RHYTHMS of the LAND

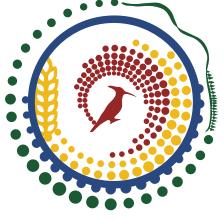
Indigenous Knowledge, Science, and Thriving Together in a Changing Climate

by Karim-Aly S. Kassam, Daler Kaziev, Leo Louis, Morgan Ruelle, and Anna Ullmann

In partnership with the communities of Sary Mogul (Kyrgyzstan), Savnob (Tajikistan), Roshorv (Tajikistan), Oneida Lake (USA), and Standing Rock Sioux Nation (USA)







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Logo Credit: Natani Notah, Karim-Aly Kassam, Anna Ullmann

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Karim-Aly S. Kassam Professor and Principal Investigator

Sary Mogul Community Members



Kubanych Aitmamatov



Mansur Aliev



Ubaidylda Jaanbaev



Mamatibraim Joldoshbaev & Tajikbai Syiymkulov



Sajida Joldoshova



Aidaraly Joljakshiev



Kuduret Jorobekov



Babanazar Karimov



Toktomamat Kenjebaev



Kanataly Kenjeev



Altynbek Kharybekov



Rafshan Korgonbaeva



Karybek Kulatov



Abdilashym Kurbanov



Zulaika Kyiasova



Ainura Adaham Kyzy



Abdusamad Mamatazimov



Uulcha Najimidinova & Murat Satybaldiev

Sary Mogul Community Members (cont.)



Mamatumar Narmamatov



Baktygul Narmamatova



Abdulashim Nishanov



Danyar Nurmamatov



Kudayar Nurmamatov



Kadyrali Orozaliev



Kochkonbai Orozaliev



Muratbek Orozaliev



Tokur Orozbaev



Adalat Rahimberdieva



Berdikul Saitov



Altynbek Tabanov



Abdilla Tashbekov



Adalat Tashkulova



Taalaibek Tashtanov



Buunisa Termechkova



Myrzakarim Tilemishov



Bashir Toktobaev



Kokonbek Tokurov



Sary Mogul Community Members (cont.)



Sainazar Turdiev



Mamatjuma Uulu



Kharbek & Aynisa

Introduction

Why is Collaborative Research Important?

This is a narrative of collaboratively generated insights for the diverse communities where we undertook research. Therefore, the audience for this collection are these communities and those who seek to work with them. It shows the human-ecological relationships that underpin their food and livelihood systems. As a result of several decades of applied and participatory research, we have learned from many Indigenous and rural societies at high altitudes and latitudes that their food and livelihood systems are fundamentally dependent on their habitat. The relationships that arise from this connection to their respective environments inform their sense of self, cultural system, social structure, and even notions of the sacred. The ecosystem is the basis of these complex, sophisticated, and mutually beneficial interactions. Unlike the thinking that has informed the European Enlightenment and Industrial Culture, these societies do not perceive their existence outside their habitat. They live *within* the planet not just *on* it. Their sacred stories describe how they are *living through* the environment not *from* it. Although characterized by outsiders as remote locations, they see their habitat as a homeland in which to engage in the process of living. Indigenous and rural societies thrive in their habitats because of their connections with other living beings, human or otherwise. This dynamic and complex web of relations informs their identity and livelihoods and brings unity between their informational and physical environment. As such, there is no separation between mind and body because both exist because of and within an ecological space. Their homeland is not a frontier to be conquered and whose riches are to be extracted. This complex connectivity stands in stark contrast to the utilitarian or instrumental approach of industrial civilization, which views the land and waters teeming with life as *objects* for exploitation. Sadly, this dominant point of view has brought us to where we are today. The devastating impacts of anthropogenic climate change imperil the whole of humanity, including Indigenous and rural societies that have contributed least to its causes.

Over several years, as we have undertaken applied research in collaboration with Indigenous and rural societies, it has become clear that while their ecological professions may differ (such as hunters, fishers, farmers, herders, orchardists, and even tourism operators), the impacts of climate change bear similarly devastating effects on their overall food and livelihood systems. Whether it is late formation of sea-ice affecting hunting of marine mammals in the Arctic or unusual climatic variation impacting farming and herding communities of the Pamir Mountains, food security and livelihoods are increasingly being threatened.

The effects of anthropogenic climate change are causing debilitating anxieties because of the inability to anticipate so that communities can adapt. This anticipatory capacity to envision the next season or year and pragmatically consider future possibilities is essential for maintaining effective and sustainable food and livelihood systems. Furthermore, this instability will have immediate impacts on urban and sub-urban communities in the long-term owing to their dependency on the fruits of the lands and seas to sustain large

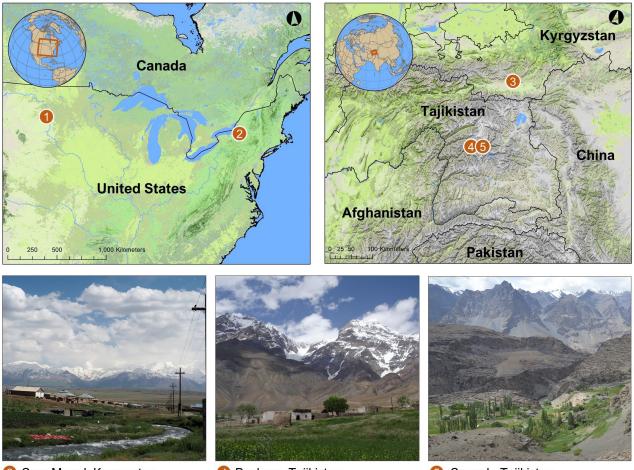
INTRODUCTION



1 Standing Rock Nation, Northern Great Plains, USA



2 Lake Oneida Watershed, New York, USA



8 Sary Mogol, Kyrgyzstan

4 Roshorv, Tajikistan

🟮 Savnob, Tajikistan

Figure 1.1: Research Context in Central Asia and North America

populations. Yet Indigenous and rural societies, which have faced the harmful impacts of colonization and now suffer the vagaries of global market and command economies, do not view themselves as mere victims. They recognize their own power and understand that while weakened by industrial domination of communist, socialist, or capitalist systems, their ecological knowledge and stewardship practices have enabled their survival for centuries if not millennia.

Rhythms of the Land Displayed Through Ecological Calendars

It is here that this work begins. It is grounded in the ecology and culture of the peoples with whom we are working. Historically, Indigenous and rural societies have developed and utilized *ecological calendars* to anticipate and then adapt to the changing rhythms of the seasons. Ecological calendars are knowledge systems to measure and give meaning to time based on close observations of one's habitat. They reveal seasonal indicators that integrate ecological phenomena (such as the first snowfall, the last frost, the flowering of a tree species, the sound of ice breaking, the appearance of an insect, or the arrival of a migratory bird) with cultural systems. Understanding these relationships has enabled Indigenous and rural societies to anticipate weather and other seasonal processes and thereby, adapt and coordinate their livelihood activities appropriately. These communities use ecological indicators to guide their actions to inform not only their food systems but also cultural events because these activities are fundamentally integrated into and are mutually reinforced through their daily lives.

We present our findings from five diverse geographical regions, ecological contexts, and cultural milieus (Figure 1.1) of Indigenous and rural societies in the Pamir Mountains of Kyrgyzstan and Tajikistan, as well as the Standing Rock Sioux Nation and Oneida Lake Watershed in the United States of America.

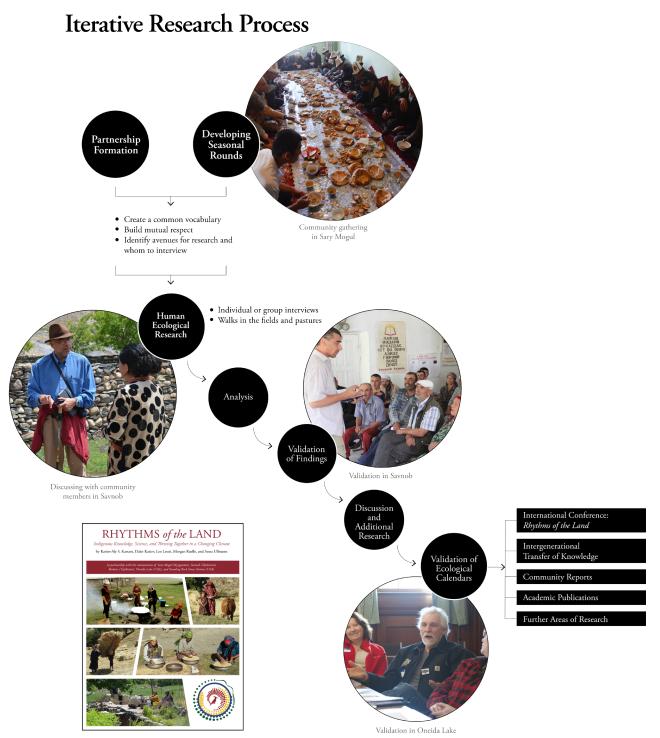
The communities that participated in this project have long-standing collaborative relations with researchers, which allowed for the mutual development of trust and understanding. This also enabled honesty during challenging moments. Given the geopolitical history where each of these communities is located, collective trust was fundamental to any research undertaken by us and key to addressing their priorities and concerns. In addition, these communities are at the forefront of anthropogenic climate change thus creating a sense of urgency for very practical and ethical reasons.

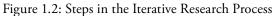
Our Collaborative Research Approach

The research problem guides the process of how we undertake research. In this case, we are seeking to build anticipatory and adaptive capacity to the effects of anthropogenic climate change at the level of specific communities. Therefore, an effective strategy must involve those affected by engaging their particular cultural and ecological systems and collaborating with their social institutions. In other words, the question of how to build anticipatory capacity and develop adaptive strategies drives the methodological approach. An adaptation strategy for any kind of change must be grounded within the local ecological and cultural contexts if it is to be effective in the long-term. An outside fix is neither relevant nor sustainable, and therefore, not appropriate.

Such an approach confounds single disciplinary expertise and demands collaboration among individuals with diverse expertise including the social, physical, and ecological sciences as well as the humanities. Collaboration is foundational because locally-grounded insights are achieved through participation of relevant professions such farming, fishing, gathering, herding, hunting, tending to orchards and so on.

To achieve this, we undertook a participatory research process that facilitated the cogeneration of insights. The first step was partnership formation through the use of local workshops (Figure 1.2). Except for the Oneida Lake Watershed, which encompasses rural Euro-American settler communities, we approached both the secular leadership (such as a tribal leader or village organization president) and spiritual leaders (such as Elders or *Khalifas*) to establish a partnership. Once there was an agreement to work together, we invited various participants who represented the different and wide-ranging knowledge found across the community based on advice of the leaders. However, partnerships with communities are not formed in a vacuum. Collaborative activities through workshops grounded in the reality of the community, anchor and cultivate this relationship. As a part of a community gathering involving a meal, our first collaborative research action was to develop a seasonal round. It forged our partnership.





Seasonal rounds are verbal articulations and visual representations of a community's sociocultural relations with their habitat. They express knowledge from engagement with spatial and temporal aspects of ecological cycles through the seasons. The spatial dimension speaks to the occupancy of landscapes used by the community. Movement across their habitat such as moving herds to summer pastures, ploughing farmland in the spring, or undertaking ice-fishing in the winter, convey the spatial dimension of the seasonal round. The temporal dimension is expressed through seasonal indicators that inform the timing of these activities, including herding, farming, or fishing. Articulation of a

seasonal round begins with broad questions such as 'How do you know that winter has ended and the next season has begun?', 'How many seasons are there?', and 'What are the names of those seasons?' As the discussion flows and deepens, the researcher serving as a facilitator gears their questions toward the specific ecological professions in the community, taking into account their distinct sociocultural and ecological contexts.

The process of articulation and physical representation of a seasonal round creates a common vocabulary and understanding among those participating in the research process. It builds mutual respect for different ways of knowing between those who are engaging in the inquiry and those who are engaging in the practice; namely, the researchers and the communities. In addition, it identifies specific avenues for further research and identifies topics to be explored through semi-structured interviews.

Finally, as seasonal variation is a reality upon which food and livelihood systems depend, this participatory process generates initial insights into: (1) a specific community's relationships with their habitat; (2) the divergent impacts of climate change upon them; and (3) locally appropriate adaptation strategies to respond to the emergent climate crisis.

After the seasonal rounds were developed, the research team lived within the communities to undertake semi-structured interviews and observe livelihood activities. This research on human ecological relations was undertaken through individual or group interviews as well as observation of livelihood activities in agricultural fields, pastures lands, fishing sites, and homes of community members.

Having compiled and analyzed the information gathered during workshops, interviews, and field observations the research team returned to each community to undertake validation of human ecological research findings at a second community workshop (Figure 1.2). Again, the secular and spiritual leadership were involved in gathering individuals to share a meal while discussing and developing a much more detailed and precise seasonal round. The researchers would ask general and specific questions to ensure an accurate understanding of the seasonal livelihood processes, examine the accuracy of the analysis, engender further discussion, add new insights, and as necessary, identify further research.

This iterative process tests the credibility of the cogenerated knowledge. It also sets the stage for identifying specific seasonal indicators for use in ecological calendars to anticipate climatic variation. Once this process was completed, the research team would analyze the information gathered for insights and indicators to be used to develop ecological calendars (Figure 1.3).

A final series of validation workshops to review each ecological calendar was planned as part of the iterative research process (Figure 1.2). However, due to the COVID-19 global pandemic these workshops were delayed. Nonetheless, under strict public health guidelines, a validation workshop was carried in July 2021 with community members in the Oneida Lake Watershed. Again, a meal was served while the draft ecological calendar was reviewed in detail and modifications made based on in-depth discussion.

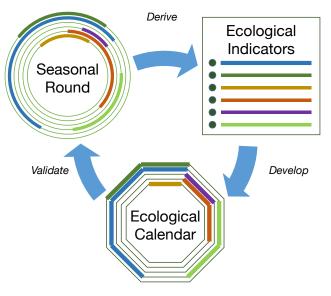


Figure 1.3: Collaborative Process of Developing Indicators for Ecological Calendars

This report is an organic outcome of the interaction between the research team and respective communities. Therefore, we have built-in flexibility – the electronic version of this report can be updated and changed after validation of the ecological calendars by the remaining communities and new insights may be added. Therefore, the long-term impacts of COVID-19 on our research process are mitigated by the strength of our collaborative relationship and the use of technology.

Diversity of Ecological Calendars

In the next sections, collaborative insights and ecological calendars are provided for the villages of Roshorv and Savnob in the Bartang Valley of Tajikistan; the village of Sary Mogul in the Alai Valley of Kyrgyzstan; the Oneida Lake Watershed in upstate New York, USA; and the communities of Bullhead, Cannon Ball, Fort Yates, Kenel, Little Eagle, Porcupine, and Wakpala in the Standing Rock Sioux Nation in North and South Dakota, USA.

The notion of an ecological calendar is universal and simultaneously particular. These calendars are diverse for obvious reasons. The first is tragic, reflecting the historical injustice of colonialism, war, and cultural genocide facilitated by dominant communist and capitalist colonial ventures that these various Indigenous and rural communities have experienced. In fact, anthropogenic climate change is, arguably, a result of instrumental industrialism across the entire planet and its peoples. In the Pamir Mountains as well as in the Standing Rock Sioux Nation, the impacts of the colonial legacy have been felt on the application, transmission, and utilization of Indigenous knowledge.

The second is that these calendars reflect the diversity of ecological professions, cultural systems, and ecological contexts. As described above, communities who see their habitat as a homeland in which to engage in the process of living share the notion of ecological calendars. However, the power and efficacy of these calendars are derived from their context-specificity because they facilitate anticipatory and adaptive capacity in a distinct sociocultural and ecological setting.

Even with its concomitant elements of historical colonial and environmental injustice, this diversity bears witness to Indigenous and local knowledge, and the agency of these respective communities in the third millennium to continue to demonstrate the relevance of their ontology or way of living. While reflecting the unique knowledge and strength of each community, this collection also puts into conversation the diversity of challenges these communities face. For instance, in the ethnic Bartangi villages of Roshorv and Savnob in the Pamir mountains of Tajikistan, where we first learned about the use of ecological calendars, the community engages in subsistence tilling of the land and orcharding at high altitudes and have some animals that they take to pastures. In contrast, the ethnic Kyrgyz village of Sary Mogul in the Pamir Mountains of Kyrgyzstan is primarily a herding culture with some cropping activities mainly potatoes for food and barley for fodder. At Oneida Lake, residents are settled in five counties within the Watershed pursuing a variety of livelihoods including farming and dairy production. In addition to their daily employment, many residents engage in fishing, gathering, hunting, orcharding, trapping and so on. However, these activities are not primarily subsistence activities as in the villages of the Pamir Mountains of Kyrgyzstan or Tajikistan. Finally, the Standing Rock Sioux Nation in North and South Dakota emerges from a painful history of cultural genocide and forced migration. The construction of the Oahe Dam destroyed the region's floodplain forests. The remaining lands in the Standing Rock encompass cultivated croplands, grasslands, hayfields, and pastures. As such, the differences among these communities are not a point of departure but rather a moment for mutual engagement to identify common options and to learn from each other.

Alai Valley, Kyrgyzstan Sary Mogul

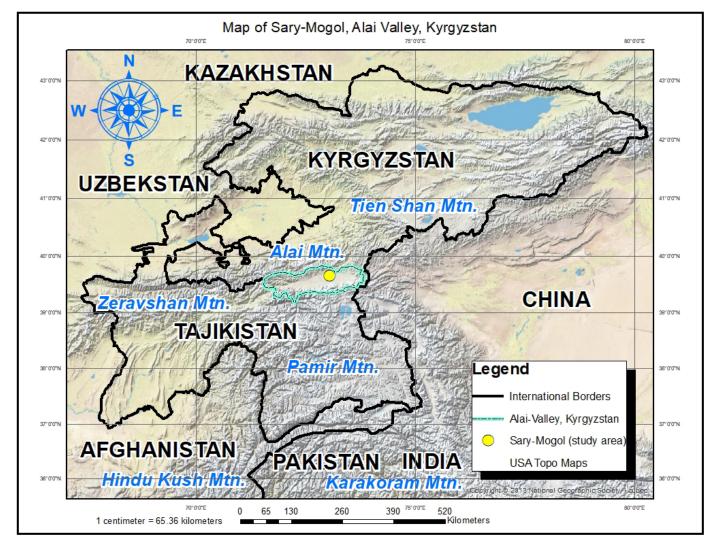


Figure 3.1: Sary Mogul in the Alai Valley

Sary Mogul Alai Valley, Kyrgyzstan

Context

The village of Sary Mogul is in the Alai Valley of southern Kyrgyzstan at an elevation of around 3100 meters above sea level (Figure 3.1). The local livelihoods depend predominantly on herding and some farming practices. Community members engage in animal husbandry raising yaks, sheep, goats, and cows as well as grow crops like barley as fodder and potatoes for human consumption. Throughout the year, villagers are engaged in making livestock and crop related decisions. However, changes in the timing and severity of snow cover, and other shifts in seasonal weather patterns influence their livelihood activities.

It is commonly believed that Sary Mogul is a community of Kyrgyz from Tajikistan, who recently settled in the Alai Valley. However, the Alai Valley had been pastureland for several tribes before Soviet colonization of the region. Sary Mogul is not a homogenous village. Historically the village is formed of tribes from many ecological zones. For example, tribes arriving from lower part of Alai Valley, where barley and potatoes have long histories of cultivation, are experimenting with alternative crop cultivation in upper Alai. The inhabitants have various professions such as teachers, doctors, drivers, entrepreneurs, and veterinarians which supplement their income and support their activities on the land. Thus, Sary Mogul represents the ecological knowledge of those who arrived from surrounding areas and have adapted their knowledge to the climatic conditions in the Alai Valley.

Following the collapse of the Soviet Union, communities in the Pamirs of Central Asia faced food shortages. After the fall of the integrated Soviet planned system, which included state provisioned food systems, communities faced challenges in terms of self-reliant food production. Communities also faced uncertainties about decision making due to a shift from top-down decision-making systems in the Soviet times to bottom-up decision-making systems in the absence of governance structures and an emerging civil society. In the aftermath of the food crisis in the Alai Valley region (1998-2000), the Aga-Khan Development Network (AKDN) piloted several potato projects. Seed was brought from Chelpek Village farm, near Yssyk Kul Lake of Kyrgyzstan. Chelpek Village is located at a similar elevation, and it was hoped that these potatoes would grow in Sary Mogul. Some seed potatoes were brought from Jar-Bashy (at the western end of the Chon Alai Valley), Kyrgyzstan, and others 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 potatoes mature in 60 days, others in 90 days. Successful potato growth depends on sunlight, soil quality, and use of livestock manure. These local experiments with seed potato varieties informed adaptation strategies for the community. The ecological calendars project seeks to build on these and other projects, by focusing on the development of anticipatory capacity, further supporting adaptation strategies.

Ecological Calendar for Sary Mogul

The Ecological Calendars and Climate Adaptation Project (ECCAP) to help build anticipatory capacity to climate change began in 2016 with the initialization workshop described in the Introduction (Figure 3.2).



Figure 3.2: Developing the Seasonal Round in Sary Mogul Village, 2016

The ecological calendar of Sary Mogul contains an enormous amount of local knowledge. This community report highlights two essential uses of ecological calendars: seasonal livestock management and crop harvest which will be discussed below. The ecological calendar supports seasonal livestock herding and crop related decisions by contextualizing the timing of livelihood activities within the local ecology and season. Changes in the timing of snow fall, and the duration of snow cover are critical for herding activities as it determines when to move livestock between grazing pastures. Due to changes in the timing and duration of winter weather, the availability of fodder in spring has become an issue. Herders rely on fodder to sustain livestock through the winter. For example, people reported that in some years the grass is not growing as high as it did in the past, especially during the summer rainy season. People associate the low productivity of grass with more snow in winter and lack of favorable weather conditions in summer. In addition, shifting times of snowmelt is creating pressure on the availability of fodder grass. If snowmelt occurs late, the community is at risk of running out of the stored fodder, especially during the lambing season. This was the case in 2016. Therefore, the ecological calendar may help to secure lambing in the spring. The revitalized ecological calendar aids in deciding when to plant potatoes and when to harvest them based on the local knowledge of appropriate biophysical conditions. The ecological calendar, thus, points out existing uncertainties and helps to anticipate changes related to crop harvesting. This community report includes a description of the

revitalized ecological calendar for Sary Mogul. It describes how the calendar can contribute to herders' decisions and seasonal mobility, which is dependent on the duration of snow cover in winter, snow melt in spring, snow free times in summer and accumulation of snow in autumn. <u>Sary Mogul's ecological calendar</u> is attached at the end of this chapter. Please read the subsequent sections along with the ecological calendar for Sary Mogul (Figure 3.10).

Seasonal Livestock Cycle

Keeping livestock is an essential livelihood represented in the calendar of Sary Mogul village. There are four distinct seasonal migration patterns such as *baarloo* spring, *jailoo* summer, autumn *kyzdoo*, and *kyshtoo* winter in the ecological calendar. Temperature related events such as snow cover change is a vital cue that informs seasonal rotation of livestock. For the herders, these migration patterns, and events such as snow accumulation (autumn), snow cover (winter), snowmelt (spring), and snow free (summer) are extremely important to anticipate when to move livestock between pastures.

Throughout the winter (November to April), herders keep their livestock (specifically cows, goats, female yaks, and sheep) in the village, which is known as *koldo-karoo*. During this period people hand-feed livestock because there is no access to grazing lands due to deep snow in the upper Alai Valley. The period of hand feeding livestock depends on the period of snow cover. In other words, this period is determined by when snow accumulates, how long it remains, and how long it takes to melt. All of this is anticipated through local observations. The arrival of snowfall is typically expected between late September to early November; however, this timing has been changing. As snow accumulates, it prevents animals from grazing in the vicinity of the village. Therefore, the animals are sheltered and hand-fed in the barns until the snow melt in April.

As the snow disappears in spring (depending on snowmelt period), livestock are herded near the open grass fields both around the village and further away (depending on snow-free area). That short period of livestock herding (April to May) is called *kezuu*, which means to graze the livestock around a stationary camp. During this period, herders pay careful attention to temperature related cues like *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 the last yellow snow). White and black snow patterns (created by bare patches of ground being revealed by melting snow) determine the departure of winter, and arrival of spring. These cues inform when to initiate activities like moving livestock into the fields. This period of herding livestock around the village does not last long depending on when winter ends and when spring begins.

Depending on the snowmelt, herders then take their livestock to the *jailoo* summer pastures. According to the ecological calendar, summer begins when *kok chykty* grass emerge. After which, *kok kubuu* livestock start grazing the newly emerged grass. Herders in Sary Mogul observe that livestock (cows, female yaks, goats, sheep) favor grazing upon fresh spring grasses as opposed to stored fodder. Herders then decide when to take their livestock to the summer pastures by observing snow melt in the pastures that are located at the southern Zaalai Range and the northern Alai Range (Figure 3.1). If herders remain in the village, managing livestock becomes impossible as new growth of barley will be in danger of being grazed by livestock. However, if it is too cold and snowy in the summer pasture valleys where they hope to graze livestock, then they must wait for the right time.

For herders, the summer is a time when more food is being produced. Throughout the warmest season (May to September), livestock produce dairy products. The period from April to October is known as *ak-chykty* (milk products). From March to October, food produced by 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), are eaten, processed, and stored in



Figure 3.3: Women from Sary Mogul Processing Dairy Products in the Pastures for Use in the Autumn, Winter and Spring. Photo credit: Karim-Aly Kassam 2016.

cold places. Dairy products are processed and stored in summer for consumption through to the following spring, especially in April and May. This period is known as the long yellow *uzun sary* (starvation period). Thus, from April to September, it is crucial to take advantage of the short growing season.

In early September when the *jailoo* summer pasture season ends, herders return to the village with their flocks to continue *kezuu* from late August to mid-September. The arrival of autumn is associated with the changing behaviors of livestock. In late August, livestock stop grazing in the higher pasture lands, and they descend to lower elevation fields due to decreasing temperatures. With the cold the livestock start to leave higher pastures even if grass is still available. This livestock behavior is called *otko-kachat*. An unexpected sudden frost during this time can threaten the herd.

Another vital decision for herders during the autumn is livestock breeding. As the winter approaches in October and November, the herders time domestic sheep breeding to plan for *baargi tol kiret* (spring lambing) in March and April. Currently, October seems to be the best time to breed sheep, because herders must be certain that lambing in spring takes place when temperatures are warmer. There is no fixed time for breeding, but people must consider the temperature changes in spring when breeding in the fall. The villagers allow for 5.5 to 6 months when breeding sheep. For example, if they breed in August, the livestock will lamb in March. When the herders return from summer pastures, and the temperatures are dropping (October or November) they begin breeding sheep and goats (known as *kochkor koshylat*). Five months after breeding, *baargi tol kiret* (spring lambing) takes place in March or April. Although some herders undertake *kyshky tol* (winter lambing), during January and February, this is not commonly practiced. Cold temperatures during the winter, the fear of exhausting fodder reserves, and the uncertainty

of spring arrival, are the primary concerns. For example, if the winter temperature is too cold, the young lambs might not survive during January.

Another essential event in the autumn is the mating and calving season of yaks (*Bos grunniens*). According to herders, yaks are very clever and climate-sensitive animals. Their mating and calving seasons are monitored to understand the seasonal shifts. Herders pay careful attention to yak mating periods, which vary from July to November; giving birth about nine months later (specifically 256-7 days after mating). Like sheep lambing season, yak calving takes place in spring when the temperature is warmer. If yaks mate early, then it is an indicator that the spring will come early, and the year would be *jenil* – meaning not difficult. *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 is an indication of the *oor* – difficult year. Pastoralists in Sary Mogul suggested that the average yak mating time should be in early October. The Yak mating season varies year-to-year, and the late mating of yaks is not desirable in the Alai Valley-signifying shifting of seasons.

Barley and Fodder Grass

The Alai Valley is known for its rich grasslands. Villagers grow barley and *Espartset (Onobrychis sativa*, known as common sainfoin) in addition to fodder grasses (*Leymus secalinus, Aceae spp., and Atipa orientalis*). Barley, common sainfoin, and fodder grass are vital for several reasons. Collectively these plants are named *ot* – fodder grass. They ensure food security for livestock throughout the long winter and lambing season. Common sainfoin is a productive fodder grass that can provide 7-10 years of yield without re-planting. According to local people, barley is a top-quality fodder, followed by sainfoin, and other grasses harvested for livestock. Community members also rely on other fodder species such as *ak-bash godo* grass (*Stipa Orientalis*), *budai bashy* grass (*Poaceae spp.*), *kara-bash* grass (*Poaceae spp.*), and *kiyak* grass (*Leymus secalinus*). These are all widely grown in the Alai Valley.

Villagers follow sequences of planting and harvesting during the short growing season. As spring arrives, barley and common sainfoin are planted in late April. The right time to move livestock to summer pastures is a month after the barley was planted, when it develops *maiza* (spikelets) at the end of April to the end of May. *Maiza* or ripening time of barley is not the only cue used to determine the summer season. Barley and common sainfoin are planted in April, while potatoes are planted by mid-May. Planting cannot begin until the soil is thawed, as it is impossible to plant seeds into the frozen ground. Knowing when the ground will thaw in spring is vital for growing crops.

Throughout the summer, villagers depend on the climate for a good growing season (the taller the grass the better the yield). Depending on how much rain the area receives during the summer, barley will be irrigated 3-4 times during the growing season. The first irrigation occurs about 40 days after planting. Barley heads turning dark is a cue to irrigate. Rainy summers reduce the need for crop irrigation. However, too much rain also prevents successful crop growth. Ideally, there is a combination of enough sunlight and rain for a successful crop to grow.

As summer is coming to an end in early August, temperature related cues indicate the beginning of the harvesting season. When autumn arrives, days become colder, and a morning wind called *galdurgan shamal* occurs. People stated that this wind, in particular, indicates the beginning of autumn. The arrival of autumn is also informed by *ot-kaity* (color change in vegetation), particularly when the *ak-bash godo* (*Stipa orientalis*) and barley bends, stops growing, and changes color from green to yellow. Farmers also observe these changes in *ak-bash godo* grass (*Stipa orientalis*), *budai bashy* grass (*Poaceae spp.*), *kara-bash* grass (*Poaceae spp.*), *kiyak* grass (*Leymus secalinus*), and *at-kulak* common sorrel (*Rumex acetosa*). Quick changes of color in grasslands inform the seasonal transition from spring to autumn. Common sainfoin is harvested two times, in July and in September. Crops such as barley, common sainfoin, and natural hay

need to be collected during August to late September before livestock returns to the village. That is when grass dries, insects disappear, frosts begin, birds leave, and snow is expected. By the time snow arrives, it is crucial that people have stored fodder grass and are ready for the long winter.

Potatoes

Villagers have a small garden plot in front of their houses where they grow potatoes. Over the past two decades growing potatoes at elevations as high as 3000 meters has become possible. Although potatoes do not reach full size due to the short season, they are still cultivated, eaten, and stored for winter and spring. Some potatoes are sold in the market, and some are kept as seed for the next growing season.

The viability of growing potatoes locally, especially since 2000, is considered a positive change. However, many factors influence their successful yield. Local people have been experimenting with various potatoes varieties since 1990 and several local varieties exist: *Germansky. Picaso, Kardinal, Agava, Jele, Super Elita,* and *Chelpek.* Villagers have different perspectives on the successful adaption of these potato varieties. Villagers plant potatoes at different times in spring depending on their individual circumstances. In addition, some use fertilizers whereas others do not. The variability in growing seasons year-to-year also determines potato yields as factors such as the shifting times of spring snowmelt has created increasing uncertainty for the villagers. Further, potatoes are in the greatest danger during the harvest season, as an early frost in autumn may cause damage to the crop.

To address these challenges, we asked specific questions. How do you know when to harvest hay, barley, and potatoes? Focusing on the biophysical cues, villagers stated that they begin planting activities after the snow melts in spring, and then harvest crops before the arrival of snow in fall. However, snow melt and arrival depended on temperature changes, especially between April and May, and then August through October. For example, people start plowing and planting barley and common sainfoin when overall winter *tokson childe* ends, after snowmelt (*kar ketet*), when the earth becomes dark (*jerdin beti kararat*), and soil warms (*kerge tap kidi*) in April. Barley and common sainfoin are planted in late April, whereas potatoes are planted in early May. Changes in soil temperature varies slightly from year-to-year. The soil must become warm enough for potatoes to be planted, known as *jerge tap kirdi*. Generally, crops (barley, sainfoin, and potatoes) are planted in April through May, and are harvested in August through September.

Potatoes are also irrigated three to four times, the first occurring about 20-30 days after planting. Throughout the summer, villagers take turns irrigating plots. Each section of the village receives threedays of water flow, administrated by the village organization. Villagers also pay attention to the flowering time for different potato varieties compared to the previous year. Throughout the summer, they till the soil, creating extra space for crops to grow. They also remove extra grass that competes with the main crop.

Temperatures changing from warm to cold, play an essential role in harvesting crops, especially potatoes. Given the presence of multiple temperature indicators (e.g., insects, animals, and plants), observing co-occurring temperature-related events provides growers with valuable knowledge to make decisions. For example, potatoes are collected when frosts begin, their leaves start to drop and change color, pasturelands start to turn yellow, and when migratory birds begin to depart. Potatoes are important for the community because they provided food, income, and seed stock. Food sources such as processed or dried dairy products and especially potatoes, are stored in root cellars to be consumed during winter and spring. Most villagers harvest potatoes before the end of September. Other indicators, such as the departure of migratory birds or hibernation of marmots, may also be informative when deciding when to harvest potatoes.

Participants shared several ecological indicators, such as frost being related to the departure of migratory birds, or hibernation of marmots. The primary threat in autumn is *kyrgyek*, a sudden frost that could kill both young livestock as well as damage potatoes. The notion *kyrgyek* referred to sudden frost and the departure of the migratory birds in the Alai Valley. Early signs of frost are vital indicators for crop harvest. Participants reported a co-occurrence between bird migration and land-use activities, especially in the fall. People also stated that crops are planted only after the arrival of migratory birds, especially *torgoi* (skylarks) and another small green bird that we could not identify. The departure or return of migratory birds informs the community about temperature changes, in particular, the arrival of cold weather in the fall.

The community harvests crops relying on biophysical events in spring and autumn. Further, by observing ecological indicators of autumn, specifically observing early signs of frost (changes in the color of potato leaves and dropping of their leaves) when collecting potatoes. Villagers collect potatoes prior to arrival of cold, frozen ground, and arrival of snow, which is usually after the second week in September. Sudden temperature declines (frost and cold weather) prevent them from keeping potatoes in the soil until October. Hence, understanding ecological cues may further aid seasonal coping strategies. By observing ecological indicators that are triggered by temperature changes (e.g., cold days, frost, and drying plants), villagers may protect potatoes from sudden frosts in fall.

Working with the Ecological Calendar

The knowledge in the calendar was collected from villagers with diverse ecological professions. Therefore, it represents a variety of needs, priorities, and decisions that can be specific to individuals, but could also be common to many villagers. Some people raise horses and others are yak herders. Some people specialize in crops like barley and potatoes. Depending on the needs and priorities of decision-making in the cycle of the season, they could be looking at different cues for different purposes at different times. To demonstrate, let us situate ourselves in spring and autumn and take a few examples of how to use the knowledge in the ecological calendar.

Springs and summers are crucial seasons for livestock (sheep, horses, and yaks) breeding in the Alai Valley. For that to occur, herders consider temperature change driven cues in spring. The days must be warm enough when sheep lambing starts. Villagers also pay close attention when snow vanishes, and icicles melt. While yaks and horses mate with minimal human involvement, sheep breeding is very important for villagers in the autumn. As mentioned above, there are two practices of sheep breeding, winter, and spring. We have learned that villagers prefer to time sheep breeding for spring because they consider cues like warmer days, snow melt, and ice melt. In addition, they are concerned that sometimes fodder grass is not developed enough in the spring. Therefore, more fodder in fall might be useful to anticipate changes (shifting seasons) in spring (Figure 3.4).

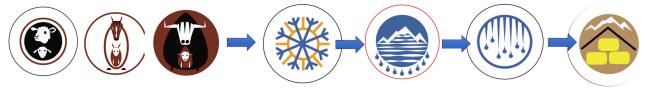


Figure 3.4: Sheep Lambing in Spring

As mentioned above and in the calendar, seasonal herding is vital to insure the wellbeing of livestock and community throughout the season. We have learned that herders pay attention to snow related changes as they move their livestock to different pastures. Snow melt in the spring informs herding livestock around the

village. As snow melts in the summer pastures, farmers take their livestock to the summer pasture during the snow free time. With temperature changes in fall and upon arrival of snow, farmers bring their livestock to the village. During the snow cover period, herders hand feed livestock in the village (Figure 3.5).



Figure 3.5: Seasonal Livestock Herding Cycle

During the short growing season, farmers do their best to grow barley, sainfoin and potatoes. Especially, potatoes are essential crops for the villagers. Farmers know the right time to plant crops by observing frosts. Then, farmers plant barley and sainfoin. With potatoes, farmers pay attention to the heat and steam coming out of soil. The soil must be right for potatoes to be planted (Figure 3.6).



Figure 3.6: Harvesting Barley, Sainfoin and Potatoes in Spring

The use of ecological calendar in spring is not limited to one or two cues. When herders make decisions, they also consider other co-occurring biophysical events in spring. For example, warmers days (temperature change), ice-break-up in the river, emergence of flowers, waking of marmots from hibernation, surfacing of grass, appearance of insects, and arrival of migratory birds all inform of the onset of spring (Figure 3.7).



Figure 3.7: Co-Occurring Indicators in Spring

An important moment of decision making occurs with the arrival of autumn with temperature changes. People prepare to harvest hay, barley, sainfoin, and potatoes. An important indicator of autumn begins with temperature changes that drive many other changes and seasonally related human decisions. As for the fodder, villagers consider color changes in the north and south facing hills and mountain valleys. As the growing season ends, rich grass fields bend and dry. That is when farmers undertake harvesting fodder grass (Figure 3.8).

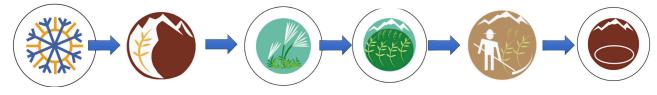


Figure 3.8: Fodder Harvest

During the harvesting season, herders do their best to store enough fodder as livestock return to the village. Farmers continue harvesting sainfoin, barley, and potatoes. One of the important weather events affecting the harvesting of potatoes is an unexpected frost. By observing early sings of frost on the grass and drying and dying potatoes leaves, farmers gather their crops. Early signs of temperature changes in the autumn are vital for a successful harvest. If not collected, frost might destroy the potatoes. By the time of ground freeze, farmers must collect potatoes and all crops (Figure 3.9).

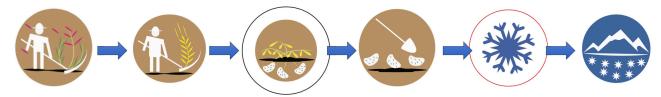


Figure 3.9: Sainfoin, Barley and Potatoes

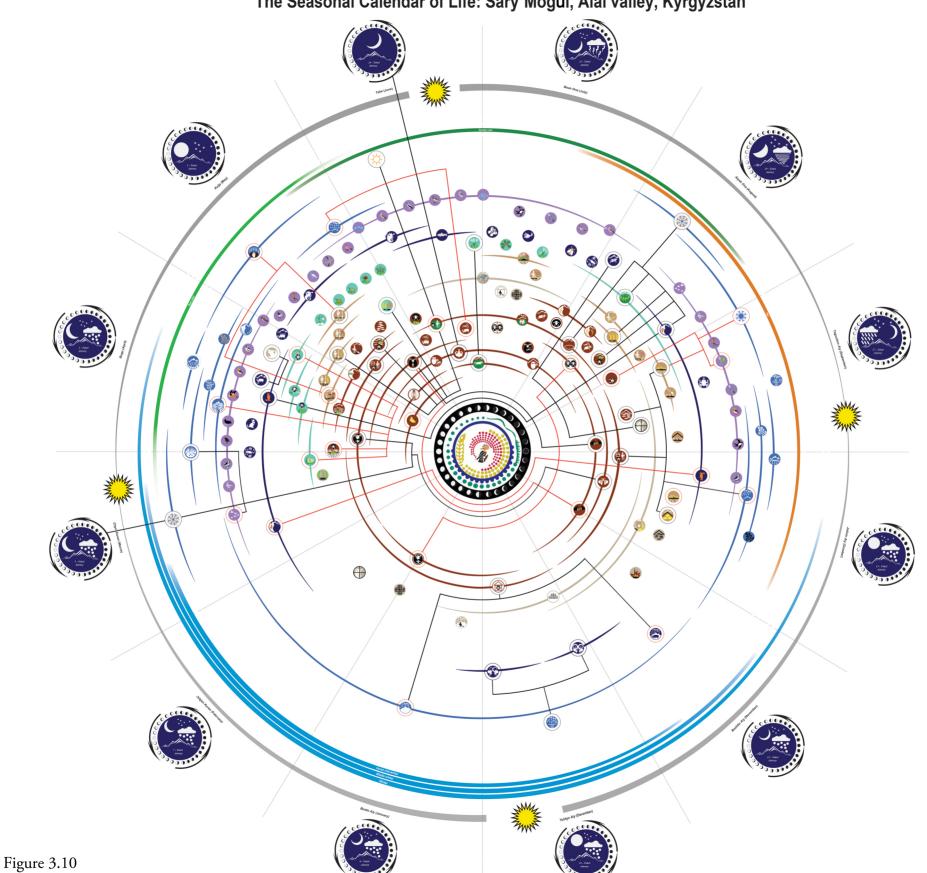
Similarly, there are co-occurring events that are anticipated during the seasonal decision making, especially in the autumn. Villagers pay attention to the arrival of wind, departure of birds, disappearance of insects, hibernation of marmots, arrival of snow and freezing water in the rivers and streams (Figure 3.10).



Figure 3.9: Co-Occurring Indicators in the Autumn

As a result of five years of collaboration with the farmers and herders, we have documented and revitalized a rich local knowledge of the ecological calendar in response to specific community needs and climate change. Changes related to snow cover during winter, snowmelt in spring, snow free in summer, and snow accumulation in autumn are key for the seasonal rotation of livestock. Hence, an ecological calendar offers practical benefit for livestock related seasonal decisions. Such a calendar may help time sheep breeding to ensure that the lambs are born in warmer spring. However, lately herders are facing shortage of fodder because of shifting spring seasons. Herders could store more fodder to prepare for increasingly variable times of snowmelt in the spring. As for the cropping and agriculture, our research with the community revealed that potatoes were essential for the villagers' food system. Although yet to be validated by the community, this draft ecological calendar reveals essential knowledge about the timing of crops, growing season, and harvesting period. Despite the challenge of frost damaging potatoes, early indicators of autumn could help villagers to harvest potatoes on time. Furthermore, given the importance of herding and animal husbandry in Sary Mogul, better understanding of timing of seasons through the ecological calendar for fodder production is fundamentally linked to livestock management and survival.





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	The light green line signifies have or spring. Recease villagers do not have when surve will disappear, upping in Alhi is standard and very short. Appl and Appl. is of the cold, survey, and rainy. Therefore, storing around fielder for Xivenedx and field for kinamas in this period is created. The activity level increases as field strong decrease.		Soil robust processes in spring. For example, two Jetter the disappearance of freems proved is a sign of spring. The Soil in Alsh dresers more than shall have interest deep. When it strats to dance, people action the fragmentation of the earth's surface, marking the cod of winter.	Ż	The name Justingsovi applies for three birds with similar tabes: Common brain (Jayar apac), Nordern Biozer Mariei (Darkoben (Frenzen, all Barr Sander (Darkod rantos), Ularkoben (Frenzen, all Barr Sander (Darkod rantos), birds, it indicates the end of summer and the beginning of summar.	6	The every specied dense took hardword was har Marson Pols Shop and Brox starts up within starlad bot sholds: The hardway sensor of meentain shops and game begin from May and container is harw. Marco Pols Shops give hard marky than Brox Sensare in lands: are resistant to the cold hard Brox. This period andorms the method of the start of the start of the start of the start of the start meeting and the spectra of the start of the start of the start meeting about part of summer.	×	The Ciyloy: Blesm (Zhean reticulator Lo) is a widely grown eibile plat in the Abi Valley. The full growth of this plant indicates the peak senses of the summer. The stems are collected and consumed.		This is an indicates period of dolling of al-dolp on the sing product Doly product indicator or alls, some - pair, however, errors, here there assume hore rails, lowper fermioned hore rails, any our yet houser, and groups, successfying λ_{ij} and λ_{ij} , some set at most burr in das theye, models are lightly space fermioned hore rails does not going to space a space of the single space of the space of these can capite, by short, and alm). The datary models will be available from Appl to October.		According to ferrares, bathey in a top-quality fielder, after bindfini and other games harvested for liverocket. If not sparserskinel, people are familiar with a bind sing days (Eq. (General), and howing games (Loncord) fame heat games). There are a start of the sparse (Loncord et al. (Loncord fame heat games) and August to and September.
	The Durber grees, lice signifies suration, surance sension. The versions sension of the syste, sinting which kind are absorption from the Lark (Dersonshita algorithm), edisolchapper, babellines 'Whenteur (Dessands and and heat, and a discribed and Astroneous Whenteer (Dessands and addression), and a service and a discretion Whenteer (Dessands and addression) and a service of surances. When elastic barget steps signing, it musks the arest of surances.		Time to plant creps, especially portotes. When jerge tap kirdli heat onten the ground, people joint potatose. This local mere articles to some comes on and solv becomes waternet. These preconcess inform functions should be a solved becomes some these processes inform functions should be injust time to begin plowing and planting.)	The same haldspace applies for three birds with similar toles: Common birds (dyna gave), Nordene Blonze Martin (Darbeiter (Dressen, all Barn Saddar (Drande rarticu), When holdspace) in seen in flocks during the departure of negrotry block, it indicates the out of sources and the beginning of sources.		The oray period when both heriverse such as Muon Polo Shop, and Beet starts by the bits of adds the indice. The handing seaso of measuring the spin and point being more than your cortinues to Juan Beeners the limb OF fex is low cold resistant than the lambs of the measuring shares, the Hex sheep mate 10-13 days after measuring shares, and gives birth after the measuring sheep.		Or-Janty menns when grass, burley, and other plants bend and stop their grawth. Specifically, Al-Baski Godo Nail grass (Sapa Oriensolia) bends and dies informing farmers to harvest craps.		It is a time of shearing yak, which beings in July and ends in Inte August, locally known is asyoe Jaydyn. The sheering of yaks takes place coce a year, close to autumn.		The articul of entrance is informed by or havy (color charge in vegetinic), Perioritarly when the ele-band goin (Signe Orientia) and Jordyn start to bed, Jange color from green in yeftion, and start to dry Bardyn is havevend. Benden take their livouries to the village.
	The Ounge line signifies hy: astrans. Astrans begins when forege dire, bends and dire, including al hosh goods, needlegross (dipt) or estavish) and how includes depend to be lower the partners that to under temperature changes. It natural, liveshold gains mans, and hands become self-outflotter (narare).		Sery-Aer, the hast heavy surve in spring can occur between only. April to Jam. The half ming work usow nucleus quickly and disupperse. In the Ashi Wilder, however, precipitions in syring in superdistuble, and therefore, it could even store in summer.)	When migratory high arrive in gring, Row-Rock Spottad Creat Rose flock (Corpudaces anorrector) also arrive Concerdly, Spottad Creat Rose flock is conzone in the region.		Kyugz tubes are far from fishing is just a nyth became these tube inhibit a sich rivers system warder they live in Tiese-Mann et Ali or Pauri Montaka As soo en Kinz Bar Bar view opens, Tillgers begin fishing fir hown tout (acline <i>mutt</i>), especially through the summer.		Or-batty is when grass dries and dies in late July. Batley and other medows hand and usp their growth. Grass color is a crucial inficient of the transition first summary to sources. That is when finder the structure of the source of the sources, <i>Karow-Bash</i> (Processe), <i>Karow-Bash</i> (Processe) and <i>Kyosh</i> (Leynus seculism).		When antrana begina, livestock behavior changes. Donassic sheep gain weight when antrana begins. Matarity of taizands is observed to understand the state of growing sensor.		In the duft stillargen noise for the assesses in larged, a large which a stratistic strategies with the inter. To two or takes or attrass strategies for four trans, during the monitor period from going to assess informing the commonly second strategies of the strategies. That is when points lowers die sort, which is expected from mid-August to mid-September.
	Biophysical inficitors such as first stave, now accumulation, usew even, suswardt, first, ground feeze, thaw and other soil related events.	X	The works because swares when summe begins. However, the bit is summary provident. Several indications user co-occur fielders hardens more investick to higher patterns. Snow mare disapper, and the importunity, a spatial of theory appens. Also, its appensively, a spatial of theory appensively more interaction in the summary pattern in the star and the summary pattern. If the interfers to an star are livencies, to the parameters, newly grown barley may be command.	2 the second	The offigure neurons meaners by the network of homelog back, the brogst of follogies, and the degrees of charging hack. Summer begins when scenare gives their. When the gray back gave back, increase as numbered. Following hole on terms on sometriz . Segure Emission Lack (Alonda overent), have hard ingest forced Lack (chronostic methods), Knochdalt – and Northern Warsteer (chronostic methods).		In summer, during the peak of summer, furmers see botterflies. Alsi Valley is abundant for butterflies.		Many people is Say Mongla Neuropi insteade. The livenised product manner, which called $\beta J_{\rm c}$ line $\lambda_{\rm c} q M_{\rm c}$ line or the manner set bet in dry in the number alter mathematical states of the math	B	When summer ends, lumbs of demostic sheep become self-sufficient loca-torsiof or independent.	1 4 80	Table is digitationing about from (logosed) is that it may devery postnetses. Therefore, people may be solider postnets when from tants to socce. We source that there gaves bein angight be following bish according to local distinitions, limits without (Polytoposter lowerd), Sylac's Mather (Dalon zerose), or deressib Walder (Polytolowyna torological), lot set are rate sort. Elsely in the dyin the poten hervest visus the temperate changes in the foll.
	Bid phenology, such as arrival, breeding, and departure tases of specific birds known by the community.		$\label{eq:response} \begin{split} & \int_{-\infty}^{\infty} \int_{-\infty}^$		Kore dash toppi (Intend Lotic (Complete observit)) is one of the breven bloch data jire birds when summer begins. They are cosmoly present throughout the region and are resident bards haven by the futures.	A d	Herden have told no that throughout the summer, formers here the sound of Cologistic (grand-paper). Locate irresion in not a lag deal in village, has a found former from low-elevation complement about them. During the het summer in Chon Alai Valley, grandoppen dentry ersps, especially comming grandauch but not in Sary Mogal.		When Joh-shyloy fresh prass starts to energy, it indicates spring, which occurs after the score disopters. Horders take their breaches, out to the fields. That is when popels above to the summer pastate. Score and and grass emergence varies year to year. Scoreitzes, grass any energes much earlier, but their sking and shifting spring coddwell be expected.		When the summer ends, lands of denestic sheep become self-efficient here-so-over or matter. Around this period, the labs are sheared as well. Smithely, the lands of montain sheep and goats also become self-sufficient and nature, which is a sing of anturan.		Propps with his low of the protocol is the granued up to trokine, their topolarity charge and the scattanian characterization of grand that topolarity characterization is the star balance of the protocol is the grand up to Code (3 + 5 th and for priori when protocol in the grand up to Code (3 + 5 th and for priori when protocol in the grand up to Code (3 + 5 th and for priori when each not come. They are collected in Supramber depending on front (Importance charge).
	Assimal and interest cores. For example, the mattime sensor of maximalia sharing (Cofur arrows prof), wild goet (Capare alsolv), as well an abbencins and emergence ineq-sized maximum (Morrowstor constitut). It also includes betterflies and insects.	90	A special wind known as galdragas sharad (Oassantopoer) signals antman. A morning wind that starts from 6.00 am to 12.00 pm. The wind laws from the east to well from and Suphradar and container to May.	Ś	Chalelogar -Jahelline Whatter (Omarike andoline) is one of the bereas both that give beth shear ansmare begins. This likel is important for an end of the shear ansmare begins. This likel is important for an end of summer. When they why signing, it marks the end of summer.		Close to antazan (late Jaly and early Augand), specifically hay harvesting period, people action an emergence of Jappon have files. There is a specific period in which howefiles emerge and disappent. It happens mostly in July and Jugost.		When gross energies in spring, it is concide to consider specificities of Spraych the smokency side of the nonzenita (valley), and prattered) and tools, the sharehold with other for an antimetry of the strength of the strength with the strength of the nonzenita (b), valleys, and sprattered). The shapes make a big difference in the process of nonv melt and gross emergence in the higher partner grounds.		Azimah such as sheep and gosta do not graze in higher pastness, and the livensick descend belower elevation. Other-heads in an excepting behavior of livensick which different the and of azaman. Even though there are plenty of pastnetisal and grass fields, the livensick descends from the higher elevations as doys become endor in full.		Storing fielder is encid to summing the livestock in the period of near encirc, which is a rinky sense in severite meson. April and expectively the dynamic of near 30 encirc of the severite mining, people near 6 folder. In uping 2106, the 'Uligars' ended byoing folder from the circ of Ook (or its order to are their livestock from unospected sing.
	Plast cuts such as the emergence of gross stall the end of the growing sensor.	E)	Formation of ice on river systems known as goar-alor (Onemappeeia), Villagers who live along the rivers notice the sound of ice.	X	Revendeds: Vaschers Wenters (Ownerfer constrict) is one of the boren birth that give briefs when wanneer begins. Northern Wanters are breeding birth that mitric in summer, only Jane, and lowe in late August.		When the summer ends, lambs of domestic sheep become self-sufficient <i>hon-service</i> or independent. Around this period, the lambs are sheared as well. Similarly, the lambs of mourtain sheep and goats also mattee and become self-sufficient.		The Encrymer of grass in the village does not neen that they energy in the summer parameters. Because the village Sup Mogel is bound in the plan villey, much of the parameters simulated at the footballs of the Ahi Mountains where ground temperature varies.	٢	During this period, some livestock may die due to cold days. Therefore, we must adelyte them. This period also co-occurs with front and ice forming in small interans.		Since fore is a real nice new the village offset "Oal Prim." villagers is flay Mogal preper coal to apply themselves with fiel exercs in address to invested mannee. In October, people prepare coal.
	Seasonality of livestock management. For example, herding seasons, breeding times of domentic sheep and posts, other specific relational activities.	3J	Keru Sau sping water. If a spring continues producing water threeghout anzara, that mores the anzara will be extended. When springs censes, it marks the only arrival of water.	\$	Treps (Bylerks (disade arressis) are hoven block that give birth when unnane bagins. Northern Thomson we beeology block that artise in summer, Jone, May, and Angeot.		When summer each, and arteam begins, Sugar Arty Leop-tailed memory (Adverse causely) bibranist. The hibraristics of surrates begins from law equation through beginser fill manuals, bibrarist and each. Memory the surray of the surray of the surray memory of the surray of the surray of the surray of the surray sectors. Skifts in merco hibraristics indicates sensonic damas. The emergence of numeric hierarchic indicates sensonic damas. The surray of hierarchic hierarchic hierarchic hierarchic hierarchic hierarchic law of hierarchic hierarchie		Once the investeds in length tasks to far willing as forgunated, hadren that during matching the second se		After the stramer selectice, we expect or-lastly the gross fields, burley, and other grosses hand and to come growing. When gross dies and changes color, it is crucial to consider specificities of longest, the sum docing side of the monutinus, valley, and partners and lonkel, the shady side of the monutania, bills, valleys and patteres.		By hybridely A - in the suscess of plential and doculatese for the community, which logan in norma and continuon foreughent the winter, Spranhen- Jammy. In this process, the low-stock will be obtained and the strengtheners are the another of the strength strength strength strength strength strength strength own that her plene to inspecial. Solvely-the strength strength strength of a bodiese or plenty, which strength strength strength strength of strength strength strength.
	Seasonality of crop management. Particular periods such as sequence platting and havesting period of common saindois, burley, and potatore.		Animit and Agenture of same, which takes place twice a year, in misk-level mark November its marks the same and en- orthalist. Using some is aspected to a sum between mich-Oxober to misk-November. Currently, new arrives as late as humany. Understanding the some correspond to its sensitial because it determines livestock berding practices.		In summer and May, the commuly membran notion that hird hirds however a bulgery began to findige. The community haves then that it is normer summer. The word forware also comes from Arabic, and it means Cancer (Croit).		All moments are hiberaring by mid-October. The hiberarios period of the lang-table marsons in about 2–7.5 months. It is also critical to cominer specifications of papes, for non-decay aids of the meanning, valleys, and partners when they khormane		In a common that the shapes and gamts are lapt in a fonced coreal during the sight. Throughout the sources, manner necessatherin in the places where frames they breach. This manner of keys core into picture spring payles ent names and a pri dramphor the names. Close where a grant through the picture spring and have a for any spring the foregame the spring of the spring of the spring of the spring of the picture spring of the spring of the spring of the spring for any spring of the spring of the spring of the spring of the spring payles of the spring of the spring of the spring of the spring part of the spring of the spring of the spring of the spring for the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring of the spring		The grans, budge, and other forage drive, dise, and terms yellow at the end of summer. This process is locally called a bary, However, specificities of beyord, the uno-facing side of the monaration and noisel, the shady side of the monaration makes a difference when growing tensors make.	0980	Semand emeranity feetivels the plote in means from Spetraber to Jamers Dering the solvely by plottic system (semantic semantic se
	Senserality of sociecultural events. A particular period of food atmatmer, sensonal festivate, and other sensonal activities.		After harvesting creps like grass, burley (aryst), common sainténi (Anodey-ohi) and potatores. <i>Jor susse</i> the deep seil freezes, which is also a sign of winter (October).		Surprisingly subody matriced for Kyly Common Cachos (Palse etre) is present in Alah Valley all summer. However, formers identify that ink Life Ook (Holene exchaft (generally) as an indicator of spring; of owner, hybr yary rifer to many telesis such as Paloth Emminis o'Cillered Dow (Strepmelin doescers) or Life Ook as they sound similar (Domenspeeid).		The arrival of score is assume is a sign of winner, but the time of mixel, a biray water. Nonetheless, if unow arrives early, especially to emark, a larger watered lar de superclus 100 mmth, and it is a stranger of the st		Carle produce masses, which called job its here April, foressen table out the masses consider to let it day throughout the summe. Once it has node in here Appatt. the forenew sum trianging low-static holes on and use them its winner. Stable weather its masses of the day the place hance through the table to a stable static state of the day of the day of the forenage the table housing them or day prings the masses to dependent on the availability of maining that wire all the scenable climate. The mach main instat and table the lower it does not day of the scenable climate. The mach main is not applied to the lower it does not day of the scenable climate. The mach main is not applied to the lower it does not	\bigcirc	In Sary Mogrå, julio semaner pattere searce het only flore annth, Jane, hly and August. Julio ends with the arrival of odd, temperate change. When the days becomes odd in full, livestock occupe from the pather, graves tams yellow, maranets lablemate, and kids begin feeling the cold.	t	In winter, people here cost and memore and sit at home. Winter is the downet time of the year and the intensity of winter activitien decline.
\bigcirc	The sign circled in black means dangerous as well as nore variable events. Some examples are the outly arrival of anigratory birds, re-bibernation of marrows in spring, only manyrance of groun gams. Bendlo correctores of stall relates (helphysical presence, Benklädy in anrival of stars and departure, flexibility of yok mining secons, afficient animatan.		Bunk term specifically refers to a sudden weather change during the mating season of mountain (<i>Orbi revenue poli</i>) sheep and wild best (<i>Cupro silviria</i>) from only December until the end of December. Here straining can occur 10-15 days after mountain sheep: The mating season of mountain sheep marks the beginning of Osbore clide, mid-strain		The villagen provided me rich knowledge about summer birds, een of which is <i>Legendon</i> or <i>hok kabour</i> Hill Pigeon (Columbe repervis).	?	This symbol refers to a molecu rearbier charge such as unconstants, mortiful, and other vertifier events locaron in hord. This imm specifically refers to a solide worker charge during the saming useous of a fair-hord model and the solid symbol region of the saming to solid the saming the saming solid symbol region of the saming sense of the saming solid symbol region of the same observation for proor of mind. Moreo Twis Sheep bygits contenting around in source of the size - a group of minds about Solid Solid symbol region of the proor of mind. Moreo Twis Sheep bygits contenting around in source of the size - a group of minds about Solid Solid Solid Solid Sheep helps predict the samenal shifts in winter and smanne.	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Parmers notice that when desportic sheep roles' duel hair that inferens the arrival of summer, as well as the time to share. The word loss in sheep (2006) inform it is time to share. The word loss in sheep (2006) inform it is time to share. Due to early, they my be wellpect to deem if notices out and rate secon.		The livestock is Sary Maynd are land-fold in the village from moleCrobber to and of April because status cover in Alai lasts longer. Keeping investock in the village and fording by hand is called <i>Kidob-harmon</i> . It is signestical, however, to not the that arrival and departure of salow varies so as the time keeping livestock in the village.	1.	In winter, sillagers clear soore. Farmers take care of the lovethock by maintaining them in shellow during the soore cover.
\bigcirc	The sign circled in black menus that ecological signs are related to another sign. For example, such the soil tomms up, people plant processes. When untere ends, the upring lambing of domestic sheep begins.		Duration of score score in Adu Valley, which is frau mid-Ocsober up to Joyfel. However, currently, it is changing, especially the arrists of score in antame, score in a score in a score of score in a score during winer hore nask, which is musual and nex Ulagers say that is mid-Nevember, some excurnition, the Adu Wildy does not receive a score does go a score and the score in a score of the score of the score of the base. Institute baseling fivestock were able vallage.	i Q	Another summer bird is Pathok Eurosian Cellarol-Dove (Streptypela decaseta).	F	(map use present the transmission is when the matrix sector of the horten is by Mapel up of east matrix the matrix sector of the hort (capue alterio), known as non-barrel. The matrix sector of the Hort (capue alterio), altern as non-barrel. The matrix of the trans- solution, December 22nd. It is important to note that December 10- wing the third 10-start (sector the transmission of the is in that the lambs of these are not solb-resistant as the lambs of the Marco Pholosupe).		Free only left to only loss. Class Goy is a long yellow period, which means the time of streaming and flood scarcity. In this period, villagers the car a photokies in hold and fold scapelies. The birence, will be exploitly by understandished due to the lack of grans. The day become longers and longer. The local commanity will be long yellowing and planting. It is in this period, the stored field acquired from the lowershow due yenge are command.	00	Krubly to' – means winter bushing. Depending on the breading time of shorp, winter bushing tables place in Jensary and February Mary formers do not prefire winter handles places in it is too old, and the module tables constants to be much folder and hard work. Only a few people method winter handles in give house. It is is not old, have is mough folder, the cold and shorp health is the main rensos shy winter handles in on preferred.		Although these are not many hasters in Sary Megal, a few hunters suggested that they have during winter. Hunters say, however, that during marting and harding serieses, it is prelabilisted to hunt.
+	The arrow shows how ecological signs are related to each other. For example, when snow flappents, green grass emerges. When arrows are charaches the strumer pointer season is over, by an example of the structure of the structure of the structure and migrature block depart.	(,) ,) ,) ,) ,) ,) ,) ,)	This symbol collectively refers to hash-held known as the aerival of inference of the second		A period when nightery birds return and deput is called haol- kaly. The return of nightery birds indicates the and of the summer tensors and the artifield ensuing when temperature change three wans to cold.		When, for the first time, load-objety firsh grans starts to appear in the field people have that visites has eached, and spring has arrived. The energoics of grans is oscirated because souri dispenses, the earth because date, and the granulands because approxed people reasons of the start of the worker changes in using, the grans could be energy early, known as judges ji fitse approx. The blast spring course entire then expected, the community does not believe that spring has arrived. This sudden warming informs the		Spring languing langui nel liver in a period when sheep and goets start giving birds. Skeep give birds between 142-156 days, which is about pring birds. Skeep give birds between 142-156 days, which is about flowaphor Gordser and Norvenber, in order to understarke opting landings, its preferent because flowares into the trading travels the warmer senses when olide ends, and spring arrives. The spring landings languing flowares flowares flowares are the spring landing languing flowares between the spring travels.	26	When male sheep are put back together with females, it is called <i>lackbor lookyint</i> . Many people in Skry Megal community breed sheep fromplement Costere and Neverate. Framers time sheep landing using of <i>low</i> in Oxiver because they petter spring landing when give become written in the Math and and pdf. J	0000 000000000000000000000000000000000	Whene engage in wroning activities in addition to other seasonal work they do a not observe that the prepare for manner, women $\lambda ry_1 yy_2 \cdots product a string from sharp work. They induce the types of a string the model graph of all yields works they for a string the string string the string of the string the string string string the string of the string st$
			When hird arigination occurs, various species of causes kardyre (Grafydromen, Deras (Dossko, er arkstepsoder tripp) often tacks and prese attrict. The prints arealist size, and land the softwise begin in April.		The presence of Chalchegol Jahellan Whertern during growing sector inform summer period. When they stop spinite, it inform the oil of summer and beginning of fall. The name of the bird is also Oceranteposis.		event of spring and the expectation of heavy snowfall in spring. When feeds genus appears for the first-time, wild and denotics azimuth start to cheave it. This lock khamb behavior samong denoticies azimuth indicative the end of visciture and beginging of prings. The term also refers to zonzhini scherg (Arkin samong polic) and zonzatning goot They: (Copera soliticity) doesnal to lowar variables.		Zoper to ¹ is when the yaks begin to give birth. Yaks start to give birth starting from mid-May ray to sind-fram. The yaks give birth in 26-0237 days, which is because 1.5 and 9 months. However, the maring sensor of yaks is are not fixed.		The maring sensors of spect-paperse yelds meanly expected from mid-lely to October, but it varies depending on the sensors. Similar to meaning norm and steep, obso males come argue separately in higher deviation and mate score argue. That will solve this distribu- tion inductors a sensorial addr.		Nonet - is a colorenion of jar upting from 21 to the 24 of March during the trans of Versal Equinor. During their event, villagers clear their yorks, equiting guoss, repress to 62-a monous, and marke good winker. This halding is solidly colorenate as New Your anong the communities in technol. None
			In the period of bird mignetion, the champlock White wagnal (Adstactile afbe) comes first. This mixed code (white and block) small bird marks spring. The local people have a special strand related to a fait, by Upus woing the block, they immediately three a whose st it out of excitment.		In annum, a thank-sice green lied arrives, and farmers notice a foot locally called by eyed. This small hold can hang or load on the areas of graves. This has not postered posters. Between Strategies, famers and an older typologo-andro handly, halv a blacked (hand read), or Generality Worked ("Hydrogen modelshift). The key as to begin proto harvers when exclusion (hard a strategies of the strategies).		Kok kalow means a behavioral change arroug theop, goats, and other animals whan game energes. They become pickly: refine to east stored fielder. That is how people notice the arrival of spring.		Allough people in Stay Mogel do sot monitor heres mating as a susmodi indicater, in summer, heres are put topelter. A single male eiger just topelter with size group of famale heres, but they do so it main randowilly. They make white thirt measures as well's strateg free line Mog. Denois start pixely that, and fare milling accoss legation. Many people in SaM Mogel and have pre-formed into the milling science, bars, and heading approprise, expectively dwirth the early milling science. In annual, heading range projets indicative bard for equipations annual, heading range projets indicative bard for equipations.	6			When grave energies, the community notices the abundance of the workers around the new. Montania sheep (<i>icits)</i> moves pub) and montanias goat the act (<i>Gypar illivita</i>) descend to lower valleys sourching newly energied grave.
			During the animal of migratory birth. Jown - chylorchyê Commes starling (Jiowna Holgoris) small and black hielis fidlow: Elwy do act star piro lo nig a tit de area et Sary Mogal. Oace they come, spring begins.	3	When Kaldagash is seen in flocks during the departure of migratury birsh, indicates the cal of summer and the arrival of aurann. The name haddagash digits for three birsh to with minist railse. Common Swift (Agor apus), Northern Hosee Marin (Delichon (Bricum), and Burn braillow (Bricum) arrival).		Skeep des after foraging too mach grass in spring. The effect of fords prave on weak hortsecks as called Josh-snave or dirattes. It is a serical period for foresteck, and a markly mater jakes in an ask-April. This process is also known to (ogoo) – a process where weak azimals dee due to submit.	•	Bedre store type: an plantic bottles for spring, begrefer store type: a plantic bottles for spring, disappear for 4 (bits). As this is definible because langue and langue. While the <i>Univer</i> Plantic is not exert, not local peeple num- ders its small beam its end for the store pueper spring. The Plantic met and the store of the store of the store of the community will not see the group of store for 40 and s.		Land non-ploving and genting, a period celled aread ony, occers in Aced Brough Mgs, Borghesing and generations in period. The second second part of heads Mgs, Borghesing and Second Second Second Second organ can be able at the second second second second second second second second second second second second second second plant Departer common using in Debudy being the second second second forming, the plant length second second second second second forming and second second second second second second second forming and second second second second second second second forming and second second second second second second second forming and the second		Farmers clean nove during the winter. Farmers take core of the lowedsk is ableter during the period of nove cores. As part of winter activity, man work in the coef anise, whereas wenne capage is wereing activities. The winter is the slowest time of the years.
			Kukhkuhh Comann Core (Phiro atre) continue to serier. One dahlang in identifying this hiel, however, has been the twop series of balas a white-banded. This term may refar to howeve, brief, and other minute, which if an adverse to the bala. In this regard, we ado some at the first indice and we be white-banded back. (Open-encoupland), and a White-banded Back (Decision percentify Resentions, assessing on the cold docciption, Reservice).		Communy members have told to that fall is noticed when flogs weeklice (cronking) in September, but we have late data about flogs.	y to	When Batchechelet Szorwdopy (galanfim) emerge, it indicates the arrival of opring.		Shearing sheap and posts is called <i>had</i> polyme, which starts from lack klop to Jance. This important to know the right frame to shear the sheap OBmark, they may do lack to suck questionly free hole the sheap OBmark, they may do lack shearing is not perform the to the trick of cold worther as well as rain.		uning, the narrow extension and participate to any, maximum events Land not activities like ploying, and planting taken place in April and May, depending on users and having of well. It is known as much sty hard nor reason.		Farmers injust crups daring short summer (Jane to August) lock inside and field consider (I do village, The farmers have a special injustion on the state of the state of the state of the state of the state of how much in the village records sharing about summer, bedry is injusted 3-4 times throughout the sensor.
		_	this term is a local name of Common Coot.	-									

Future Directions

As we have demonstrated, the potential to develop ecological calendars exists across differing ecological and cultural contexts. The diversity of breadth and depth in these community reports is not a point of departure, but a moment of learning. The idea of ecological calendars is simultaneously universal and particular. Because of the connectivity that Indigenous and rural people have to their homeland, ecological calendars are inherently particular as they reflect the specific knowledge of a particular habitat. That connectivity also makes it universal because communities in different places and in other moments of time can develop such calendars precisely because of their linkage to their habitat. This is what gives the ecological calendar its anticipatory and adaptive potential. Where local knowledge has been diminished by a history of colonialism and injustice as well as the continuing global trend of unchecked industrialization, there is potential of rebuilding and revitalizing it through collaborative research.

It is our hope that through this report, other communities are inspired to develop their own ecological calendars. There is a demonstration effect resulting from this project, namely that other Indigenous and nonindigenous communities may also have or are now considering developing their own ecological calendars. At a dismal moment in human history, where industrial civilization irrespective of its ideological roots in capitalism, communism, or socialism has undermined the linkage individuals and societies have with their habitat, the collaborative act of developing such calendars is empowering on several fronts. First, it creates a heightened awareness of one's own habitat whether it is urban or rural or some space in between. This heightened sense, brings forth an understanding of relationships inherent in that ecological space. Therefore, both the individual and community become conscious of the *rhythms* of their lands and cognizant of the consequences of their actions. Second, this exercise of awareness and understanding is the first step to co-creating an ecological calendar that suits a particular community and their cultural and ecological context. Third, with such an outlook, human-induced climate change ceases to be simply an overwhelming global phenomenon, it becomes particular because understanding these changes, anticipating their impacts, and developing adaptive capacity can be empowering when arising from uniquely place-based knowledge. Yet a response to climate change demands global commitment and action. That commitment cannot take place in a vacuum, it must be grounded in the knowledge and reality that is locally informed.

The process that we have described in these reports has been iterative and organic. It is an engagement that co-created insights through deliberative discussions even while a global pandemic ravaged the planet and, in some instances, armed conflicts destroyed the lives of people where we work. The very fact of the commitment of these diverse communities and our research team speaks to the necessity of this work and its capacity to build a meticulous methodology of hope. Therefore, several more tasks remain.

First, the ecological calendars for the communities in the Pamir Mountains and the Standing Rock Sioux Nation need to be validated. Given this publication and the intent of having it available electronically on the web, means the validation can be achieved more easily. In addition, new insights and ecological relationships can easily be added.

Second an international conference that brings together scientific, local community, civil society, and governmental institutions will help strategies for future action, research, and policy formulation. Such a conference entitled *Rhythms of the Land: Indigenous Knowledge, Science, and Thriving Together in a Changing Climate* has been organized for October 2021 at Cornell University.

Third, an effort must be made that the Indigenous and local knowledge that is contained in ecological calendars is not only communicated but is also revised and revitalized by future generations in their respective communities. This is most easily achieved through environmental education and curriculum development not only in the social sciences and humanities but concomitantly in the biophysical sciences. Climate change knows no disciplinary, geopolitical, or cultural boundaries. Similarly, the response to understanding and adapting to its impacts must reflect that consciousness.

Fourth, policy in terms of hunting, fishing, farming, herding, or broadly land stewardship must reflect the insights that communities and researchers are collaboratively reporting through their ecological awareness and insights. This will have direct impact on regulations for hunting and fishing seasons. In addition, land use plans, policies, and practices will need to be examined in the context of the changing climate and in light of specific insights arising from these localized ecological calendars.

Finally, when communities described their ecological relationships, their knowledge, although fractured by the impact of industrialization and a colonial legacy, was intimate. Descriptions of their habitats did not separate their presence on the land from other living beings. They were cognizant that they are *living through* the environment not *from* it. There was no separation between mind and body because both exist because of and within an ecological space. This perspective should give us hope and inspire us to explore it in our own lives.







