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Authors: Postigo, Julio C., and Laura Valdez, Sonia

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The Sociocultural Construction of Soil Among Communities of the Bolivian Altiplano: Potential for Supporting Transitions to Sustainability

***Julio C. Postigo*[1]* *and Sonia Laura Valdez*[2]**
** Corresponding author: jpostigo@iu.edu*

[1] *Department of Geography, Indiana University, 701 E. Kirkwood Ave, Bloomington, IN 47405, USA*
[2] *Graduate School for Development, Universidad Mayor San Andrés, Rosasani No. 55, Obrajes, La Paz, Bolivia*

The health of soil, a fundamental resource for life on Earth, is severely compromised by global environmental change. Evidence shows that the knowledge of Indigenous Peoples and local communities influences sustainable land management, hence the importance of understanding Indigenous soil classification. Using a participatory approach, we conducted semistructured interviews, focus groups, and collective mapping of soils in 4 Aymara communities of the Bolivian Altiplano. We found that families in the 4 communities organize their territory in homogenous zones, based upon characteristics perceivable by sight, touch, smell, and taste. The description and meaning of the zones refer to characteristics such as location, soil color, preferred land use, and topography. We argue that homogenous zones are kaleidoscopic and polysemic units of spatial organization of the Aymara territory. Each meaning conveyed is like a face of a kaleidoscope and refers to different features of the zone. They are polysemic because the descriptions of the zones refer to multiple elements of different kinds (eg color and fertility). Indigenous and local knowledge of soils has coevolved with thousands of years of Altiplano farming, leading to prescriptive and flexible homogenous zones of sustainable land management. These knowledge systems and the cultures they belong to constitute crucial elements for generating knowledge supporting transitions to sustainability.

Keywords: *soils; Indigenous knowledge; coproduction of knowledge; landscape management; Aymara; Andes.*

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Introduction

Interactions between microbes and weather drove the formation of soil from 3.5 billion years ago until 12,000 BP, when humans began to practice agriculture. As the practice of caring, protecting, and exploiting other organisms that serve as food—ie agriculture—spread throughout the planet, the processes underpinning soil formation transitioned from being fundamentally natural to anthropogenic. In this transition, soil became the material foundation of agrarian civilizations such that, for instance, current provision of food for 95% of population is based upon soil for farming (Handelsman 2021), and good child nutrition is associated with practices that maintain soil's health (Vanek et al 2016).

The Andes, as one of the cradles of agrarian civilizations, offers a long socioenvironmental history of soils. Indigenous groups in the South American mountain range have been crucial agents in the transition of soils from natural to social products. Andean peoples' worldview of the unity of humans and nature guides their knowledge of soils and how they work with them. For the Aymara, their spiritual life originally played a prominent role mediating human–nature relations; however, more recently, compounding religion, social, and environmental conditions have become the dominant lenses through which the Aymara understand nature (Rist et al 2003). Consistently, scholars and practitioners argue that the environment, the political, and the socioeconomic are interwoven in *Suma Qamaña* or *Good Living*—the Aymara identity paradigm (Apaza Huanca 2019). In this paradigm, sacred Mother Earth (*Pachamama*) exists as a living entity wherein the physical and nonphysical worlds, as well as humans, plants, and animals, are interrelated (de Munter and Note 2009; Estermann 2013; Apaza Huanca 2019). This interrelationship also happens through time, whereby past and present interact via people's learned/taught practices for addressing ongoing challenges (de Munter and Note 2009).

Andean soils are a crucial element of landscapes shaped by the diverse environmental and ecological conditions along the elevational gradient (Pestalozzi 2000; de Valenca et al 2017). The knowledge and labor of Andean Indigenous Peoples and local communities are paramount for producing soils that are able to sustain farming and informing practices to maintain healthy soils (Pestalozzi 2000; de Valenca et al 2017).

The interactions and feedback between knowledge and daily farming are a distinctive feature of farmers' way of knowing. The accumulated experiences of traditional and modern farming practices coalesce in the knowledge of soils and land management (ie ethnopedology) (Zimmerer 1994;

TABLE 1 Population, elevation, annual precipitation, temperature, and land of the communities in the study area.

Community	Population (2012)	Elevation (masl)	Annual precipitation (mm)	Temperature range (°C)	Area (ha)	Arable land (%)	Average land per household (ha)
Cutusuma	448	3812–3880	700–800	−2–15.7	707	51	4.7
Igachi	720	3811–4047	700–800	−2–15.7	1972	42	7.9
Huallatiri	134	3805–3868	398–547	−10–14	3290	82	60.9
Aroma	115	3710–3727	150–250	−12–20	3961	10	123.8

Sources: INE (n.d. a, n.d. b) and authors based on data from Rocha (2013), Osorio (2011), Morales et al (2000), and SENAMHI (n.d.).

WinklerPrins and Barrera-Bassols 2004). This constitutes a fruitful interaction without diluting the different coalescing components. Further, the interacting components may even incorporate and transform elements of the other components, benefiting from them. A broad definition of ethnopedology implies that knowledge is attuned with many landscape processes that are modified to improve soils for farming (WinklerPrins and Barrera-Bassols 2004). Ethnopedology informs and is informed by farming, whereby farmers' empirical knowledge forms part of specific ecological, cultural, and economic rationales (Sillitoe 1998; Barrera-Bassols and Zinck 2003; WinklerPrins and Barrera-Bassols 2004). After millennia of interactions among Indigenous groups, and with non-Indigenous peoples since the mid-16th century, Aymara knowledge is both Indigenous knowledge and knowledge that is informed by other ways of knowing. For instance, farmers in the Bolivian Altiplano have incorporated dung and artificial fertilizer to increase soil fertility (Pestalozzi 2000).

The knowledge of Indigenous Peoples and other land users has great potential to address the impacts of global climate change (Brondizio et al 2019; Postigo 2019), specifically impacts compromising soil health, such as erosion and degradation (Pestalozzi 2000; Handelsman 2021). However, transitions to sustainable soils will require the convergence of multiple knowledge systems (Pestalozzi 2000; WinklerPrins and Barrera-Bassols 2004). We argue that Indigenous Aymara soil knowledge is crucial for such a transition in the Altiplano. This paper presents how Indigenous Aymara farmers spatially organize their territories and classify their soils using a multicriteria system. We discuss our results as potential entry points for coproducing soil knowledge, thus bridging Indigenous, local, and scientific soil knowledge systems.

Study area

The study area is on the Altiplano plateau. The elevation ranges from 3700 to 4050 masl (Table 1). The climate is cold and dry, though there is a large daily temperature variation ranging from −12°C at night to 20°C at noon. The rainy season in the Altiplano is from October to March, and the precipitation in the study area ranges from 150 mm in the south Altiplano to 800 mm in the north (SENAMHI n.d.), increasing from south to north. The vegetation of this dry alpine ecosystem is characterized by xerophytic grasses and shrubs, including tolerant woody species such as kiswara (*Buddleja incana*) and queñua (*Polylepis* spp).

We carried out fieldwork in 4 Aymara Indigenous communities (Figure 1). The communities of Igachi and Cutusuma are in the north Altiplano, surrounding Lake Titicaca, and belong to the department of La Paz (municipality Batallas). The community Huallatiri is also in La Paz (Caquiviry municipality), though in the middle Altiplano in the sector of the river Desaguadero. The community Aroma is in the south Altiplano, near the Uyuni salt flat, in the department of Oruro (municipality of Salinas de Garcí Mendoza). Table 1 presents data on communities' demographics and land tenure.

Though Aymara recognize themselves as having a unique culture and an original language, they consider their territory as a First Nation (*Pueblo Originario* in Spanish). It is possible that being a First Nation generates a status that grants differential treatment for using resources, such as water and minerals, and accessing government programs, such as bilingual education. However, this double layer of recognition may also create tensions between being Indigenous and a First Nation. As such, Igachi and Cutusuma consider themselves communities, whereas Huallatiri is a *Pueblo Originario* and Aroma belongs to the Killakas Nation.

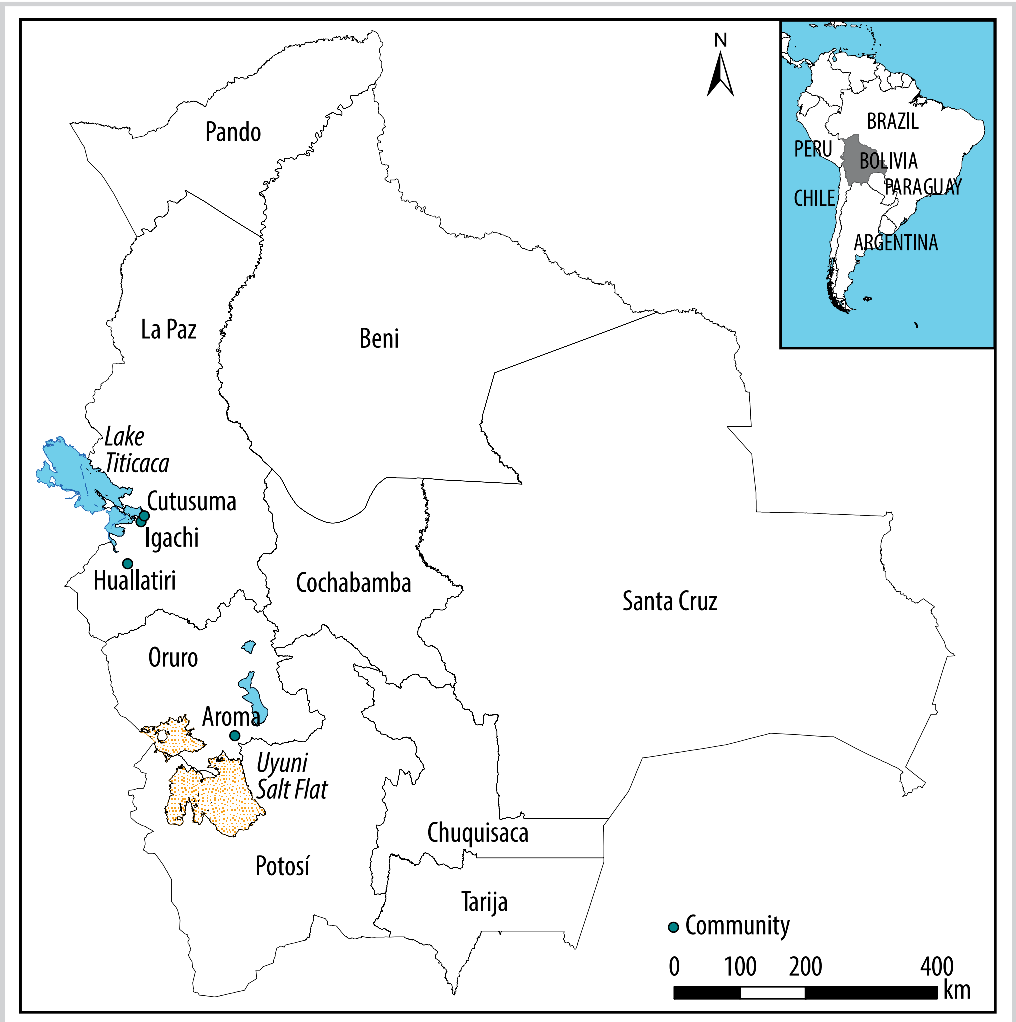
The households' subsistence economy in these communities is based upon rainfed cultivation of potato, oca (*Oxalis tuberosa* Molina), papaliza (*Ullucus tuberosus* Caldas), quinoa, cañahua (*Chenopodium pallidicaule*), and forage (ie barley, oats, and alfalfa). Agrobiodiversity decreases with rainfall, from north to south. In the south Altiplano, quinoa and South American camelids are the main crop and livestock, respectively.

Methods

This study was guided by agreements with the communities with the aim of researching soil degradation, land use change, and decreasing productivity. Research activities were guided by the principles of complementarity, reciprocity, equity, and sustainability. Additionally, respect and transparency were considered crucial to combining Indigenous and non-Indigenous knowledge systems. As articulated by the communities, Western soil science can complement Indigenous soil knowledge in understanding the problems and identifying possible solutions (Figure 2A). Similarly, data collection and analysis guided by reciprocity and equity and involving communities' knowledge holders would enhance the collaboration between farmers and technicians (Figure 2B).

The research design and goals were codeveloped with the Aymara communities. We coproduced the paper with

FIGURE 1 Communities of the study area in the departments of La Paz and Oruro. Inset map, Bolivia in South America. (Map by Rafael Paredes Argote)

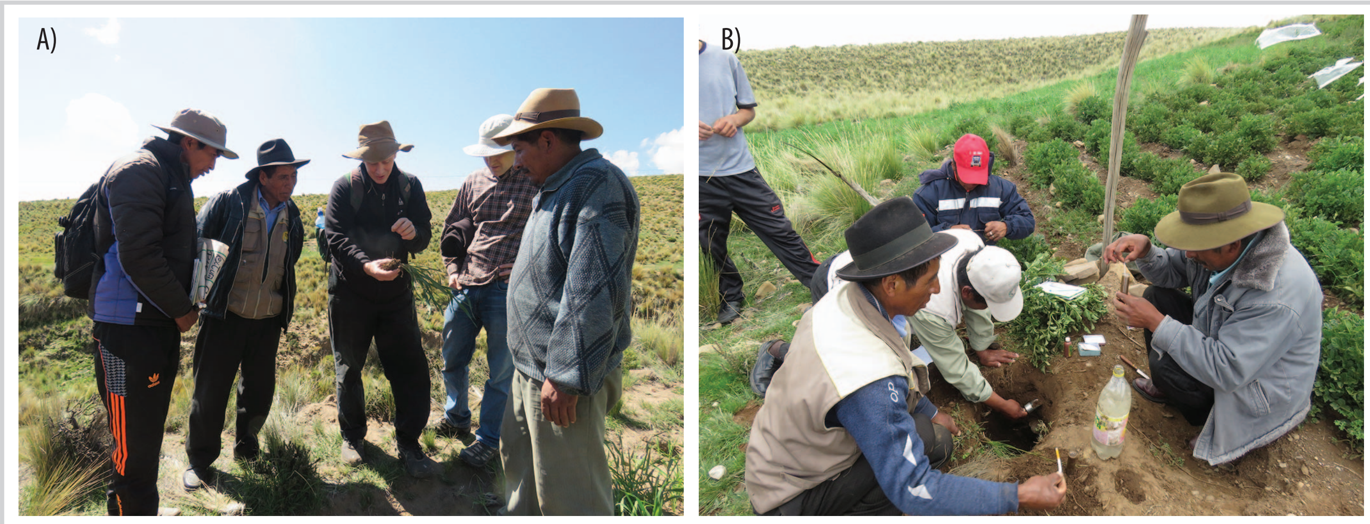


farmers, authorities, and expert farmers from the 4 communities. The project began as motivated by Aymara farmers' recognition and concern that their soil productivity was decreasing and crop yield reducing; this is a broad pattern observed in the Bolivian Andes (Rist et al 2003). Intrigued by the declining condition of the soils and yield, the Aymara partnered with the NGO (nongovernmental organization) PROSUCO to investigate the status of their soils to address their current problems. In doing so, they moved from believing that religion shapes nature to focusing on the relations between spiritual life and socioenvironmental conditions (Rist et al 2003). It was expected that the knowledge generated would inform the best land uses for the different soils of the communities.

First, we conducted 19 semistructured interviews (6 in Cutusuma, 5 in Igachi, 4 in Huallatiri, and 4 in Aroma) (Figure 3) and field observations to identify the homogenous zones and register their coordinates. Following Aymara cultural norms, sharing coca leaves and chewing coca mediated and facilitated all interactions with community members, particularly with the elderly. We identified the zones using questions about their characteristics, the types of soils, and their location. Second, we digitized the zones on maps based on satellite images from Google Earth. To validate the maps, we conducted 8 focus groups (3 in Cutusuma, 2 in Igachi, 1 in Huallatiri, and 2 in Aroma) with expert farmers, community members, and communal authorities. We gave a questionnaire to one expert farmer per community, where expert farmers are elderly community members recognized as wise and knowledgeable. Survey data complement the description of the homogenous zone, including soil characteristics, local name, taste, color, and ideal land use. Furthermore, an Aymara linguist verified that the meaning of the names of different soil types and of the communities' sections identified in the field were consistent with the information in dictionaries.

Though we used the Spanish term *zonas homogéneas* (homogenous zones) for these community sections, each zone has an Aymara name. We presented preliminary results to community members during assemblies and field visits. We carried out 6 workshops (3 in Cutusuma and 1 in each of the other communities) to validate the information on names, the meaning attributed to zones, and soil types (Figure 4). The meanings presented here come from information provided by local people, dictionaries, and chronicles. Definitive results incorporating the comments of the validation were presented to the community through community assemblies, schools, and municipalities.

FIGURE 2 (A) Indigenous Aymara farmers discussing soils' characteristics with Western soil scientists. (B) Indigenous Aymara farmer calibrating the instrument to measure pH content of soils collected. (Photos by Sonia Laura Valdez)



Results

Aymara communities in the Altiplano organize their territories into "homogenous zones" (Figure 5; Table 2). The zones are distinctive parts of the territory and are variable in size. Their names are Aymara words that usually refer to a distinctive feature characterizing the zone. This characteristic makes that part of the territory homogenous and recognizable. Characteristics are diverse, including shape, color, degree of steepness, ownership, and type of soil (Table 2, second column; Figure 6). The farmers also told us whether conditions in a particular zone were favorable or unfavorable for farming activities and indicated prescribed zone-specific land uses.

Aymara farmers' delineation of homogenous zones is based upon characteristics perceivable by sight, touch, smell, and taste. The description of the zones is generally prescriptive rather than proscriptive. Any proscriptive elements are more like warnings to other farmers alerting them to conditions that may be challenging, like the frequency of extreme weather events (eg cold spells) or unsuitable soil. The internal consistency between the characteristics described and the uses prescribed is founded on experience-based knowledge or trial and error transmitted through generations. Both description and prescription may change over time as farmers and communities adjust to environmental modifications or learn from daily experience. The flexibility in the content of the zones is akin to the fuzzy boundaries among production patches of mountain agriculture (Zimmerer 1999).

FIGURE 3 Interviewing an Aymara Indigenous farmer. (Photo by Edwin Mamani)

Though the description of the homogenous zones encapsulates multiple meanings, we identify some patterns. The descriptions of almost all the zones in the 4 communities include at least one reference to the soil. This can be about the dominant material of the soil (eg sand), the size of the stones when the ground is rocky, or the color of the soil.

The descriptions in the 4 communities often refer to biophysical features of the zone, such as the topography, elevation (eg foothill or summit), and geology (eg presence of big rocks, abundance of salt). Another shared element in the descriptions is an indication of suitability for farming (eg Pampa Grande in Igachi community). In some cases, the indication even specifies crops suitable for the zone (eg Pusi Ñuñuni in Igachi community). In line with this, there are also indications of the unsuitability of the zone for farming, such as Acoterio in Huallatiri community.

FIGURE 4 Workshop for validation of preliminary homogeneous zones depicted on a map. (Photo by Sonia Laura Valdez)

FIGURE 5 Homogenous zones identified by Aymara farmers in 4 communities of the Bolivian Altiplano. (Map by Rafael Paredes Argote)

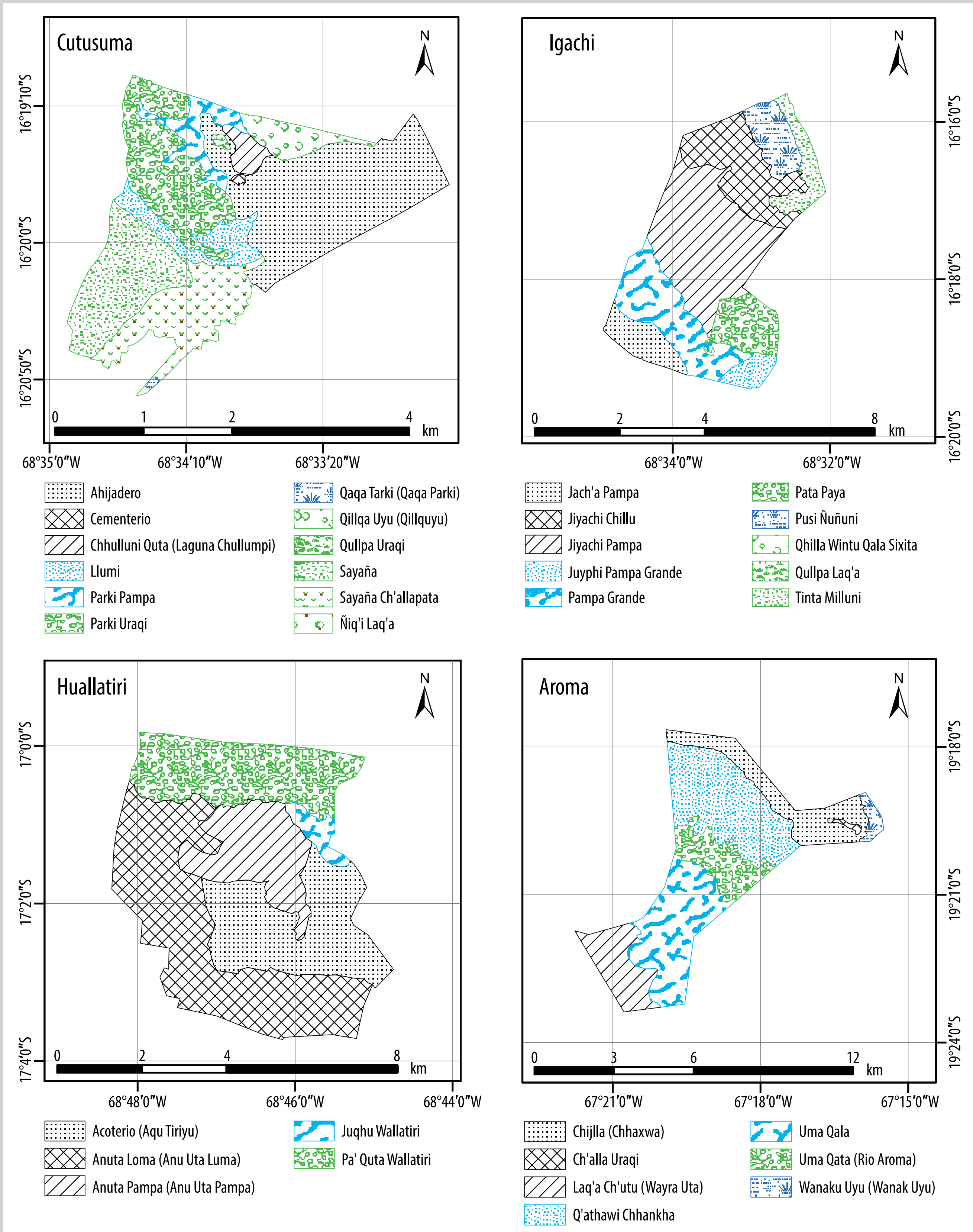


TABLE 2 Aymara name of homogenous zones, the meaning of the name, the farmers' description, and prescription in the 4 communities of the study. (Table continued on next page.)

Zone	Meaning	Description	Prescription
Community Cutusuma (municipality Batallas, department La Paz)			
Ahijadero	Rangeland part of the community	Former part of the landlord estate	Livestock grazing, particularly sheep
Qillqa Uyu (Qillquyu)	Letter, wall	Land with gravel and a few mineral salts	
		In the past, people wrote on the wall	
Qullpa Uraqi	Saltpeter, plot	Land with mineral salts	
Cementerio	Cemetery	Land with mineral salts and water	
Parki Pampa	Foothill with slope, flat land	Land with high slope	Very good for crops
		Located in the low-elevation parts of the community	
Llumi	Soil soft and fertile for agriculture	Red fertile soil, very good for agriculture	Intensive agriculture
Parki Uraqi	Mountain with significant slope	Land in the upper half of a mountain, with steep slope	Agriculture
		Good for cultivating *mili* potato (early potato)	
		Zone is not get impacted by cold spells	
Sayaña (Saya-ña)	Part of the community that belongs to a family	Plot	
		Family's estate formed by a house and plots in the community	
Sayaña Ch'allapata	Part of the community land dominated by light sand	Divided plots with good type of soil used for housing	
	Sand hill		
Qaqa Tarki (Qaqa Parki)	Rocky mountain or slope	Rocky terrain with brittle stones	Livestock herding and farming
	Fading color	Parceled land	
Ñiq'i Laq'a	Muddy soil	Zone constantly full of mud	Crops and fodder
		Parceled land	
Chhulluni Quta (Laguna Chullumpi)	To have reeds	Lake with reeds	
	Lake	Belongs to the community, though it has been parceled for using the reeds as forage	
Phasil Parki	Rocky mountain with a gentle slope	Land with an easy slope	Suitable for farming
		Soft and sweet soil	

Interestingly, climatic characteristics are concentrated in Igachi community. Though these references are warning statements about extreme events and temperatures happening in the zones, the name Jach'a Pampa informs that extreme events like cold spells do not occur there. It is possible that extreme events happen in other zones, but their occurrence is implicit or assumed in another characteristic. For example, the occurrence of cold spells is implicit in homogenous zones located at high elevation. It may also be that extreme events are explicitly included in the description of the zones or embedded in the prescribed land use where they could have a negative impact, particularly on agriculture or livestock herding.

Another pattern identified is that Qullpa and Suma Laq'a are general terms referring to the zone's salt content and fertility, respectively. Qullpa soils are those with different types of salt. The use of a single name for the parts of the territory with salty soils might indicate livestock's need for a source of salt. Suma Laq'a are good fertile soils, with colors such as black, dark brown, or gray. This name is also used for pristine montane peatbogs, which are good soils, though impacted by cold spells or with some level of salt. The

TABLE 2 Continued. (First part of Table 2 on previous page.) (Table continued on next page.)

Zone	Meaning	Description	Prescription
Community Igachi (municipality Batallas, department La Paz)			
Jiyachi Chillu	Cone of yarn Clay	Rocks weathering forming good soil	Purple clay for pottery
Jiyachi Pampa	Cone of yarn Flatland, plain	Flatland	Generally used for livestock grazing
Jach'a Pampa	Flatland, plain	Large, very productive zone known as a valley Not impacted by cold spells In the past, it was known as *aynuqa*	
Pampa Grande	Large plain	Large flatlands or plains	Used for agriculture, livestock herding, and housing
Juyphi Pampa Grande	Cold spell, flatland	Large portion of land always impacted by cold spells	
Qhilla Wintu	Shape of a human heel	Place with piles of stones	Suitable for agriculture
Qala Sixita		The soils are like ash, as they are high-quality, fine grain, and soft soils with some ash	
Qullpa Laq'a	Saltpeter soil	Whitish soil dominated by saltpeter	Used to cultivate cañahua
Pata Paya	On top At high elevation Disorientation	Zone very cold and at high elevation Impacted by mild cold spells A sacred place, which causes bearings to be lost	
Pusi Ñuñuni	To have four breasts	Rocks elevated, which look like four breasts or concave shapes	Used to cultivate native potatoes
Tinta Milluni	Substance of color beige To have aluminum sulfate	Zone wherein the water changes color, ranging from yellowish to beige and sometimes blueish Minerals present Very little agriculture	
Commuty Huallatiri (municipality Caquiaviri, department La Paz)			
Pa' Quta Wallatiri	Two lakes Andean goose (*Chloephaga melanoptera*)	There are two lakes with Andean geese called *wallatas*	
Anuta Loma (Anu Uta Luma)	Fox's house at the hill	Uppermost part of a hill Foxes (*Lycalopex culpaeus*) used to live here, particularly in the caves	
Anuta Pampa (Anu Uta Pampa)	Fox's house at the plain	Plain where foxes used to roam There are caves that were inhabited by foxes	
Juqhu Wallatiri	MireAndean goose	Lake with peatbogs where Andean geese live	
Acoterio (Aqu Tiriyu)	N/A	A type of stone with little soil Lime vein	Not suitable for agriculture

consideration of Suma Laq'a as good soil seems consistent with high level of carbon observed in peatlands, which would explain the black color of this soil. Furthermore, the existence of these 2 general terms indicating relevant characteristics for livestock (ie the availability of salt and the existence of wetlands) reflects the importance of pastoralism as a livelihood in the drylands of the Altiplano.

Finally, Huallatiri is the only community that describes the zones as habitats of animals. For instance, Pa' Quta Wallatiri are lakes where there are Andean geese. Similarly, Anuta Loma, and Anuta Pampa are high and low plains, respectively, wherein foxes used to roam. Further, in these Anuta zones there are caves that used to be inhabited by foxes. The description does not mention the implication of

TABLE 2 Continued. (Previous part of Table 2 on previous page.)

Zone	Meaning	Description	Prescription
Community Aroma (municipality Salinas de Garci Mendoza, department Oruro)			
Wanaku Uyu (Wanak Uyu)	Corral for vicuña (*Vicugna vicugna*)	Large area with corrals for vicuña	Human-made lake for the animals to drink water
Chijlla (Chhaxwa)	Pile of small stones	Place with abundant small stones	Little suitability for crops
Ch'alla Uraqi	Sand, plot	Land dominated by sand often impacted by dust swirls	Sand land with sediments making it suitable for crops, though prone to crop losses due to strong winds and swirls
		Impacted by cold spells and light hailstorms	
Q'athawi Chhankha	Limestone	Rugged and soft stones	
		There are seashell fossils, which indicates that the place was underwater in the past Stones are "cooked" in ovens to be used in the construction of walls and houses	
Uma Qata (Rio Aroma)	Water, to drag	Section of the river Aroma with fast currents due to low slopes	
Uma Qala		Sector with slippery and hard stones	
		Considered brave stones because their resistance	
Laq'a Ch'utu (Wayra Uta)	Land at the top of a hill or at high elevation	Dunes shaped like houses by strong winds and swirls	
Jaru Uma	Bitter water	Name of town Aroma, derived from bitter water	

animal presence or human use of the zone. However, these recognizable characteristics and habitats tacitly inform community members about conditions such as remoteness and difficult access.

Homogenous zones are kaleidoscopic and polysemic units of spatial organization of the Aymara territory. They are kaleidoscopic because the meaning being conveyed (ie what face of the kaleidoscope you look at) depends on different features of the zone (columns "Meaning" and "Description" in Table 2). Table 3 organizes the homogenous zones of each community by farmers' perceived relevant characteristics (ie face of the kaleidoscope). Homogenous zones are also polysemic because their descriptions usually refer to more than one element of different kinds (eg color, fertility, suitable land use, topography; "Description" column in Table 2). An example of the kaleidoscopic and polysemic nature of the homogenous zones is Parki Pampa. It is kaleidoscopic as the zone can be seen as terrain of low slope, high elevation, and suitable for farming, depending which element of the description is used. Simultaneously, Parki Pampa is polysemic as its description refers to topography, elevation, and suitability for agriculture. Though one unique cohesive description can be made, it is unlikely that the parts of Parki Pampa at high elevation with steep slopes are very good for crops.

FIGURE 6 Indigenous Aymara farmer presenting different soils collected throughout the community. (Photo by Sonia Laura Valdez)

The meaning of the homogenous zone underscores the conspicuous elements that distinguish the zone from the rest in the community (Table 3). The description considers multiple parameters that have been collectively agreed upon, while showing shared local knowledge of the zone (Table 2). The zone, thus, is socially constructed, regulated, cared for, monitored, and managed.

Discussion

The homogenous zones of Aymara communities result from the human modification of biophysical conditions and the adjustment of land use and governance to the variable ecological and environmental characteristics of the Altiplano. The descriptions of the homogenous zones reflect both landscapes modified and landscapes to which one must adjust. As such, the elements included in the descriptions of the zones also constitute multidimensional guidelines, including suitable land use, threats, extreme events, and limiting factors for human activities such as agriculture. Further, land use and soil management practices reflect local knowledge of soils and their properties (Zimmerer 1994; Pestalozzi 2000; Rist et al 2003; de Valenca et al 2017).

TABLE 3 Characteristics of homogenous zones per community.

Community	Physiography	Land use	Geology	Mineral content	Soil texture
Cutusuma	Parki Pampa, Parki Uraqi, Phasil Parki	Ahijadero, Cementerio, Sayaña, Sayaña Ch'allapata, Chhulluni Quta	Qillqa Uyu (Qillquyu), Qullpa Uraqi, Llumi, Qaqa Tarki		Ñiq'i Laq'a
Igachi	Jiyachi Pampa, Jach'a Pampa, Pampa Grande, Juyphi Pampa Grande, Qhilla Wintu Qala Sixita, Pata Paya, Pusi Ñuñuni	Tinta Milluni	Jiyachi Chillu	Qullpa Laq'a	
Huallatiri	Anuta Loma, Anuta Pampa	Pa' Quta Wallatiri, Juqhu Wallatiri	Aqu Tiriyu		
Aroma	Uma Qata (Rio Aroma), Uma Qala	Wanaku Uyu, Laq'a Ch'utu (Wayra Uta)	Chijlla	Q'athawi Chhankha	Ch'alla Uraqi

The knowledge of Indigenous Aymara is fundamental for the creation of homogenous zones, which guide practices of use, conservation, and modification of soils. In doing so, the zones might be seen as powerful instruments for transforming the landscape. The power, though, appears disseminated because the parameters for describing the zones are collectively agreed upon and publicly known, including the prescribed uses. The distribution of power is consistent with Indigenous knowledge that has been deconcentrated and fragmented without a leader, authority, or special group knowing it all (Sillitoe 1998). However, soil conservation policies may improve its implementation and legitimacy by incorporating soil knowledge from both Indigenous and local communities (Zimmerer 1994; Sillitoe 1998; Johnson et al 2021). Such incorporation may be facilitated by the Bolivian constitution's recognition (since 2009) of ancestral knowledge as the country's heritage and, more specifically, for the inclusion of this knowledge in the 2021 Law of Conservation and Sustainable Management of Soils. Further, fully recognizing multiple soil knowledges is crucial for soil knowledge coproduction to address challenges like degradation and erosion.

Aymara homogenous zones demonstrate a kaleidoscopic and polysemic system of spatial organization of their territory. The system results from knowledge coproduction as it uses the 4 research principles of such knowledge (Norström et al 2020): (1) It is context based as the zones reflect specific socioenvironmental conditions of the communities. (2) It is plural because the collective nature underlies the definition and description of the homogenous zones. (3) The characteristics of the zones include description and prescription, which relate to the community's expectations and goals for that part of the territory. (4) The collective work is iterative, leading to adjustments in the descriptions of the zones as community expectations and environmental conditions change in the territory. As coproduced knowledge, Aymara Indigenous soil knowledge might be an ideal candidate for the inclusion of knowledge from stakeholders, such as Western scientists, practitioners, and policymakers.

Despite the potential benefits of soil knowledge coproduction, there are challenges. Although in the last decades Indigenous knowledge has gained legitimacy in Bolivia at the constitutional level, the interactions with non-Indigenous knowledge at the community and local levels have delivered heterogeneous outcomes. Unequal power relations, top-down technoscientific approaches, and divergent agendas hinder the linking of Western soil science and other knowledge systems. Our findings may contribute to bridging the divide by identifying holders of Indigenous knowledge who can work in coproducing soil knowledge. Aymara knowledge of soils has a fine spatial resolution, which complements the larger scale of global soils classifications.

The use of multiple parameters confirms Aymara farmers' deep experience-based soil knowledge (Zimmerer 1994; WinklerPrins and Barrera-Bassols 2004). The heterogeneity of parameters, however, might indicate the lack of hierarchy for organizing soils in the way that soil science does and might constitute a gap between the 2 types of knowledge. The parameters used to describe homogenous zones appears to be of *communicative utility*, whereby the aim is to provide useful information for community members. Moreover, the needs addressed by using this knowledge are potential research topics to be shared with Western scientists and practitioners. In doing so, these topics may become foundational components of a research agenda for knowledge coproduction. While understanding the service-oriented nature of this soil classification offers a great opportunity for bridging this gap, coproduction of soil knowledge might require flexible scientific soil categories to include community-defined useful information. Furthermore, hybrid categories (ie Indigenous–scientific) linking knowledge systems might be fundamental for coproduction of soil knowledge.

Knowledge coproduction faces challenges that result from the convergence of different knowledge systems, multicultural tensions, and country-to-local dynamics. Our case greatly benefited from a participatory approach and the long-term local work of an NGO. The NGO PROSUCO aligned their work with requests from the communities and mediated between technicians and Indigenous peoples, illustrating the potential contribution of practitioners for knowledge coproduction.

Conclusion

Indigenous Aymara spatially organize and make sense of their territory by creating distinctive areas called homogenous zones without a hierarchical classification and based upon heterogeneous parameters. The Aymara soil knowledge system uses categories both polysemic and kaleidoscopic; they have multiple meanings, and each meaning leads to a distinct domain characterizing the zone. A classification lacking hierarchy and systematic parameters challenges a linkage with soil science. However, since homogenous zones seem to result from knowledge coproduction, the zones may offer fertile terrain for involving Western scientists, policymakers, and other stakeholders in a broader coproduction toward sustainable soils.

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MOUNTAINVIEWS IN THIS FOCUS ISSUE

Papers in the MountainViews section of this focus issue present Indigenous knowledge, local knowledge, or place-based perspectives. They were assessed by a Peer Advisory Circle formed by the Guest Editors of this issue and an Associate Editor of MRD.

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