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Authors: López-Sandoval, María, and Maldonado, Paola

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Change, Collective Action, and Cultural Resilience in *Páramo* Management in Ecuador

María López-Sandoval[1]* and Paola Maldonado[2]

** Corresponding author: maflopez@flacso.edu.ec, https://orcid.org/0000-0002-3234-4276*

[1] Departamento Desarrollo Ambiente y Territorio, FLACSO-Ecuador; Calle La Pradera E7-174 y Av. Diego de Almagro, 170518, Quito, Ecuador
[2] Fundación ALDEA, Asturias N24-02 y Gonzalo de Vera, 170408, Quito, Ecuador

This study examines how agricultural frontier expansion and grazing practices develop in the páramos *under communal tenure in the northern Ecuadorian Andes and how rules to control them emerge within communal governance. We approach these questions through the lens of collective action and cultural resilience, to understand the evolution of communal governance. We analyze a case study of the Comité de Páramo Ñukanchik Urku, a multicommunal organization created in the 1990s for collective resource management. We use the analytical framework of social–ecological systems (SES) to approach changes of the agricultural frontiers and grazing activities as conservation outcomes resulting from changes in resource units, actors, and governance structures. Through a mixed-method approach combining air photo analysis (years 1956, 1993, and 2008) and qualitative research, we examine spatial patterns of settlement and agricultural frontier expansion, historical grazing practices, and the main elements of current collective* páramo *management. Our results indicate that: (1) the demarcation of an agreed agricultural frontier as a territorial landmark is a response aiming to control the increase of crops and dwellings at higher elevations, and to limit grazing activities; (2) the authority's legitimation of the Committee and its Board is crucial to develop rules and to enforce them; and (3) legitimation is achieved through conservation knowledge and autonomous decisions to control* páramos *considered a communal territory. A broader comprehension of the context and history of cultural change is needed to understand the emergence of communal governance of* páramos. *Cultural-political dimensions are key to the cultural resilience of social systems in SES and to strengthening rules and institutional diversity to manage the commons in Andean communities.*

Keywords: páramos*; cultural resilience; social–ecological systems; collective resource management, communal governance; Ecuador; Andes.*

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Introduction

Páramos are the mountain grasslands of the humid tropical Andes. They extend from northern Peru to Venezuela, at elevations between ca 3200 and 4700 m. They host high levels of biodiversity and endemism (Luteyn 1992) and fulfill key hydrological functions, while having a significant capacity to store soil carbon (Buytaert et al 2007; Chimner and Karberg 2008). Water provision for both consumption and irrigation in the highly populated and urbanized Andes region of Ecuador and Colombia strongly depends on the *páramos* (Buytaert and De Bièvre 2012). Conversion to agricultural uses, overgrazing, burning, and reforestation with exotic species are, however, significantly affecting the distribution and provision of ecosystem services (Farley et al 2004; Balthazar et al 2015). Ecuadorian and Colombian environmental legislation declares the *páramos* a fragile but strategic ecosystem for water production (MMAC 2002; PND 2017). Conservation instruments, such as water funds, protection of specific areas, and financial incentives, are being deployed by the governments to stimulate behavioral change, especially among peasant and indigenous communities (Bremer et al 2014; Hayes et al 2015).

In Ecuador, the *páramos* are the only areas in the high Andean mountains where communal land ownership exists alongside other forms of public tenure (eg protected areas) and large private land holdings (Medina and Mena-Vásconez 2001). The estimated surface area of the *páramos* in 2009 was 1.3 million ha, around 5% of the country's area (Beltrán et al 2009), and was mostly under communal tenancy. The Comité de Páramo Ñukanchik Urku (CPÑU) is a multicommunal self-governed organization that manages ca 4380 ha of *páramo* in northern Ecuador. It has developed rules for collective resource management, while maintaining a high level of autonomy from governmental conservation initiatives. As is the case with other *páramo* communities today, CPÑU must develop or strengthen its rules and institutions to ensure long-term water supply and adequate social organization to support it (Boelens et al 2014; Hayes et al 2015).

In light of this, the present article addresses 2 research questions: (1) How have agricultural frontier expansion and grazing practices developed in the social–ecological system (SES) of Ñukanchik Urku? (2) How did current rules to control agricultural expansion and overgrazing emerge within communal governance? To answer these questions, we

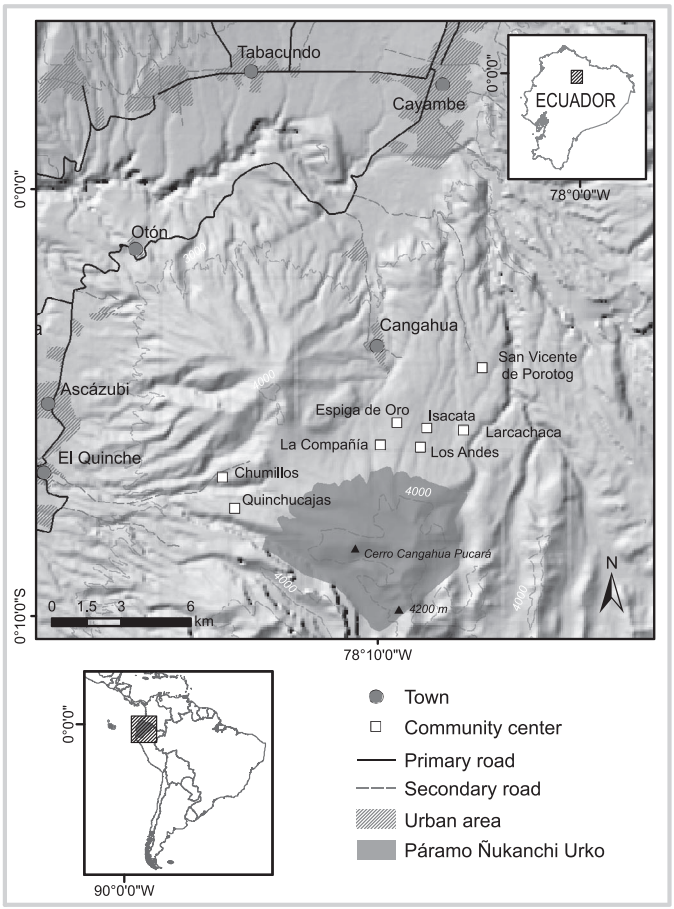
use the analytical SES framework developed by McGinnis and Ostrom (2014). First, we examine the evolution of the SES and land use outcomes (eg agricultural frontier and grazing practices) over 60 years. We consider change in social, economic, and political contexts, its influence under the conservation conditions of the *páramos* as a resource system, evolution of resource units demanded by users, and their interactions in a long-term retrospective. Second, we analyze the emergence and enforcement of current rules to control overgrazing and crop expansion in recent communal governance structures. To do so, we use 2 theoretical lenses: (1) We understand the emergence of rules and institutions as a means to overcome the conditions of congestion and overuse involved in the use of common-pool resources (Hardin 1968; Ostrom 1990; Ostrom et al 1994). We thus focus on institutional change as the foundation for successful commons governance (Dietz et al 2003). (2) We rely on the normative dimension of cultural resilience, "the ability to maintain livelihoods that satisfy both material and moral (normative) needs in the face of major stresses and shocks" (Crane 2010), as a condition to achieve long-term support for communal *páramo* management. According to the categories developed by Baland and Platteau (1999), the CPÑU's collective management operates with social regulation, where a local authority is charged with laying down and enforcing rules. The governing structure of CPÑU follows that of the Ecuadorian Andean *comunas*, where the *cabildo*, the main decision-making body, is generally directly accountable to the communal assembly (Korovkin 2001).

This study thus contributes to the discussion about contexts that motivate mountain communities to develop their own institutional arrangements to collectively manage natural resources (Baland and Platteau 1999; Dietz et al 2003; Hayes et al 2017). It acknowledges the importance of approaching institutional diversity as an evolutionary process (Becker and Ostrom 1995) to strengthen social organization. It also provides arguments for the importance of the cultural and political dimensions of those arrangements, in the context of the Andean commons.

Study area and methods

Páramo Ñukanchik Urku (PÑU), or "Our Mountain" in English, is located in Cangahua parish, in the buffer zone of Cayambe-Coca National Park, which was created in 1979 (Figure 1). The area is about 70 km northeast of Ecuador's capital, Quito, and a 30-minute drive to the city of Cayambe. It extends from ca 3700 m up to 4218 m (the highest point is on Mount Cangahua-Pucará). This herbaceous *páramo* hosts valuable fodder species (eg *Stipa*, *Calamagrostis*, *Festuca*, *Poa*), while a few remnants of humid montane scrub and bush are located in gulches. Up to an elevation of 3400 m, intensive soil erosion has occurred; above that, more intense agriculture is practiced because of the availability of fertile soils and irrigation. The lower areas of the valley, up to ca 2800 m in elevation, are densely covered with greenhouses of export-oriented flower plantations, while small-scale farming dominates at elevations above 3200 m. Local residents, mostly indigenous, are organized in *comunas* and associations that were legally recognized in the 1970s through early 1990s after Ecuador's Agrarian Reforms came into force (in 1964 and 1973). These communities are

FIGURE 1 Study area and locations of field work conducted in 2015. (Source: IGM map ñIII-B2-Cangahua-3993-1; design P. Maldonado, M. López-Sandoval 2019)



politically ascribed to the Government of the Kayambis Indigenous Peoples.

Since *hacienda* times, communities using PÑU lands have practiced agro-pastoralism based on the family farming model. They collectively use grazing areas, and functionally keep livestock as a capital reserve and for manure production (López-Sandoval 2004). Crop rotation (eg potato–Andean tubers–barley–beans–pasture) is typical of the agricultural frontier in the *páramos*. Bunching onion is the most important cash crop for families living at the lower limit of the PÑU. Rain-fed farming is practiced in areas above the main irrigation canal (ca 3700 m). Up to the mid-1990s livestock was key to subsistence livelihoods, and as a result the *páramo* was used exclusively for grazing. Since the 1980s, many household economies have become dependent on off-farm employment, mainly in the flower agribusiness sector (Knapp 2017). The CPÑU was created in 1995, as an intercommunitarian initiative to manage the *páramo* to improve water availability for both irrigation and consumption.

This analysis is part of broader land use and land-cover–change research carried out in 2015–2016 in two sites of the northern Ecuadorian Andes and the continuation of a study conducted between 2000 and 2002 (López-Sandoval 2004). For the present analysis, we used a mixed-methods approach. We evaluated changes in the agricultural frontier through a multitemporal analysis of air photos (IGM, 1:60,000 scale, years 1956, 1993, 2008). We considered the years in which

agrarian reforms came into force and corresponding photo availability. After orthorectification, a visual analysis was conducted to identify recent and historical locations of the agricultural frontiers, dwellings, and changes in land fragmentation. Following the analytical framework of López-Sandoval (2004) for air photo analysis, we contrasted a temporal with a permanent agricultural frontier. The temporal agricultural frontier refers to the elevational limit of agricultural plots that are under long-fallow cultivation systems (Sarmiento 2000). The permanent agricultural frontier is the limit of permanent crops and dwellings, which extend from lower elevations into the *páramos* as fixed permanent parcels. In addition, for 2008, we defined an agreed agricultural frontier as an institutionalized landmark in an area of communal *páramo* management.

We conducted qualitative research through semistructured interviews, a narrative drive and walk, and group interviews. Participants were randomly selected according to the group they belong to; groups included (1) members of the CPÑU, including local guides ($N = 3$), settler-users ($N = 11$, 1 group interview), *urkukamas* ($N = 4$, 1 group interview), and local historians ($N = 2$), and (2) external experts ($N = 5$). We also drew from 2 life histories of the local historians (age 65 and 71), who were also former community leaders. These life histories were recorded as part of previous research in 2000 (López-Sandoval 2004) to recall the history of *páramo* use in the *hacienda* system and, specifically after the agrarian reforms, of access to land in the *páramo* and the expansion of agriculture. Given the limited narratives used for this analysis, we supported interpretations with literature review. We analyzed and coded $N = 18$ transcripts. We used thematic analysis (Flick 2009) to identify codes and categories, which resulted in 4 thematic domains. The first 2, "historical grazing practices" and "communal rules and management in the CPÑU," were analyzed to recall the historical governance and land use change since *hacienda* times up to the establishment of CPÑU. The further thematic domains "conservation knowledge" on water and *páramo* and "authority" for water and territorial rights were the basis for the analysis of drivers of rule emergence and conditions required to support rule enforcement. We organized and synthetized other narrative information to provide a deeper understanding of codes and categories (Appendix S1, Supplemental material, https://doi.org/10.1659/MRD-JOURNAL-D-19-00007.1.S1).

Results

Evolution of the socioecological system and land use change

During the 60-year observation period, PÑU's SES has evolved with changing social, economic, and political contexts (Figure 2). Agrarian reforms, the effects of overgrazing, and the strengthened political organization of the community significantly influenced the feedback loops between SES elements and outcomes of *páramo* conservation. Changes in, for example, grazing areas in the *hacienda* system, land for cultivation and residential uses after the agrarian reforms, and the use of water for drinking and irrigation also affected the evolution of governance arrangements. Among the actors historically involved in the SES (eg landowners, *hacienda* workers, state, and nongovernmental organizations [NGOs]) today, communities, water boards, and the CPÑU are the most central to SES communal governance, which indicates an evolution of the system.

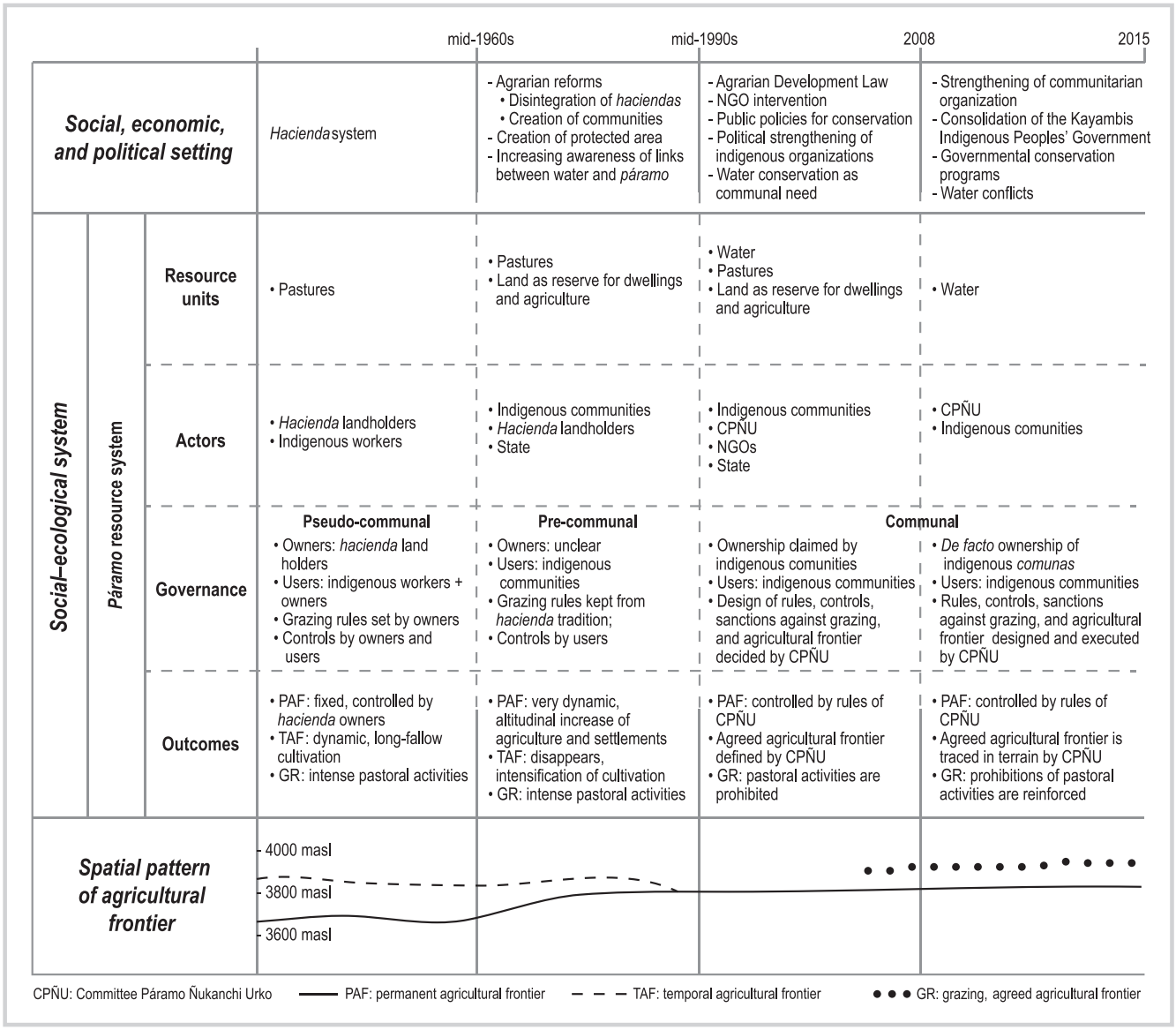
Our historical analysis shows how the outcomes of the SES are a result of evolution of the agricultural frontier and grazing practices, as well as of a changed context of governance fundamentally influenced by agrarian reforms. Pseudo-communal governance evolved over time starting with the *hacienda* up to the agrarian reforms. The users, the *hacienda* workers and landowners, shared pastoral practices, but rules for use and control of the pastures as the main resource unit of *páramo* were set by the landowners. As identified in the thematic analysis, historical grazing practices were institutionalized by the *hacienda* system. Permanent grazing (eg for fattening bulls or dry cows) at higher elevations enabled indigenous workers to access *hacienda* pastures by including their animals in the landowner's herds. Through the daily and vertical displacement of herds, letting them graze in the lower grasslands close to the agricultural frontier, SES users took advantage of the *hacienda*'s *páramos* for fodder, manure production, and fertilization. Hence, shared pastoral practices, for example, a shift in herding labor by mountain guards (*urkukamas*), cattle round ups (*rodeos*), or group herding by children, converted the *páramos* into "land of communal use" (Ibarra and Ospina 1994: 83). Although rules for checks and sanctions were defined by owners, all users of *páramos* reinforced the idea of communal tenure through grazing activities, as supported by literature on *hacienda* functioning (de la Torre 1980; Borchart de Moreno 1989).

After the *hacienda* was dissolved in the 1970s and 1980s, indigenous workers strengthened communal organization up to the mid-1990s, focusing on the reinforcement of the political structures of the community, to acquire agricultural land and to regulate land partitions among community members (Barsky 1984; Martínez 2016). In this period, the *páramos* were under precommunal governance. Grazing practices were replicated from the *hacienda*, but no organized body steered communitarian forms of collective management of the *páramos*. A settler-user from Isacata said: "It was clear to us: what the *hacienda* did for years was what we thought we had to do as well: to use [the *páramo*] for animals and burnings." Despite arrangements about grazing locations between each of the adjoining communities of the CPÑU, no regulations on issues such as the amount of livestock, rotations, or calendars were established among community members.

As a result, grazing in the *páramos* increased dramatically, as did burning. Up to the mid-1990s, local narratives around grazing practices emphasized problems related to the high number of animals in the *páramos*. One member of the CPÑU Board mentioned: "The problem was the same everywhere: before, animals used to be free in all of the *páramo*, every community took its animals there: sheep, pigs. Cattle in the upper part would be grazed in the swamps; the water only consisted of drops."

Burning and overgrazing became a major concern for local communities, in light of a higher demand for water and changes in livelihood structures. In addition, the intervention of other actors, such as local environmental NGOs, became a key factor in the development of communal governance structures that were based on interactions of the CPÑU, water boards, communities, and community members, as we analyze later.

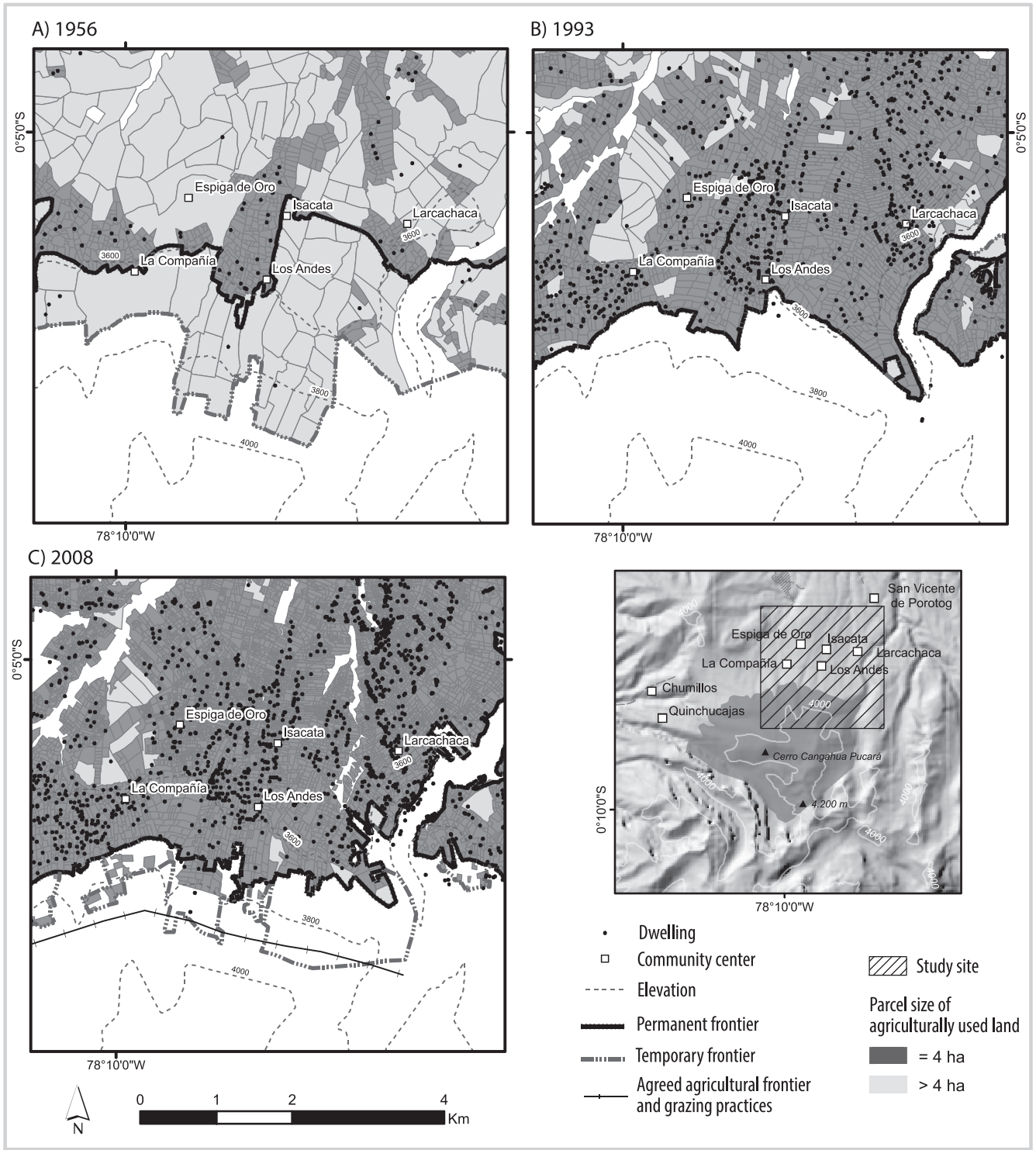
FIGURE 2 Evolution of the social–ecological system of Páramo Ñukanchik Urku and land use changes. (Source: Field work 2015, design D. Carvajal, M. López-Sandoval 2019)



These changes in the elements that structure the SES of Ñukanchik Urku influenced its land use changes, particularly those in the agricultural frontier (Figure 3). Aerial photos of the study area from 1956—before the first agrarian reform of 1964—show the location and structure of the settlements of land workers (*huasipungueros*) living in *hacienda* territory, with dwellings ($N = 81$) located on small agricultural plots (Figure 3A). With time, some of these settlements became the centers of communities (eg in the case of La Compañía, Los Andes, Larcachaca, Espiga de Oro, and Isacata centers). The highest elevation of the temporal agricultural frontier of cereal production was at ca 3900 m, while the permanent frontier of agriculture and dwellings was located at ca 3600 m. The increase of dwellings to $N = 815$ by 1993 is particularly notable (Figure 3B), as well as the disappearance of the temporal agricultural frontier. While long-fallow cultivation plots were not observed in that year, permanent crops developed intensively at elevations between 3400 and 3700 m. This indicates the replacement of traditional, long-fallow agriculture by more intense, permanent cultivation. The expansion of the permanent agricultural frontier corresponds to increasing peasant occupations of land, which first took place in former *haciendas* and afterward swiftly expanded vertically to the higher *páramos*. As a result, between 1956 and 1993 the elevation of the permanent agricultural frontier and of settlements expanded by an average of ca 150 m (up to ca 3750 m).

This spatial evidence shows that *páramo*, besides being a pasture zone, became a land reserve to satisfy needs for housing and cultivation after the agrarian reforms. The expansion of the permanent agricultural frontier observed in the past 4 decades needed to be controlled to avoid its further rise. This explains the establishment of an agreed agricultural frontier, which became a landmark in 2013 to control grazing and the expansion of crops. Figure 3C shows the limits of permanent agriculture and the agreed

FIGURE 3 Change in the agricultural and settlement frontiers 1956–2008. (Source: IGM map ñIII-B2-Cangahua-3993-1; air photos, scale 1:60,000; years 1956, 1993, 2008; fieldwork 2015; design P. Maldonado, M. López-Sandoval 2019)



agricultural frontier in 2008; despite the growth of isolated plots of permanent agriculture up to an elevation of 3820 m, the agreed agricultural frontier was demarcated as a straight line fluctuating between 3600 and 3900 m. Dwellings increased in the observed area to $N = 1529$, indicating a much higher population density in the agricultural zone bordering the *páramo*. All these land use changes, though, took place below the agreed agricultural frontier, which suggests a certain degree of effectiveness of the rules that had evolved since the late 1990s. As analyzed in the following section, communal governance developed around the environmental need for water protection, in the form of the creation of robust norms and rules for collective *páramos* management.

Institutions for *páramo* management in current communal governance

In a broader historical context, communal governance of CPÑU was achieved relatively recently. Qualitative analysis found that current rules for *páramo* management in Ñukanchik Urku have resulted in the creation of 3 institutions: (1) the CPÑU and its Board, (2) the agreed agricultural frontier, and (3) rules to control grazing and crop expansion. The CPÑU was created in 1995 and is currently supported by 15 organizations: 7 adjoining and 2 beneficiary communities and 6 water boards. The general assemblies of the CPÑU are attended by around 2500 people on average, while the Board has around 35 members, including a president, vice president, treasurer, and secretary. In addition, each organization has a representative and an *urkukama*. Although the committee has no legal registration, local organizations and public institutions working in the area (other indigenous political organizations, local water boards, communities, NGOs, and governmental institutions) recognize and acknowledge its role, especially regarding the development and enforcement of rules and political coordination. The legitimacy of the committee ultimately relies on the broad recognition of its authority by communities and, particularly, by the water boards. As mentioned by a former leader of the CPÑU: "The situation in Cangahua is highly complex because 7 or 8 communities are owners of the *páramos*, but through the water boards, for example, in Guanguilqui, between 45 and 48 communities are water beneficiaries. There is a lot of pressure on water use."

The agreed agricultural frontier line (*frontera agrícola*) constitutes a further institutionalization of collective management. Testimonies concur that carrying through the strongly contested decision to eliminate all pastoral activities above this line was the main innovation introduced by the CPÑU. This process was supported by the work of a local NGO, Instituto de Ecología y Desarrollo para las Comunidades Andinas (IEDECA). In 2000, the CPÑU Board, community leaders, and tenants of land located in the frontier area started a process of complex negotiations, to finally define the agricultural frontier as a straight line between 3600 and 3900 m. Up to this line, CPÑU would permit agriculture, house construction, and animal keeping or grazing. The agreed agricultural frontier was materially demarcated with a ditch where *Polylepis* trees were planted in 2013. In the area below the agreed agricultural frontier, there has been a progressive increase in agricultural plots and grazing activities at varying rates, according to individual and communitarian needs. Rules are applied above this line.

The rules crafted by the CPÑU were developed to restrict land use change and grazing, to monitor restrictions and *páramo* conservation, and to sanction rule violations. Regarding restrictions, the main rule is to not surpass the agreed agricultural frontier, with crops, animals, or burning. Monitoring is carried out largely through (1) walks along the agreed agricultural frontier by *urkukamas*, who record rule-breaking, and whose role is set by CPÑU assemblies, and (2) through *mingas*, collective visits to the upper zones of the *páramo* to observe vegetation conditions or to maintain canals or other water infrastructure. Sanctions consist of expensive fines, the confiscation of animals, and, sometimes, the application of indigenous justice.

Drivers for rule development and compliance

Conservation knowledge: The qualitative analysis of how rules for collective management emerged pinpoints that environmental knowledge about the relationship between water and *páramo* boosted institutional change and rule development. Informants of the 2 groups (CPÑU leaders and settler-users) agreed that the radical decision to stop agricultural expansion and grazing was needed to protect the *páramos* and allow water sources to recover. However, this currently agreed statement was shaped through negotiations, influenced by both local and expert knowledge, demands of water users, and diversification of domestic economies. The first CPÑU leaders were aware of the environmental links between *páramos* vegetation, water availability, burning, and trampling. They asked IEDECA for assistance with environmental education to convince people to support the decision to move animals down and stop agriculture in the *páramos*. As an NGO expert stated: "I remember in 2000, in an assembly they set the goal to totally eliminate animals within 5 years. When I heard that, I thought 'these guys [*estos compañeros*] are crazy, they won't make it.' We just wanted to help change pastoral practices." Actually, the intervention of this NGO, which had previously carried out successful pioneer work on communitarian irrigation systems linked to *páramo* conservation in the region, became crucial to spreading conservation knowledge about the relationship between *páramo* and water.

Through environmental education activities, such as meetings, training, and field trips, users of PÑU became more aware of the importance of *páramo* vegetation. Testimony of IEDECA staff included the following:

> *At the beginning only communal and water board leaders agreed to take animals down. Users insisted they must have at least a few animals. Environmental education was needed to enhance* [understanding of] páramo *importance. Through that, people were convinced. We took them to other places: we took them to successful experiences in Ambato, but also to Chimborazo and Carihuayrazo where water problems and overgrazing were dramatic, with no water in sight.*

In addition, pressure increased on the communities just outside the PÑU who claimed tenancy rights. This pressure came from various water users directly, as well as indirectly through the water boards. For instance, the Guanguilquí and Porotog irrigation systems, members of CPÑU, mobilized at least 2000 families around issues of water provision (Hoogesteger 2013).

Authority for water and territory: We identify the thematic domain "authority for water and territorial rights" as the factor that most effectively supports rule enforcement. The CPÑU's collective management operates with social regulation (Baland and Platteau 1999). The board lays down and enforces rules; however, this requires the authority's legitimation and investment to initiate the regulatory tasks. Testimonies of *páramo* users indicate that although not all individuals in the area approved of the grazing prohibition, CPÑU's control and the authority of its Board were broadly acknowledged, partly because its election follows a similar process as those of a communal *cabildo*, through designation of CPÑU's general assembly. For some users, however, the

rules and ways to shape normative behavior through rigid sanctioning mechanisms were perceived as excessive and unfair. Feelings of deprivation of the benefits of keeping animals in the grasslands were mentioned. These contested positions point to an impact of greater inequality between members, especially regarding the possibility of undertaking successful collective action (Baland and Platteau 1999). In other words, it is expected that better endowed participants will more easily contribute and cooperate. Hence, some users mentioned the need for at least monetary compensation or for rule modification.

According to our qualitative analysis, communitarian autonomy and territorial self-determination were further factors that contributed to the legitimization of CPÑU's authority. Communal CPÑU leaders and external experts underlined the importance of the autonomy of the community, as a sign located at the lower limit of the agricultural frontier indicates: "Comité de Páramo Ñukanchik Urku. With much effort we have recovered the vegetation to maintain our water sources; an achievement obtained through community organization."

The unwillingness of the CPÑU Board to get a legal status or to participate in conservation payment programs such as SocioPáramo reflect their political conviction that the outcomes of current collective *páramo* management should remain solely with the community. An *urkukama* explained: "In other places, foundations have now introduced contracts to take care of the *páramo* in exchange for money, but with conditions. We have not accepted this; where would all what we have done go? We have been working on this for 20 years. If someone wants to help, this is very welcome, but without conditions."

Board members justify these actions to control the *páramo* by referring to the need for self-determination over its territory, recalling the International Labour Organization Convention 169, which recognizes "the ancestral territories of indigenous communities." In the words of a former CPÑU leader: "This *páramo* is our territory; it is not owned by *haciendas* or the state, or the ministries. We have made great efforts to convince everyone to take care of the *páramo* because it is ours."

As pointed out by 2 external experts, the assistance of the Government of the Kayambis Indigenous Peoples has been important to generate a political discourse around *páramo* management, water conservation, and customary rights as forms of territorial self-determination. The recognition of the authority of the CPÑU Board as legitimate tenants of the *páramo* is reinforced through written regulations (*reglamento)* about the functions and structure of the committee and—most importantly—the rules to control *páramo* use. This recognition has strengthened their capacity to collectively and normatively steer conservation outcomes.

We acknowledge that these drivers of rule development are contextualized in main changes of livelihood strategies that indicate less pressure over agriculture. Although not specifically addressed in this study, other research (Gasselin 2000; Martínez 2009; Knapp 2017) and narratives collected in the fieldwork suggest that domestic income diversification is important for the prioritization of water conservation in the *páramo*. Wage labor in flower plantations and bunching crop cultivation were repeatedly mentioned in the interviews when asked about domestic income composition. The short distances between dwellings at the lower limit of the *páramo* and flower plantations as well as improved roads now facilitate daily commutes to work in the plantations. As can be seen in the aerial photo analysis, the increase of dwellings in the lower limit of the *páramo* suggests higher demands for drinking water.

Discussion and conclusion

The goal of this study was to analyze how rules to control agricultural expansion and overgrazing have emerged and are enforced as a result of the evolution of communal governance in the SES of PÑU. We found that, in the past 60 years, land use change involved the retreat of traditional long-fallow cultivation and the vertical expansion of permanent agriculture and of settlements, while overgrazing resulted from a lack of robust communal regulations. Collective *páramo* management is a recent phenomenon in the PÑU that responds to a strong demand for water in the past 3 decades and to an increasing demand by local communities for their territorial rights. These findings concur with studies that show that communal regulations for *páramo* conservation have not taken place until in the past decade (Hayes et al 2017), mostly in the context of the development of collaborative multi-stakeholder models (Iñiguez Gallardo et al 2013) and the recognition of the political agency of water-user movements (Boelens et al 2016).

Although less pressure over agricultural and grazing lands in the *páramos* is related to changes in livelihood strategies, we found that knowledge of *páramo* conservation, historical land use changes, and recognition of the community authority enforcing water and territorial rights boosted the emergence of collective management rules. In our study, increased conservation knowledge (Berkes and Turner 2006), strongly supported by NGOs, became key to the development and the enforcement of rules. This knowledge in turn was crucial in the discourse of leaders to legitimize the authority of the CPÑU-Board and helped to deal with user resistance to rule compliance. As suggested by Boelens and Seeman (2014), legitimacy and authority are often invoked through claims on knowledge. In CPÑU, this has influenced the view of positive outcomes of *páramo* management as being "autonomous" and "communitarian." Given that *páramo* management occurs under social regulation, in light of the political structure of the Andean *comunas*, the authority's work is fundamental to the coordination and the initiation of processes of collective action (Baland and Platteau 1999).

The political aspect of collective water management is hotly debated in the Andes, from a political-ecological perspective and in relation to the concept of hydro-social or water territories (Hoogesteger 2013; Boelens et al. 2016). These refer to spaces conceived as social–environmental and political relationships, which constitute home bases in terms of cultural belonging and socio-productivity for indigenous or peasant livelihoods and for the construction of a political community (Boelens et al 2014). Our analysis incorporates the cultural/political and territorial dimensions of collective *páramo* management from the perspective of normative cultural resilience, to interpret change in the social subsystems in the PÑU. Resilience is considered central to the evolution of an SES (Folke et al 2016). However, there is a

strong critique to the approach of analyzing cultural resilience through concepts of ecosystem resilience (Cote and Nightingale 2012), pointing at a failure to consider the capacity of systems to absorb disturbances or to retain essential functions under stressors (Walker et al 2004).

Crane (2010) views cultural resilience as subjective and cultural processes that are needed to maintain the SES as a space that contextualizes and constitutes life experiences. In this sense, our analysis shows that SES outcomes, for example, control of land use changes and grazing, result from a long-term environmental and cultural/political evolution. Hence, SES resilience is not just an adaptation of the social system to recover the ecological system's functionality, but rather a milestone of wider historical change where communal management of *páramo* is a means of territorial control and of communal authority's legitimation. Current communal governance in the CPÑU is an outcome of cultural resilience as it responds to both an environmental concern and a normative cultural process. Rules and institutions are also a means of exerting territorial rights. Hence, landmarks as the agreed agricultural frontier are not only an expression of spatial control and territoriality (Sack 1983) of the CPÑU, but also the material representation of long-term, autonomous, and communitarian action for territorial self-determination. These elements have until now contributed to cultural resilience in PÑU. However, this study is limited to the analysis of the diversity of positions on rule enforcement and authority recognition among the diverse groups of users involved in the CPÑU. A deeper analysis of social and economic inequality among community members is needed to assess possible threats to the resilience of the SES.

We conclude that there is a need to understand the broader context of cultural change and resilience that motivates communities to overcome challenges of collective management. The focus of the analysis of communal management on present situations restricts the understanding of rule development as a response to scarcity and salience (Gibson et al 2007), while ignoring the history of cultural/political transformations that have motivated communities to mobilize. Such motivations must be acknowledged when supporting the strength of rules and institutional diversity to manage the commons, as Andean communities are now acting as the main stewards of water conservation and resistance to extractive models and uses, such as afforestation with exotic species or mining. Cultural and political aspects should be considered in transforming knowledge (Mathez-Stiefel et al 2017) required to maintain the functionality of Andean SES.

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Supplemental material

APPENDIX S1 Questionnaires, participants, thematic analysis of qualitative data.

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