers could not move livestock to the summer pasture. Although grasses may occur around the village, by now, they should appear in the summer pastures as well. That was when people moved to the summer pasture.

Once livestock was brought back to the village in September, herders took shifts herding livestock around the village until snow accumulated. Each day, different shepherds from the village herded sheep, goats, and cows. This type of herding was called *Noat,* which began in mid-September and continued until November. Usually, heavy snow was expected by mid – November, which made it impossible to keep livestock at summer pastures. Thus, from November to April (during the snow over a period), livestock was kept in the village under human care. As the snow melted, this type of village-based herding practice continued during April and May (known as *Kezuu*) until people moved to the summer pastures.

It was common for sheep and goats to be kept in a fenced corral during the night. Throughout the summer, manure accumulated in the places where farmers keep livestock. The manure *kyk-kesyy* was cut into pieces during spring and autumn. With the end of winter and the beginning of spring, people cut manure and dried it throughout the summer. Close to the end of summer, during the pasture season at the end of August, the farmers cut the livestock manure again and left it for the next year. During the following year, when they come to the summer pasture, they will use dried manure as fuel for fires.

Cattle produced manure called *kyk*. In late April, farmers took the manure outside to let it dry throughout the summer. Once it was dried in late August, the farmers started bringing manure indoors and used it for fire in winter. Stable weather in summer was required to dry the piled manure known as *ganek*. If wet weather anomalies occurred, it might damage the *kyk*, not allowing them to dry. Drying the manure was dependent on the availability of sunlight, wind, and a favorable climate. Too much rain was not good for *kyk* because it did not dry.

Farmers noticed that when domestic sheep *tuloit* shed hair, that informed the arrival of summer, as well as shearing time. The wool loss in sheep (*Urloo*) indicated it was time to shear, but if sheared too early, the sheep may be subject to death if sudden cold and rain occurred.

From early April to early June, *Uzun Sary* was a long yellow period, which indicated the time of starvation and food scarcity. During this time, villagers faced a reduction in food and fodder supplies. The livestock would be *arykchylyk* undernourished due to the lack of grass. The days became longer, and the local community was busy plowing and planting. At this time, stored food acquired from livestock and crops were consumed.

Spring lambing *baargi tol kiret* was a period when sheep and goats started giving birth. Sheep gave birth between 142-156 days of gestation, which was about five months. Many people in the Sary Mogul community bred sheep throughout October and November in order to undertake spring lambing. It was preferred because farmers timed the breeding towards the warmer season when *childe* ended and spring arrived. The spring lambing occurred during March to April.

Topoz tol was when the yaks began to give birth, from mid-May up to mid-June. The yaks give birth after 256-257 days of gestation, which is between 8.5 and 9 months. However, the mating season of yaks were not fixed at a certain time.

Although people in Sary Mogul did not monitor horse mating as a seasonal indicator, horses were bred in the summer. A single male *aigyr* was put together with *uiur* a group of female horses, but they did not mate randomly. They mated when their time came as well. Starting in late May, horses gave birth, and the milking season began. Many people in Sary Mogul drink *kymyz* fermented horse milk for traditional healing purposes, especially during the early milking season. In autumn, herders stored *kymyz* in plastic bottles for spring.

Beginning from the 15th of May, the Pleiades set in the west and disappeared for 40 days. At this time, day length became longer. While the *Urkor* Pleiades was not seen, the local people drank *Saamal* horse milk. People believe that drinking *Saamal* can be much healthier during horse lambing. Around the 24th of June, the Pleiades re-appeared from the east. As the stars rise, the community will notice the growing process of grass higher and higher.

Shearing sheep and goats were called *koi kyrkym,* which started from late May to June. It was important to know the right time to shear sheep. Otherwise, they may die due to cold, especially if they were sheared too early in spring. Therefore, early shearing was not preferable due to the risk of cold weather as well as rain.

When wild and domestic herbivores have eaten enough newly-emerged fresh grass, spring arrived and was called *Kokko toiuu*. This particular indicator informed pastoralists of spring.

The village of Sary Mogul was located in the alpine area. Farmers took their sheep to the edges of snow near glaciers of the Alai Mountains. Snowmelt occurred differently in different pastures. Therefore, without snowmelt near glacier pastures, people could not take their livestock to those areas.

In the Sary Mogul, *jailoo* summer pasture season lasted only three months, June, July, and August. When the snow disappeared in the summer pastures, and new grass emerged, herders moved livestock to the summer pasture. *Jailoo* ended with the arrival of cold temperature changes. During summer, farmers produced dairy products and stored food for the spring. When migratory birds left, marmots hibernated, and kids began feeling the cold, farmers moved to the village.

The villagers moved livestock to summer pastures when the barley started to grow, and spikelets emerged (*Maiza*). In the summer pastures, farmers herded livestock. Most herders returned during late August because kids must go to school on the 1st of September. The end of August was officially the end of the summer pasture period. However, some herders who had barns in summer pasture areas stayed all year round. Some farmers tried to stay as long as possible, waiting for the arrival of the first snow. In mid-October, the first snow was anticipated, and the summer pasture season fully ended.

In the context of Sary Mogul, the notion *Jer-kopty* refers to the growing process of vegetation or grasslands. After some period when fresh grass appears, the grasslands raise up, covering the ground's surface. Day by day, the star *Urkor* Pleiades begins to rise up higher and higher. Some people refer to this period, *jer kopty*, *at koptu* enriched grassland, during which horses become viral. From late May to mid- June, the community will not see Pleiades, the group of stars, for 40 days.

In late June, the herders separate male sheep and herding them separately, known as *kochkor bolynot.* The male sheep are herd separately from June to October. Specialized herder *kochkorchy* herds male sheep separately.

This sign indicates a period of viability of *ak-chykty* white dairy products. Dairy products include *syt* - milk, *airan* – yogurt, *kaimak* cream, *kurut* cheese, *saamal*- horse milk, *kymyz*- fermented horse milk, *sary-mai* yak butter, and *syzmo*, processed yogurt, *syt* milk, *karyn-mai* stored butter in duck shape, *meshke mai* lighter yak butter, *kurut* hard cheese and other types of cheese (*uuz*, *ejigei*, *byshtak*, and *tolto*). The dairy products will be available from April to October.

It is a time of shearing yak, which begins in July and ends in late August, locally known as *topoz kyrkym*. The shearing of yaks takes place once a year, close to autumn.

When autumn begins, livestock behavior changes. Domestic sheep gain weight when autumn begins. Maturity of animals is observed to understand the state of the growing season.

When summer ends, lambs of domestic sheep become self-sufficient *kozu-torolot* or independent.

When the summer ends, lambs of domestic sheep become self-sufficient *kozu-torolot* or mature. Around this period, the labs are sheared as well. Similarly, the lamb of mountain sheep and goats also become self-sufficient and mature, which is a sign of autumn.

Animals such as sheep and goats do not graze in higher pastures, and the livestock descend to lower elevation. *Otko-kachat* is an escaping behavior of livestock which informs the arrival of autumn. Even though there are plenty of pastureland and grass fields, the livestock descends from the higher elevations as days become colder in fall.

During this period, some livestock may die due to cold days. Therefore, we must shelter them. This period also co-occurs with frost and ice forming in small streams.

After the summer solstice, we expect *ot-kaity* the grass fields, barley, and other grasses band and to cease growing. When grass dries and changes color, it is crucial to consider specificities of *kyngoi*, the sun-facing side of the mountains, valleys, and pastures and *teskei*, the shady side of the mountains, hills, valleys and pastures.

The grass, barley, and other forage dries, dies, and turns yellow at the end of summer. This process is locally called *ot-kaity*. However, specificities of *kyngoi*, the sun-facing side of the mountain and *teskei*, the shady side of the mountain makes a difference when growing season ends.

In Sary Mogul, *jailoo* summer pasture season last only three month, June, July and August. *Jailoo* ends with the arrival of cold, temperate change. When the days become cold in fall, livestock escape from the pasture, grass turns yellow, marmots hibernate, and kids begin feeling the cold.

The livestock in Sary Mogul are hand-fed in the village from mid-October to end of April because snow cover in Alai lasts longer. Keeping livestock in the village and feeding by hand is called *Koldo-karoo*. It is important, however, to note that arrival and departure of snow shifts. Therefore, hand-feeding livestock in the village is variable.

Kyshky tol – means winter lambing. Depending on the breeding time of sheep, winter lambing takes place in January and February. Many farmers do not prefer winter lambing because it is too cold, and the mother sheep consumes too much fodder and hard work. Only a few people undertake winter lambing in Sary Mogul. Although there is enough fodder, the cold and sheep health is the main reason why winter lambing is not preferred.

When male sheep are put back together with females, it is called *kochkor koshylat.* Many people in Sary Mogul community breed sheep throughout October and November. Farmers time sheep lambing *baargi tol kiret* in October because they prefer spring lambing when days become warmer in late March and early April.

The mating season of *topoz jugurot* yaks is usually expected from mid-July to October, but it varies depending on the season. Like mountain goats and sheep, *buka* males often graze separately in higher elevations and mate once a year. If male yaks visit (*jele)* a place where female yaks are milked and leave without mating, this indicates a seasonal shift.

This symbol represents the activity of storing food in autumn. Close to winter, herders prepare food, especially dairy products *sary-mai* yak butter, and *syzmo*, processed yogurt, *syt* milk, *karyn-mai* stored butter in duck shape, *meshke mai* lighter yak butter, *kurut* hard cheese, and other types of cheese (*uuz, ejigei, byshtak,* and *tolto*) for spring.

Many people in Sary Mogul keep livestock. The livestock produce manure, which is called *kyk*. In late April, local people take out the manure to let it dry in the sun throughout the summer. When they take out the manure, they create a pile called *Ganek*, a special way of building *kyk* so that wind can go through and dry them effectively. In late August, local people start bringing the dried manure indoors and store it. In winter, they use it as fire.

LAND USE PRACTICES

Land use, plowing, and panting, a period called *amal-aiy*, occurs in April through May. Biophysical processes in spring known as *jerge tap kirdi* the entrance of heat into the ground, and the emergence of the steam out of the soil informs land use activities. However, this process varies from year to year. In this period, people plant barley *arpa* and then plant *Espartset* common sainfoin (*Onobrychis*). The potatoes are planted much later, by the end of May. Due to the late departure of snow and thawing, the land use activities shift from April to May, sometimes even June.

Land use activities like plowing and planting occur in April and May, depending on snow melt and thawing of soil. It is known as *amal-aiy* land use season.

Farmers know the right time to begin planting barley when snow and soil thaw from April through May. When the soil becomes warmer, it informs land use activities in spring.

When spring arrives, people notice a biophysical process known as *jerge tap kirdi*; people plant *Espartset* Common Sainfoin (*Onobrychis*).

Potatoes are planted a little later when soil *jerge tap kirdi* becomes warm enough. Potatoes are planted in the third and fourth weeks of May depending on the thawing season.

In the summer of 2018, I noticed that farmers pay attention to the flowering time of potatoes in spring. However, it is important to mention that people plant various potatoes seeds that may also impact flowering times. For example, the seeds are *Germansky. Picaso, Kardinal, Agava, Jele, Super Elita,* and *Chelpek.* Some of these seeds grow sixty days, whereas others grow in nighty days, all of which have to be considered.

People harvest *Espartset* Common Sainfoin (*Onobrychis*) when purple leaves fall. Common Sainfoin is harvested two times in July and in September depending on the growing season. Crops such as barley, Common Sainfoin, and natural hay are important crops collected from August to mid-September before the livestock arrive in the village.

The arrival of autumn is informed by *ot-kaity* (color change in vegetation). Particularly when the *ak-bash godo (Stipa orientalis)* and barley start to bend, change their color from green to yellow, and start to dry, all of which marks the transition. If it rains too much during the harvesting, we risk losing harvest of fodder because wet grass turns dark and spoils.

According to farmers, barley is a top-quality fodder after Sainfoin and other grass harvested for livestock. If not generalized, people are familiar with *ak-bash godo* grass *(Stipa Orientalis), budai bashy* grass *(Poaceae) kara-bash* grass *(Poaceae)*, and *kiyak* grass *(Leymus secalinus).* They are harvested between mid-August to mid-September.

The arrival of autumn is informed by *ot-kaity* (color change in vegetation). Particularly when the *ak-bash godo (Stipa Orientalis)* and barley start to bend, change color from green to yellow, and start to dry. Barley is harvested. Herders take their livestock to the village.

In the fall, villagers notice frost known as *kyrgyek*, during which a thumb-size green bird arrives. Frost could occur three, sometimes four times, during the transition period from spring to autumn, informing the community to accommodate crop harvesting. That is when potato leaves die out, which is expected from mid-August to mid-September.

What is frightening about frost (*kyrgyek)* is that it may destroy potatoes. Therefore, people rush to collect potatoes when frost starts to occur. We assume that these green birds might be following birds according to local classification, Hume's Warbler (*Phylloscopus humei*), Syke's Warbler (*Iduna rama*), or Greenish Wabler (*Phylloscopus trochiloides*), but we are not sure. The key is to begin the potato harvest when the temperature changes in the fall.

People wish to leave the potatoes in the ground up to October, but temperature change and the occasional ground frost forces farmers not to take a risk. Farmers in Sary Mogul collect potatoes much earlier in September. Only a few people leave their potatoes on the ground up to October 10-15 until the point when potatoes develop harder skin to be fully enriched. However, it is not often the case. They are collected in September depending on frost (temperature change).

Storing fodder is crucial to sustaining the livestock in the period of snow cover, which is a risky season for several reasons. April and May are the lambing seasons, but it is hard to predict the spring, especially the departure of snow. To secure lambing people need fodder. In spring 2016, the villagers ended up buying fodder from the city of Osh in order to save their livestock from unexpected icing in Spring.

SOCIAL CULTURAL ACTIVITIES

Since there is a coal mine near the village called "Osh Prim," villagers in Sary Mogul prepare coal to supply themselves with fuel sources in addition to livestock manure. In October, people prepare coal.

Byshykchylyk - is the season of plentiful and abundance for the community, which begins in autumn and continues throughout the winter, September- January. In this period, the livestock will be salubrious enough. The community will have enough fodder and food supplies to meet the winter and prepare for spring. Most of the community celebrations and events take place in this period. *Tokchylyk*- this term refers to the period of abundance or plenty, which starts from autumn and continues throughout the winter.

Seasonal community festivals take place in autumn from September to January. During the *tokchylyk* plenty or *byshykchylyk* abundance season, most of the community celebrations such as *beshik toi* newborn celebration, *jeentek* food share after newborn, *bala oturguzuu* – circumcision, *chach ordy* - braiding, *kyz uzatuu* – marriage, *toi-tamasha* – feast, *uigo bata aluu*- new house blessing celebrations are renowned during the abundance season.

In winter, people burn coal and manure and sit at home. Winter is the slowest time of the year and the intensity of winter activities decline.

In winter, villagers clear snow. Farmers take care of the livestock by maintaining them in shelter during the snow cover.

Although there are not many hunters in Sary Mogul, a few hunters suggested that they hunt during winter. Hunters say, however, that during mating and lambing seasons, it is prohibited to hunt.

Women engage in weaving activities in addition to other seasonal work they do. In order to prepare for summer, woman *Jyn yiryy* – convert a wool into string. Women of Sary Mogul seasonally produce carpets from sheep wool. They include various types of rugs (*taar, chadar, gajary, eki jyzdyy,* and *terme*), yurt decorations (*boo, uug tizgich*, and *jel boo*) and specially designed felts (*ak kyiyz, orgo kyiyz, kara kyiyz, choimo kyiyz, oimo,* and *shyrdak with jeek*).

Nooruz – is a celebration of *jaz* spring from 21 to the 24 of March during the times of Vernal Equinox. During this event, villagers clear their yards, organize games, prepare food - *sumanak*, and make good wishes. This holiday is widely celebrated as a New Year among the communities in Central Asia.

When grass emerges, the community notices the abundance of the wolves around the area. Mountain sheep (*Ovis ammon poli*) and mountains goat Ibex (*Capra sibirica*) descend to lower valleys searching newly emerged grass.

Farmers clean snow during the winter. Farmers take care of the livestock in shelter during the period of snow cover. As part of winter activity, men work in the coal mine, whereas women engage in weaving activities. The winter is the slowest time of the year.

Farmers irrigate crops during the short summer (June to August) both inside and fields outside of the village. The farmers have a special irrigation schedule upon which they rely during the irrigation season. Depending on how much rain the village receives during a short summer, barley is irrigated 3-4 times throughout the season.

CELESTIAL KNOWLEDGE

The four suns signify Equinox and Solstice. The Vernal Equinox is called *Navruz* and autumn Equinox is called *kyzgy taraza.* In early summer, the sun stops its movement known as *kyn toktoit* or summer solstice. After the summer solstice, *kyn-kaity* occurs, day length shortens until *kyshky taraza* or winter solstice, during which mating season Ibex (*Capra sibirica*) take place.

Cosmology plays a central role in Kyrgyz ecological calendar. The key is to be aware that any celestial data reveals terrestrial activities. Like many other communities, the calendar in Alai is based on lunar, which engages weather changes such as snow, wind, cold, storm, and rain. Terrestrial changes are also perceived through the collision of stars with the moon.

The sign circled in black means dangerous as well as more variable events. Some examples are the early arrival of migratory birds, re-hibernation of marmots in spring, early emergence of green grass, flexible occurrence of soil related biophysical processes, flexibility in arrival of snow and departure, flexibility of yak mating season, and frost in autumn.

The sign circled in black means that ecological signs are related to another sign. For example, when the soil warms up, people plant potatoes. When winter ends, the spring lambing of domestic sheep begins.

The arrow shows how ecological signs are related to each other. For example, when snow disappears, green grass emerges. When marmots hibernate, the summer pasture season is over. Farmers must collect potatoes when early signs of frost occur, and migratory birds depart.

REFERENCES

Akmataliev. A. (1996). Kirghiz Craftsmanship (Кыргыз Кол Өнөрчүгү). Bishkek. Kyrgyzstan.

Afonso, E., Knapp, J., Tête, N., Umhang, G., Rieffel, D., van Kesteren, F., Ziadinov, I., Craig, P. S., Torgerson, P. R., & Giraudoux, P. (2015). Echinococcus multilocularis in Kyrgyzstan: similarity in the Asian EmsB genotypic profiles from village populations of Eastern mole voles (Ellobius tancrei) and dogs in the Alay valley. *Journal of Helminthology*, *89*(6), 664–670. https://doi-org.proxy.library.cornell.edu/10.1017/S0022149X15000474

Басилов, В. Н. (1986). *Древние обряды, верования и культы народов Средней Азии*.

Alexander K. Fedosenko, & David A. Blank. (2005). Ovis ammon. *Mammalian Species*, *773*, 1–15.

Ayé, R., Schweizer, M., & Roth, T. (2012). *Birds of Central Asia*. Bloomsbury Publishing.

Barash, D. P. (1989). *Marmots: social behavior and ecology*. Stanford University Press.

Bernshtam, A. N. (1952). *Istoriko-Arkjeologicheskie Ocherki Tsentral'nogo Tyan'-Shanya I Pamiro-Alaya (*Historical-Archeolopgical Essay on the Central Tian Shan and Pamiro-Alai Mountain Region), IA 26, Akademii Nauk SSSR, Moscow

Bliss, F. (2006). *Social and economic change in the Pamirs (Gorno-Badakhshan, Tajikistan).* London: Routledge.

Bliss, L. C. (1971). Arctic and Alpine Plant Life Cycles. *Annual Review of Ecology & Systematics*, *2*, 405–438. https://doi-org.proxy.library.cornell.edu/10.1146/annurev.es.02.110171.002201

Blumstein, D. T., Im, S., Nicodemus, A., & Zugmeyer, C. (2004). Yellow-bellied marmots (Marmota flaviventris) hibernate socially. *Journal of Mammalogy*, *85*(1), 25-29.

Blumstein, D. T., & Arnold, W. (1998). Ecology and social behavior of golden marmots (Marmota caudata aurea). *Journal of Mammalogy*, *79*(3), 873-886.

Buus-Hinkler, J., Hansen, B. U., Tamstorf, M. P., & Pedersen, S. B. (2006). Snow-vegetation relations in a High Arctic ecosystem: Inter-annual variability inferred from new monitoring and modeling concepts. *Remote Sensing of Environment*, *105*(3), 237–247. https://doi-org.proxy.library.cornell.edu/10.1016/j.rse.2006.06.016

Brower, D. (2003). *Turkestan and the Fate of the Russian Empire.* Routledge: Routledge. Retrieved from https://search.ebscohost.com/login.aspx?custid=s9001366&groupid=main&profid=pfi&authtype=ip,guest&direct=true&db=edspub&AN=edp1656809&site=eds-live&scope=site

Bryant, J. P., Chapin III, F. S., & Klein, D. R. (1983). Carbon/nutrient balance of boreal plants in relation to vertebrate herbivory. *Oikos*, 357-368.https://doi-org.proxy.library.cornell.edu/10.2307/3544308

Bryman, A. (2003). *Quantity and quality in social research*. Routledge.

Bryman, A. (2008). *Social research methods.* (3rd ed.). Oxford: Oxford University Press.

Bryman, A. (2016). "Ethnographic and participant observation", *Social research methods*. Oxford university press.

Bunnell, F. L. (1982). The lambing period of mountain sheep: synthesis, hypotheses, and tests. *Canadian Journal of Zoology = Journal Canadien de Zoologie*, *60*(1), 1–14.

Callahan, E. M., Jr. (2014). To rule the roof of the world: Power and patronage in Afghan Kyrgyz society [ProQuest Information & Learning]. In *Dissertation Abstracts International Section A: Humanities and Social Sciences* (Vol. 74, Issue 7–A(E)).

Cobbold, R. P. (1900). *Innermost Asia : travel & sport in the Pamirs*. London : W. Heinemann.

Cooper, E. J., Dullinger, S., & Semenchuk, P. (2011). Late snowmelt delays plant development and results in lower reproductive success in the High Arctic. *Plant Science*, *180*(1), 157–167. https://doi-org.proxy.library.cornell.edu/10.1016/j.plantsci.2010.09.005

Cochran, F. V., Brunsell, N. A., Cabalzar, A., van der Veld, P.-J., Azevedo, E., Azevedo, R. A., Pedrosa, R. A., & Winegar, L. J. (2016). Indigenous ecological calendars define scales for climate change and sustainability assessments. *Sustainability Science*, *11*(1), 69. https://doi-org.proxy.library.cornell.edu/10.1007/s11625-015-0303-y

Cohen, J. L. (1), Furtado, J. C. (1), Barlow, M. A. (2), Alexeev, V. A. (3), & Cherry, J. E. (3). (n.d.). Arctic warming, increasing snow cover and widespread boreal winter cooling. *Environmental Research Letters*, *7*(1). https://doi-org.proxy.library.cornell.edu/10.1088/1748-9326/7/1/01400

Charmantier, A., & Gienapp, P. (2014). Climate change and timing of avian breeding and migration: evolutionary versus plastic changes. *Evolutionary Applications*, *7*(1), 15.

Chmielewski, F. M., Heider, S., Moryson, S., & Bruns, E. (2013). International phenological observation networks: concept of IPG and GPM. In *Phenology: An integrative environmental science* (pp. 137-153). Springer, Dordrecht.

Clark, J. L. (1994). *The great arc of the wild sheep / by James L. Clark ; foreword by Richard M. Mitchell*. xxxvi.

Crimmins Theresa M., Crimmins Michael A., & Bertelsen C. David. (2010). Complex responses to climate drivers in onset of spring flowering across a semi-arid elevation gradient. *Journal of Ecology*, *98*(5), 1042–1051.

Crawford, R. M. M. (n.d.). Cold climate plants in a warmer world. *Plant Ecology and Diversity*, *1*(2), 285–297. https://doi-org.proxy.library.cornell.edu/10.1080/17550870802407332

Davydov, G. S. (1991). Some characters of two populations of the long-tailed marmot. *Population structure of the marmot, proceedings of scientific investigations. USSR Theriological Society (In Russian), Moscow*, 188-216.

Devendra, C. (1995). Nutritional ecology of the ruminant. 1994: Peter J. van Soest, Cornstock Publishing Associates, Cornell University Press, Eage House, 512 East State Street, Ithaca, NY 14850, USA. HB US $71.50. ISBN 0-8014-2772-X. 476 pp.

Dörre, A., Kreutzmann, H., & Schütte, S. (2016). Pamirs at the Crossroads: Changing challenges and perspectives. Berlin Geographic Papers Vol.45 Centre for Development Studies (ZELF) Institute of Geographical Sciences Freie Universität Berlin.

Dobson, F. S., & Murie, J. O. (1987). Interpretation of intraspecific life history patterns: evidence from Columbian ground squirrels. *The American Naturalist*, *129*(3), 382-397.

Dor, R. (1993). Ооган Памириндеги кыргыздар (The Kirghiz in Afghanistan) Bishkek, Kyrgyzstan.

Duffy, J. P., Cunliffe, A. M., DeBell, L., Sandbrook, C., Wich, S. A., Shutler, J. D., ... & Anderson, K. (2018). Location, location, location: considerations when using lightweight drones in challenging environments. *Remote Sensing in Ecology and Conservation*, *4*(1), 7-19.

Dubé, P. A., Perry, L. P., & Vittum, M. T. (1984). Instructions for phenological observations:

lilac and honeysuckle. *Bulletin/Vermont Agricultural Experiment Station (USA)*.
Dunn, P. (2004). Breeding Dates and Reproductive Performance. *Advances in Ecological Research*, *35*, 69–87. https://doi-org.proxy.library.cornell.edu/10.1016/S0065-2504(04)35004-X
Dye, D. G. (1,2). (n.d.). Variability and trends in the annual snow-cover cycle in Northern Hemisphere land areas, 1972-2000. *Hydrological Processes*, *16*(15), 3065–3077. https://doi-org.proxy.library.cornell.edu/10.1002/hyp.1089
Emmerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). Writing ethnographic fieldnotes. *Chicago, IL: University of Chicago*.
Euskirchen, E. S., McGuire, A. D., Kicklighter, D. W., Zhuang, Q., Clein, J. S., Dargaville, R. J., Dye, D. G., Kimball, J. S., McDonald, K. C., Melillo, J. M., Romanovsky, V. E., & Smith, N. V. (2006). Importance of recent shifts in soil thermal dynamics on growing season length, productivity, and carbon sequestration in terrestrial high-latitude ecosystems. *Global Change Biology*, *12*(4), 731–750. https://doi-org.proxy.library.cornell.edu/10.1111/j.1365-2486. 2006.01113.x
Evans-Pritchard, E. E. (1939). Nuer time-reckoning. *Africa*, *12*(2), 189-216.
Evans, R. D., & Fonda, R. W. (1990). The influence of snow on subalpine meadow community pattern, North Cascades, Washington. *Canadian Journal of Botany = Journal Canadien de Botanique*, *68*(1), 212–220.
Fedosenko, A. K., & Blank, D. A. (2005). Ovis ammon. *Mammalian Species*, *2005*(773), 1-15.
Фиельструп, Ф. А. (2002). *Из обрядовой жизни киргизов начала XX века*. Наука.
Foster, J. L. (1989). The Significance of the Date of Snow Disappearance on the Arctic Tundra as a Possible Indicator of Climate Change. *Arctic and Alpine Research*, *21*(1), 60–70. https://doi-org.proxy.library.cornell.edu/10.2307/1551517
Fihl, E. (2002). *Exploring Central Asia: Collecting Objects and Writing Cultures from the Steppes to the High Pamirs 1896-1899. Vol. 1-2* (Doctoral dissertation, Thames & Hudson).
Futter, M. N. (2003). Patterns and Trends in Southern Ontario Lake ice Phenology. *Environmental Monitoring and Assessment: An International Journal Devoted to Progress in the Use of Monitoring Data in Assessing Environmental Risks to Man and the Environment*, *88*(1–3), 431. https://doiorg.proxy.library.cornell.edu/10.1023/a:1025549913965
Gaunavinaka Leba (2010). Regional differences by an analysis of main land use/land cover and bioregional conditions in the Kyrgyz part of the Pamir-Alai Transboundary Conservation Area (PATCA. Course in Geoecology and Field Informatics Division of Earth System Science Graduate School of Environmental Science Hokkaido University. Master's Thesis Hokkaido University.
Geertz, C. (1973). *The interpretation of cultures: selected essays.* New York: Basic Books. Retrieved from https://catalog.hathitrust.org/Record/000719830?signon= swle:https://shibidp.cit.cornell.edu/idp/shibboleth
Giraudoux, P., Raoul, F., Afonso, E. V. E., Ziadinov, I., Yang, Y., Li, L. I., ... & Wen, H. (2013). Transmission ecosystems of Echinococcus multilocularis in China and Central Asia. *Parasitology*, *140*(13), 1655-1666.
Gwinner, E. (n.d.). Circannual clocks in avian reproduction and migration. *Ibis*, *138*(1), 47–63. https://doi-org.proxy.library.cornell.edu/10.1111/j.1474-919x.1996.tb04312.x
Hardiman, S. C., Kushner, P. J., & Cohen, J. (2008). Investigating the ability of general

circulation models to capture the effects of Eurasian snow cover on winter climate. *Journal of Geophysical Research: Atmospheres*, *113*(D21).

Haynes, M. A., Kung, K.-J. S., Brandt, J. S., Yongping, Y., & Waller, D. M. (2014). Accelerated climate change and its potential impact on Yak herding livelihoods in the eastern Tibetan plateau. *Climatic Change*, *123*(2), 147–160. https://doi-org.proxy.library.cornell.edu/10.1007/s10584-013-1043-6

Hedin, S. A. 1865-1952., & Bealby, J. T. (John T. 1858. (1898). *Through Asia*. London : Methuen.

Huntington, E. 1876-1947. (1919). *The pulse of Asia, a journey in Central Asia illustrating the geographic basis of history*. Boston, New York, Houghton, Mifflin Company.

Hjeljord, O., & Histøl, T. (1999). Range-body mass interactions of a northern ungulate–a test of hypothesis. *Oecologia*, *119*(3), 326-339.

Ibraeva, G. et al., (2016). Gender Scoping Study. Prepared in the framework of the “Bai Alai” – Small and Medium Enterprise Development Programme in Alai and Chon-Alai. This report was prepared by PIL Research Company in the framework of the «Bai Alai» programme – “Small and Medium Enterprise Development in Alai and Chon Alai districts of the Osh Oblast” programme developed and financed by the Government of Switzerland.

Imanaliev K., Mukumbaev D. (1966). History, Ethnography, Language and Folklore of the Pamir and Kara-Tegin Kyrgyz. Frunze.

Ismailbekova, A. (2012). *" The native son and blood ties": kinship and poetics of patronage in rural Kyrgyzstan* (Doctoral dissertation, Philosophische Fakultät I, Martin-Luther-Universität Halle-Wittenberg Halle/Saale).

Izumiyama, S., Anarbaev, M., & Watanabe, T. (2009). Inhabitation of larger mammals in the Alai Valley of the Kyrgyz Republic. *Geographical Studies*, *84*(1), 14-21

Inouye, D. W., Barr, B., Armitage, K. B., & Inouye, B. D. (2000). Climate change is affecting altitudinal migrants and hibernating species. *Proceedings of the National Academy of Sciences*, *97*(4), 1630-1633.

Jaagus Jaak, & Ahas Rein. (2000). Space-time variations of climatic seasons and their correlation with the phenological development of nature in Estonia. *Climate Research*, *15*(3), 207–219.

Jeff Schmaltz. (2003). Hindi Kush satellite image [jpg]. URL (https://earthobservatory.nasa.gov/images/4103/hindu-kush)

Jenni, L., & Kéry, M. (2003). Timing of autumn bird migration under climate change: advances in long–distance migrants, delays in short–distance migrants. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *270*(1523), 1467-1471.

Jeong, J.-H., Ou, T., Linderholm, H. W., Kim, B.-M., Kim, S.-J., Kug, J.-S., & Chen, D. (2011). Recent recovery of the Siberian High intensity. *JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES*, *116*. https://doi-org.proxy.library.cornell.edu/10.1029/2011JD015904

Jorgenson, J. T., Festa-Bianchet, M., Lucherini, M., & Wishart, W. D. (1993). Effects of body size, population density, and maternal characteristics on age at first reproduction in bighorn ewes. *Canadian Journal of Zoology*, *71*(12), 2509-2517.

Jumabaev B. (2009). Th*e Pamir: Geopolitical Struggle of the Great Empires at the end of 19th ‘ century*. Bishkek. Kyrgyzstan.

Jumabaev, B.M. (2012) Russian Expedition to Pamir and Alai in the late 19th and early 20th century. Accepted in 1996, Kyrgyz State University, Bishkek, Kyrgyzstan. Published at LAV Lambert Academic Publishing.

Juvayni, `Ala' al-Din `A.ta Malik, [1226-1283.], Boyle, J. A., Morgan, D. O., & Unesco. (1997). Genghis Khan: the history of the world conqueror. In *kh-i jahangusha.* (p. lxvii). UNESCO; Manchester University Press.

Johnson, J. T., Howitt, R., Cajete, G., Berkes, F., Louis, R. P., & Kliskey, A. (2016). Weaving Indigenous and sustainability sciences to diversify our methods. *Sustainability Science*, *11*(1), 1. https://doi-org.proxy.library.cornell.edu/10.1007/s11625-015-0349-x

Jie Liu, & Teiji Watanabe. (2014). Assessment of the Current Grazing Intensity and Slope Status of Pastures in the Alai Valley, Kyrgyzstan. *Geographical Studies*, *88*(2), 70. https://doi-org.proxy.library.cornell.edu/10.7886/hgs.88.70

Jie Liu, & Teiji Watanabe. (2015). Seasonal Pasture Use and Vegetation Cover Changes in the Alai Valley, Kyrgyzstan. *Mapping Transition in the Pamirs : Changing Human-Environmental Landscapes*, 113. https://doi-org.proxy.library.cornell.edu/10.1007/978-3-319-23198-3_8

Karasartov, A., Japiev, J. (1989). *Ala-Too Journal.* Frunze (Bishkek City). Kyrgyzstan

Khan, B., Khan, M. Z., Ali, R., Khan, G., Ali, F., & Ali, M. (2012). Shimshal Pamir Lakes: a prospective high altitude wetlands site for transboundary collaboration between China and Pakistan. *Rec. Zool. Surv. Pak*, *21*, 1-9.

Kassam, K.-A. (2009a). Viewing change through the prism of indigenous human ecology: findings from the Afghan and Tajik Pamirs. *Human Ecology: An Interdisciplinary Journal* , *37*(6), 677–690.

Karim-Aly Kassam. (2009b). *Biocultural Diversity and Indigenous Ways of Knowing : Human Ecology in the Arctic*. University of Calgary Press.

Kassam, K.-A., Karamkhudoeva, M., Ruelle, M., & Baumflek, M. (2010). Medicinal plant use and health sovereignty: findings from the Tajik and Afghan Pamirs. *Human Ecology: An Interdisciplinary Journal* , *38*(6), 817–829.

Kassam, K.-A., Bulbulshoev, U., & Ruelle, M. (2011). Ecology of Time: Calendar of the Human Body in the Pamir Mountains. *Journal of Persianate Studies*, *4*(2), 146–170. https://doi-org.proxy.library.cornell.edu/10.1163/187471611X600369

Kassam, K.-A. (2013). Keeping all the Parts: Adaptation Amidst Dramatic Change in the Pamir Mountains. *Continuity & Change in Cultural Adaptation to Mountain Environments*, 303.

Kassam, K. A. (2015). Engendering a New Generation of Public Intellectuals. *Speaking Power to Truth: Digital Discourse and the Public Intellectual*.

Kassam, K.-A. S., Ruelle, M. L., Samimi, C., Trabucco, A., & Xu, J. (2018). Anticipating Climatic Variability: The Potential of Ecological Calendars. *Human Ecology: An Interdisciplinary Journal*, *46*(2), 249. https://doi-org.proxy.library.cornell.edu/10.1007/s10745-018-9970-5

Kassam, K, A. (2021). Ecological time, climate change, and the sacred: The role of ecological calendars in the Pamir Mountains of Central Asia. In Understanding Climate Change through Religious Lifeworlds (In press.). Bloomington, IN: Indiana University Press.

Khan, B., Ablimit, A., Khan, G., Jasra, A. W., Ali, H., Ali, R., Ahmad, E., & Ismail, M. (2016). Abundance, distribution and conservation status of Siberian ibex, Marco Polo and Blue sheep in Karakoram-Pamir mountain area. *Journal of King Saud University -*

Science, *28*(3), 216–225. https://doi-org.proxy.library.cornell.edu/10.1016/j.jksus.2015.02.007
Khazanov, A. M. (1994). *Nomads and the outside world* (J. Crookenden (Ed.); p. LIX). University of Wisconsin Press.
Koponen, H. T., & Martikainen, P. J. (2004). Soil water content and freezing temperature affect freeze–thaw related N2O production in organic soil. *Nutrient Cycling in Agroecosystems*, *69*(3), 213. https://doi-org.proxy.library.cornell.edu/10.1023/b:fres.0000035172.37839.24
Kryštufek, B., & Vonhralík, V. (2013). Taxonomic revision of the Palaearctic rodents (Rodentia). Part 2. Sciuridae: Urocitellus, Marmota and Sciurotamias. *Lynx, series nova*, *44*.
Kryštufek, B., & Vohralík, V. (2012). *Taxonomic revision of the Palaearctic rodents (Rodentia): Sciuridae: Xerinae 1 (Eutamias and Spermophilus)*. na.
Kraudzun. (2012a). Livelihoods of the 'New Livestock Breeders' in the Eastern Pamirs of Tajikistan. *Pastoral Practices in High Asia : Agency of "Development" Effected by Modernisation, Resettlement and Transformation*, 89. https://doi-org.proxy.library.cornell.edu/10.1007/978-94-007-3846-1_5
Kraudzun. (2012b). From the Pamir frontier to international borders: Exchange relations of the borderland population. *Subverting Borders : Doing Research on Smuggling and Small-Scale Trade*, 171. https://doi-org.proxy.library.cornell.edu/10.1007/978-3-531-93273-6_9
Kraudzun, T. (2017). Sovereignty as a resource: Performing securitised borders in Tajikistan's Pamirs. *Geopolitics*, *22*(4), 837-862.
Karmysheva, B. (2009). *The Kirghiz of the Kara-Tegin* (Karateginskie Kirgizy). Institute of Ethnology and Anthropology named after Miklukho-Maklaia N.N. RAN. Russian Humanitarian Science Foundation.
Kreutzmann, H. (2002). Recent results of yak research in Western High Asia. *Yak production in central Asian highlands*, 76
Kreutzmann, H. (2003). Ethnic Minorities and Marginality in the Pamirian Knot: Survival of Wakhi and Kirghiz in a Harsh Environment and Global Contexts. *The Geographical Journal*, *169*(3), 215–235.
Kreutzmann, H. (2009). Transformations of High Mountain Pastoral Strategies in the Pamirian Knot. *Nomadic Peoples*, *13*(2), 102–123.
Kreutzmann, H. (2011). Pastoralism in the Pamirs: regional contexts, political boundaries, and market integration in Central Asia. *Economic Spaces of Pastoral Production and Commodity Systems: Markets and Livelihoods*, 174-193.
Kreutzmann, H. (Ed.). (2012). *Pastoral practices in High Asia: Agency of'development'effected by modernisation, resettlement and transformation*. Springer Science & Business Media.
Kurmushiev, T. (2016). *History of Sary Mogul*. Amalker. Osh Oblast. St. Lenin. 300-1.
Gaku Kudo. (1991). Effects of Snow-Free Period on the Phenology of Alpine Plants Inhabiting Snow Patches. *Arctic and Alpine Research*, *23*(4), 436–443. https://doi-org.proxy.library.cornell.edu/10.2307/1551685
Larl, I., & Wagner, J. (2006). Timing of reproductive and vegetative development in Saxifraga oppositifolia in an alpine and a subnival climate. *PLANT BIOLOGY*, *8*(1), 155–166. https://doi-org.proxy.library.cornell.edu/10.1055/s-2005-872888
Leuenberger, C. (2015). Knowledge-Making and its Politics in Conflict Regions: Doing

Research in Israel/Palestine. In *Contributions from European Symbolic Interactionists: Reflections on Methods* (pp. 19-41). Emerald Group Publishing Limited.

Leroux, O., Jackson, M. E., & Freeman, M. A. (1994). *Inuit Women Artists: Voices from Cape Dorset*. Douglas & McIntyre Publishing Group; Canadian Museum of Civilization.

Levin, T., Daukeyeva, S., & Köchümkulova, E. (2016). *The Music of Central Asia*. Indiana University Press.

López, B. C., Pino, J., & López, A. (2010). Explaining the successful introduction of the alpine marmot in the Pyrenees. *Biological Invasions*, *12*(9), 3205. https://doi-org.proxy.library.cornell.edu/10.1007/s10530-010-9712-0

Lopez, B. C., Lopez, A., Potrony, D., & Potrony, M. (2009). Macro-Habitat Selection of the Alpine Marmot (Marmota Marmota) in the Southern Pyrenees. *VIE ET MILIEU-LIFE AND ENVIRONMENT*, *59*(2), 189–197.

Londono, S. C., Garzon, C., Brandt, E., Semken, S., & Makuritofe, V. (2016). Ethnogeology in Amazonia; surface-water systems in the Colombian Amazon, from perspectives of Uitoto traditional knowledge and mainstream hydrology. *Special Paper - Geological Society of America*, *520*, 221–232. https://doi-org.proxy.library.cornell.edu/10.1130/2016.2520(20)

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*, *87*, 16–29. https://doi-org.proxy.library.cornell.edu/10.1016/j.worlddev.2015.10.041

Littledale, G. (1892, January). A journey across the Pamir from North to South. In *Proceedings of the Royal Geographical Society and Monthly Record of Geography* (Vol. 14, No. 1, pp. 1-35). Royal Geographical Society (with the Institute of British Geographers), Wiley.

Legewie H. ATLAS.ti – How it all began. A grandfather's perspective. In: ATLAS.ti user conference 2013: fostering dialog on qualitative methods [Internet] 2013 [cited 2016 May 10]. Available from: https://depositonce.tu-berlin.de/bitstream/11303/5125/1/02_legewie_4414.pdf

Marston, C., & Giraudoux, P. (2019). On the Synergistic Use of Optical and SAR Time-Series Satellite Data for Small Mammal Disease Host Mapping. *REMOTE SENSING*, *11*(1). https://doi-org.proxy.library.cornell.edu/10.3390/rs11010039

Maanaev E. and Ploskikh V. (1983). Na 'Kryshe mira' (Istoricheskie ocherki o Pamiro-alayskikh kirghizakh). Mektep. Frunze.

McCarty, J. P. (2001). Ecological consequences of recent climate change. *Conservation biology*, *15*(2), 320-331.

Meier, C., Knoche, M., Merz, R., & Weise, S. M. (2013). Stable isotopes in river waters in the Tajik Pamirs: regional and temporal characteristics. *Isotopes in environmental and health studies*, *49*(4), 542-554.https://doi-org.proxy.library.cornell.edu/10.1080/10256016.2013.835809

Масальский, В. И. (1913). *Туркестанский край* (Vol. 19). Изд. АФ Девріена.

Mezhzherin, S., Brandler, O., Lyapunova, E., Morozov-Leonov, S., & Vorontsov, N. (1999). Genetic relationships and differentiation in ground squirrels Marmotinae Pocock, 1923 (Rodentia, Sciuridae) from Palearctics. *RUSSIAN JOURNAL OF GENETICS*, *35*(6), 639–646.

Mostowlansky, T. (2017). *Azan on the moon: Entangling modernity along Tajikistan's Pamir Highway*. University of Pittsburgh Press.

Malhi, Y. (2017). The concept of the Anthropocene. *Annual Review of Environment and Resources*, *42*, 77–104. https://doi-org.proxy.library.cornell.edu/10.1146/annurev-environ-102016-060854
Murgab Communism. (1998). “Will Aga Khan Stop Its Support?” Murgab Communism Newspaper, (May); 2.
Middleton, R., & Thomas, H. (2008). Tajikistan and the high Pamirs. *A Companion and Guide (Odyssey Illustrated Guides) Paperback–June*, *23*(200), 8.
Middleton, R., & Thomas, H. (2008). Tajikistan and the high Pamirs. *A Companion and Guide (Odyssey Illustrated Guides) Paperback–June*, *23*(200), 8.
Molau Ulf. (1996). Climatic Impacts on Flowering, Growth, and Vigour in an Arctic-Alpine Cushion Plant, Diapensia Lapponica, under Different Snow Cover Regimes. *Ecological Bulletins*, *45*, 210–219.
Middleton, R. (2017). *Legends of the Pamir*. https://www.pamirs.org
Maikhuri, R. K., Rao, K. S., Anarbaev, M., Safaralikhonov, A. B., Saxena, K. G., & Liang, L. (2015). Farming and Environmental Conservation in Asian Cold Deserts: A Review. *International Journal of Ecology and Environmental Sciences*, *41*(3-4), 217-241.
Makuritofe, V., & de Castro Palao, H. (2008). *Ciclo anual muina+: el ciclo del año empieza en el verano de gusano y termina en el enfriaje de canangucho; propuesta calendario ecológico anual muina*. Tropenbos internacional Colombia.
McDonald, K. C., Kimball, J. S., Njoku, E., Zimmermann, R., & Zhao, M. (2004). Variability in Springtime Thaw in the Terrestrial High Latitudes: Monitoring a Major Control on the Biospheric Assimilation of Atmospheric CO2 with Spaceborne Microwave Remote Sensing. *Earth Interactions*, *8*(1), 1–23. https://doi-org.proxy.library.cornell.edu/10.1175/1087-3562(2004)8<1:VISTIT>2.0.CO;2
Nasritdinov, E., & Schenkkan, N. (2012). A portrayal of absence: Households of migrants in Kyrgyzstan. *Bishkek: Open Society Foundation*.
Namgail T. (2006). Winter habitat partitioning between asiatic ibex and blue sheep in Ladakh, northern India. *Journal of Mountain Ecology*, *8*, 7–13.
Nowak, A., Nowak, S., Nobis, M., & Nobis, A. (2014). Vegetation of solid rock faces and fissures of the alpine and subnival zone in the Pamir Alai Mountains (Tajikistan, Middle Asia). *Phytocoenologia*, *44*(1-2), 81-104.
Nowak, A., Nowak, S., Nobis, M., & Nobis, A. (2016a). Vegetation of screes of the montane and colline zones in the Pamir-Alai Mts in Tajikistan (Middle Asia). *Tuexenia*, *36*, 223-248.
Nowak, A., Nowak, S., Nobis, A., & Nobis, M. (2016b). Vegetation of feather grass steppes in the western Pamir Alai Mountains (Tajikistan, Middle Asia). *Phytocoenologia*, *46*(3), 295-316.
Ogden, L., Heynen, N., Oslender, U., West, P., Kassam, K. A., & Robbins, P. (2013). Global assemblages, resilience, and Earth Stewardship in the Anthropocene. *Frontiers in Ecology and the Environment*, *11*(7), 341-347.
Layne G. Adams, & Bruce W. Dale. (1998). Reproductive Performance of Female Alaskan Caribou. *The Journal of Wildlife Management*, *62*(4), 1184–1195. https://doi-org.proxy.library.cornell.edu/10.2307/3801982
Odland, A. (2011). *Estimation of the growing season length in alpine areas: effects of snow and temperatures*. na.

Ockendon, N., Leech, D., & Pearce-Higgins, J. W. (2013). Climatic effects on breeding grounds are more important drivers of breeding phenology in migrant birds than carry-over effects from wintering grounds. *BIOLOGY LETTERS*, *9*(6). https://doi-org.proxy.library.cornell.edu/10.1098/rsbl.2013.0669

Olufsen, O. (Ole), 1865-1929., Carlsbergfondet, C. D., Denmark. Ministeriet for kirke-og undervismingsvzwsement., & Danske Pamirexpedition, 2d, 1898-1899. (1904). *Through the unknown Pamirs; the second Danish Pamir expedition 1898-99*. London, W. Heinemann.

Oliva, M., & Ruiz-Fernandez, J. (2018). Late Quaternary environmental dynamics in Lenin Peak area (Pamir Mountains, Kyrgyzstan). *The Science of the Total Environment*, *645*, 603. https://doi-org.proxy.library.cornell.edu/10.1016/j.scitotenv.2018.07.178

Prober Suzanne M., O'Connor Michael H., & Walsh Fiona J. (2011). Australian Aboriginal Peoples' Seasonal Knowledge : a Potential Basis for Shared Understanding in Environmental Management. *Ecology and Society*, *16*(2).

Propastin, P. A., Kappas, M., & Muratova, N. R. (2008). Inter-Annual Changes in Vegetation Activities and Their Relationship to Temperature and Precipitation in Central Asia from 1982 to 2003. *Journal of Environmental Informatics*, *12*(2), 75–87.

Petr, T. (Ed.). (1999). *Fish and fisheries at higher altitudes: Asia* (Vol. 385). Food & Agriculture Org..

Philip C. Miller. (1982). Environmental and Vegetational Variation across a Snow Accumulation Area in Montane Tundra in Central Alaska. *Holarctic Ecology*, *5*(2), 85–98.

Peter A. Cotton. (2003). Avian Migration Phenology and Global Climate Change. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(21), 12219–12222.

Pohl, E., Knoche, M., Gloaguen, R., Andermann, C., & Krause, P. (2014). The hydrological cycle in the high Pamir Mountains: How temperature and seasonal precipitation distribution influence stream flow in the Gunt catchment, Tajikistan. *Earth Surf. Dyn. Discuss*, *2*, 1155-1215.

Raimberdi, A.M. (2012). Les plantes medicinales du Pamir Oriental et leur utulisation en medicine Populaire. Published by the Kyrgyz Ate Foundation. Bishkek. Kyrgyzstan.

Rachlow, J. L., & Bowyer, R. T. (1991). Interannual variation in timing and synchrony of parturition in Dall's sheep. *Journal of Mammalogy*, *72*(3), 487-492. https://doi-org.proxy.library.cornell.edu/10.2307/1382131

Рябицев В. К. (2019), *Птицы Средней Азии*. Москва. Екатеринбург. Ревенкова А.И. (1965). Nikolai Vasilivich Vavilov 1887-1943 (Николай Иванович Вавилов 1887–1943). Izd-vo s.-x. lit., jurn. i plokadov. pp. 272 (М.: Изд-во с.-х. лит., журн. и плакатов, 1962. 272 с).

Reznichenko, N. V., Andrews, G. R., Geater, R. E., & Strom, A. (2017). Multiple origins of large hummock deposits in Alai Valley, Northern Pamir: Implications for palaeoclimate reconstructions. *Geomorphology*, *285*, 347-362.

Rezouki, C., Tafani, M., Cohas, A., Loison, A., Gaillard, J.-M., Allaine, D., Bonenfant, C., & Boulinier, T. (2016). Socially mediated effects of climate change decrease survival of hibernating Alpine marmots. *Journal of Animal Ecology*, *85*(3), 761. https://doi-org.proxy.library.cornell.edu/10.1111/1365-2656.12507

Saether, B. E., Andersen, R., Hjeljord, O., & Heim, M. (1996). Ecological correlates of regional variation in life history of the moose Alces alces. *Ecology*, *77*(5), 1493-1500.

https://doi-org.proxy.library.cornell.edu/10.2307/2265546
Shahrani, N. M. (1979). *The Kyrgyz and Wakhi of Afghanistan: adaptation to closed frontiers*. University of Washington Press, Seattle, Washington, USA.
Smejkalova, T., Edwards, M. E., & Dash, J. (2016). Arctic lakes show strong decadal trend in earlier spring ice-out. *SCIENTIFIC REPORTS*, *6*. https://doi-org.proxy.library.cornell.edu/10.1038/srep38449
Salas, E. A. L., Valdez, R., Michel, S., & Boykin, K. G. (2018). Habitat assessment of Marco Polo sheep (Ovis ammon polii) in Eastern Tajikistan: Modeling the effects of climate change. *ECOLOGY AND EVOLUTION*, *8*(10), 5124–5138. https://doi-org.proxy.library.cornell.edu/10.1002/ece3.4103
Sayre, N. F., Kelty, R., Simmons, M., Clayton, S., Kassam, K. A., Pickett, S. T., & Chapin III, F. S. (2013). Invitation to earth stewardship.
Sary-Kol. (2002). “Intentional Aid: The main mission of Aga Khan Fund is to support people”. Sary-Kol Newspaper, (August); 6, 4163.
Sary-Kol. 2003. Aga Khan Fund Report 2002. Sary-Kol Newspaper, (January); 1, 4169.
Soelberg, J., & Anna K. JÃ¤ger. (2016). Comparative ethnobotany of the Wakhi agropastoralist and the Kyrgyz nomads of Afghanistan. *Journal of Ethnobiology and Ethnomedicine*, *12*(1), 2. https://doi-org.proxy.library.cornell.edu/10.1186/s13002-015-0063-x
Sonntag., C. (2016). The Nexus of Settlement Development and Today’s Energy Use in Sary-Mogol, Alai Valley, Kyrgyzstan. *Erdkunde*, *70*(2), 153–168.
Sparks, Tim H., Humphrey QP Crick, Peter O. Dunn, and Leonid V. Sokolov. "Birds." In *Phenology: an integrative environmental science*, pp. 451-466. Springer, Dordrecht, 2013.
Shirasaka, S., Watanabe, t., Song, F., Liu, J., & Miyahara, I. (2014). Transhumance in the Kyrgyz Pamir, Central Asia. *Geographical Studies*, *88*(2), 80-101.
Shirasaka, S., Song, F., & Watanabe, T. (2015). Diversity of Seasonal Migration of Livestock in the Eastern Alai Valley, Southern Kyrgyzstan. *Mapping Transition in the Pamirs : Changing Human-Environmental Landscapes*, 127. https://doi-org.proxy.library.cornell.edu/10.1007/978-3-319-23198-3_9
Schuyler, E. (1876). Turkistan: Notes of a journey in Russian Turkistan, Khokand, Bukhara and Kuldja. Vol. II.
Schaller, G. B., & Kang, A. (2008). Status of Marco Polo sheep Ovis ammon polii in China and adjacent countries: conservation of a Vulnerable subspecies. *ORYX*, *42*(1), 100–106. https://doi-org.proxy.library.cornell.edu/10.1017/S0030605308000811
Shackleton, D. M., & Shank, C. C. (1984). A review of the social behavior of feral and wild sheep and goats. *Journal of Animal Science*, *58*(2), 500–509.
Schöffmann, J. (2001). Forellen in Zentralasien–dem östlichsten natürlichen Verbreitungsraum von Salmo trutta L. *Österreichs Fischerei*, *54*, 54-58.
Schwartz, M. D. (Ed.). (2003). *Phenology: an integrative environmental science* (p. 564). Dordrecht: Kluwer Academic Publishers.
Schwartz, M. D., Beaubien, E. G., & Crimmins, T. M. (2013). and Jake F. Weltzin. *Phenology: An Integrative Environmental Science*, 67.
Scheimreif, K. A., & Kassam, K.-A. S. (2018). *Ecological calendars for climate change adaptation in Sary Mogol, Kyrgyzstan.* Ann Arbor, Michigan: ProQuest Information and Learning. Retrieved from https://doi.org/10.7298/X4XD0ZW1

Shutova, E., Wielgolaski, F. E., Karlsen, S. R., Makarova, O., Berlina, N., Filimonova, T., Haraldsson, E., Aspholm, P. E., Flø, L., & Høgda, K. A. (2006). Growing seasons of Nordic mountain birch in northernmost Europe as indicated by long-term field studies and analyses of satellite images. *International Journal of Biometeorology*, *51*(2), 155. https://doi-org.proxy.library.cornell.edu/10.1007/s00484-006-0042-y

Stow, D., Daeschner, S., Hope, A., Douglas, D., Petersen, A., Myneni, R., Zhou, L., & Oechel, W. (2003). Variability of the Seasonally Integrated Normalized Difference Vegetation Index Across the North Slope of Alaska in the 1990s. *International Journal of Remote Sensing*, *24*(5), 1111. https://doi-org.proxy.library.cornell.edu/10.1080/01431160210000 20144

Sturm, M., & Wagner, A. M. (2010). Using repeated patterns in snow distribution modeling: An Arctic example. *WATER RESOURCES RESEARCH*, *46*. https://doi-org.proxy.library.cornell.edu/10.1029/2010WR009434

Sykes, E. C., & Sykes, P. M. (1920). *Through deserts and oases of Central Asia*. London: Macmillan.music

Svendsen, G. E. (1974). Behavioral and Environmental Factors in the Spatial Distribution and Popualtion Dynamics of a Yellow-Bellied Marmot Population. *Ecology*, *55*(4), 760-771. https://doi-org.proxy.library.cornell.edu/10.2307/1934412

Tryjanowski, P., Kuzniak, S., & Sparks, T. (2002). Earlier arrival of some farmland migrants in western Poland. *IBIS*, *144*(1), 62–68.

Tryjanowski, P., Flux, J. E., & Sparks, T. H. (2006). Date of breeding of the starling Sturnus vulgaris in New Zealand is related to El Niño Southern Oscillation. *Austral Ecology*, *31*(5), 634-637.

Tafani Marion, Cohas Aurélie, Bonenfant Christophe, Gaillard Jean-Michel, & Allainé Dominique. (2013). Decreasing litter size of marmots over time: a life history response to climate change? *Ecology*, *94*(3), 580–586.

Taipov B (2002) *Sary Kol tarykhyndyn kyskacha ocherkteri*. Murgab.

Taylor, W., Shnaider, S., Abdykanova, A., Fages, A., Welker, F., Irmer, F., Seguin-Orlando, A., Khan, N., Douka, K., Kolobova, K., Orlando, L., Krivoshapkin, A., & Boivin, N. (2018). Early pastoral economies along the Ancient Silk Road: Biomolecular evidence from the Alay Valley, Kyrgyzstan. *PLoS ONE*, *13*(10), 1–19. https://doi-org.proxy.library.cornell.edu/10.1371/journal.pone.0205646

Taubmann, J., Koustubh Sharma, Kubanychbek Zhumabai Uulu, James E. Hines, & Charudutt Mishra. (2016). Status assessment of the Endangered snow leopard Panthera uncia and other large mammals in the Kyrgyz Alay, using community knowledge corrected for imperfect detection. *Oryx*, *50*(2), 220–230. https://doi-org.proxy.library.cornell.edu/10.1017/S0030605315000502

Toropov, S. A., & Zhdanko, A. B. (2007). The Butterflies (Lepi doptera, Papilionoidea) of Dzhungar, Tien Shan, Alai and Eastern Pamirs, vol. 1: Papilionidae, Pieridae, Satyridae.

Valikhanov, C. Ch. (1904). *Sochinenia*. S. Petersburg. Tipografia Glavnogo Upravlenia.

Kim André Vanselow. (2015). Who Is Mapping the Pamirs? A Review on Plant and Vegetation Sciences. *Mapping Transition in the Pamirs : Changing Human-Environmental Landscapes*, 41. https://doi-org.proxy.library.cornell.edu/10.1007/978-3-319-23198-3_3

Van der Wal, R., Madan, N., Van Lieshout, S., Dormann, C., Langvatn, R., & Albon, S. D. (2000). Trading forage quality for quantity? Plant phenology and patch choice by Svalbard reindeer. *Oecologia*, *123*(1), 108-115.

Valdez, R., Michel, S., Subbotin, A., & Klich, D. (2016). Status and population structure of a hunted population of Marco Polo Argali Ovis ammon polii (Cetartiodactyla, Bovidae) in Southeastern Tajikistan. *Mammalia: International Journal of the Systematics, Biology and Ecology of Mammals*, *80*(1), 49. https://doi-org.proxy.library.cornell.edu/10.1515/mammalia-2014-0116

Visser Marcel E. (2008). Keeping up with a Warming World; Assessing the Rate of Adaptation to Climate Change. *Proceedings: Biological Sciences*, *275*(1635), 649–659. https://doi-org.proxy.library.cornell.edu/10.1098/rspb.2007.0997

Visser Marcel E., Holleman Leonard J. M., & Gienapp Philip. (2006). Shifts in Caterpillar Biomass Phenology Due to Climate Change and Its Impact on the Breeding Biology of an Insectivorous Bird. *Oecologia*, *147*(1), 164–172. https://doi-org.proxy.library.cornell.edu/10.1007/s00442-005-0299-6

Vuren, D. V., & Armitage, K. B. (1991). Duration of snow cover and its influence on life-history variation in yellow-bellied marmots. *Canadian Journal of Zoology*, *69*(7), 1755-1758.

Watanebe, T., Izumiyama, S., Gaunavinaka, L., & Anarbaev, M. (2010).Wolf depredation on livestock in the Pamir. *Geographical Studies*, *85*(1), 26-36.

Watanebe, T., Anarbaev, M., Liu, Y., Sawagaki, T., Izumiyama, S., Miyahara, I., &Komatasu, T. (2014). Place Names as an Ecotourism Resource for the Alai Valley of the Kyrgyz Pamir. *Geographical Studies*, *88*(2), 102-116.

Watanabe, T., & Shirasaka, S. (2016). Kezüü and novad: A form of pastoralism in the eastern Alai Valley, Southern Kyrgyzstan. In *Mapping Transition in the Pamirs* (pp. 145-158). Springer, Cham.

Wang, M., Blank, D., Wang, Y., Xu, W., Yang, W., & Alves, J. (2019). Seasonal changes in the sexual segregation patterns of Marco Polo sheep in Taxkorgan Nature Reserve. *Journal of Ethology*, *37*(2), 203. https://doi-org.proxy.library.cornell.edu/10.1007/s10164-019-00590-w

Walker, D. A., Billings, W. D., & De Molenaar, J. G. (2001). Snow-vegetation interactions in tundra environments. *Snow ecology*, 266-324.

Walther, G. R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T. J., ... & Bairlein, F. (2002). Ecological responses to recent climate change. *Nature*, *416*(6879), 389-395.

, G., Han, J., & Long, R. (2003). *The yak*. FAO Regional office for Asia and the Pacific.

Wielgolaski, F. E., & Inouye, D. W. (2013). Phenology at high latitudes. In *Phenology: An Integrative Environmental Science*(pp. 225-247). Springer, Dordrecht.

Wiener, G., Han, J., & Long, R. (2003). *The yak*. FAO Regional office for Asia and the Pacific.

Yasuaki, N., Kaoru, I., Yasoichi, E., Katsuhisa, K., & Toshiichi, K. (2005). Do you know YUKIGATA. *J. Visualization Soc. Jpn*, *25*, 121-122.

Zech, R., Abramowski, U., Glaser, B., Sosin, P., Kubik, P. W., & Zech, W. (2005). Late Quaternary glacial and climate history of the Pamir Mountains derived from cosmogenic 10Be exposure ages. *Quaternary Research*, *64*(2), 212-220.

Zandler, H., Senftl, T., & Vanselow, K. A. (2020). Reanalysis datasets outperform other gridded climate products in vegetation change analysis in peripheral conservation areas of Central Asia. *Scientific Reports*, *10*(1), 1-16.