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Water Co-management between public and community actors as a tool for adaptation to Global Climate Change: the case of Santa Clara de San Millán Commune, DM Quito

Cogestión del agua entre actores públicos y comunitarios como herramienta de adaptación al Cambio Climático Global: el caso de la Comuna Santa Clara de San Millán, DM Quito

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Abstract

Water management in rural, urban, and peri-urban communities is a priority topic for human development. In this article, ideas related to the adequate co-management of this resource (between community and public actors) are specified as a tool for adaptation to contemporary scenarios of Global Climate Change. The study area corresponds to a peri-urban zone of Quito. The information was ordered and processed using ATLAS.ti software and a geographic information system; current regulations were ranked through a Kelsen Pyramid. The results generated are divided into three sections that conceptualize the bases for adequate water management, considering management models with a territorial approach and adaptation measures to Climate Change made by co-management actors. This action model generates a consistent tool for managing water resources, as well as other natural resources.

Keywords: Water Co-management, Quito, Santa Clara de San Millán Commune, Climate Change adaptation, legal

regulations, territorial management.

Resumen

La gestión del agua en comunidades rurales, urbanas y periurbanas es un tema prioritario para el desarrollo del ser humano; en el presente artículo se puntualizan ideas relacionadas con la cogestión adecuada de este recurso (entre actores comunitarios y públicos) como una herramienta de adaptación a escenarios contemporáneos de Cambio Climático Global. El área de estudio corresponde a una zona periurbana de Quito. Se ordenó y procesó la información con el software ATLAS.ti y un sistema de información geográfica; la normativa vigente fue jerarquizada a través de una Pirámide de Kelsen. Los resultados generados se dividen en tres apartados que conceptualizan las bases para un adecuado manejo del agua, considerando modelos de gestión con enfoque territorial y medidas de adaptación al Cambio Climático ejecutadas a través de la cogestión entre actores. Este modelo de acción constituye una herramienta consistente para el manejo del recurso agua, así como de otros recursos naturales.

Palabras clave: Cogestión del agua, Quito, Comuna Santa Clara de San Millán, adaptación al Cambio Climático, normativa legal, gestión territorial.

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1 Introduction

Since ancient times, water has been considered a source of life and a sacred symbol for the communities, nationalities, and indigenous peoples of the Andes; however, historically they have been deprived of several rights, including the right to access this resource in conditions of adequate quality and quantity, required for proper human health (Boelens, 2011). If revising history, water has always been an element that has generated confrontations, not only because of the quality of the resource, but also because of the initiatives to establish norms for its use; in Latin America, since colonial times, the most influential groups have been favored. In the republican period, very few or no changes were made; water continued to be monopolized by power groups and influential socio-political people (Granda et al., 2004); even today, water sources continue to be highly coveted by the large companies that provide service in the cities (Gómez, 2009).

In response to these realities, initiatives for co-management of this resource have originated in the Andean zone of Ecuador; one of them the Pesillo Regional Drinking Water Project in Imbabura, in cooperation with the community, state and international actors involved, in which the elements for the co-management of water are: access, availability, project design, financing, implementation and administration (Perugachi and Cachipuendo, 2020); these being the main elements that enable adequate management of the resource.

The main weaknesses of community water systems, generally managed by water and sanitation boards, revolve around the lack of economic resources and technical designs to make their catchment, transportation, purification, and service distribution systems more efficient (Molina et al., 2018).

For Pinos (2020), good water management is part of a healthy urban and rural metabolism, and usually depends on the governance of people involved. Sandoval and Günther (2013) mention that the integral management of water is usually composed of public, social and private actors; while the competence of water regulation is in charge of the environmental control entity, in this country: the Ministry of Environment, Water and Ecological Transition of Ecuador (MAAE).

There are few ancestral communities in the Andean zone of Ecuador that have managed water sources by their own, promoting their management and conservation; one of them, adjacent to the city of Quito, is Santa Clara de San Millán commune (hereinafter referred to simply as Commune or CSCSM) (Pacheco, 2019). It was originally separated from the city and with the passage of time and the consequent population growth of the city, it has been gradually integrated as a peri-urban element.

Changes in land use have caused this Commune to give part of its territory and resources, transforming them into spaces with urban characteristics (Jácome, 2018; Pacheco, 2019). It is worth mentioning that the struggle for water has not been an alien process for the people of this commune; for example, history shows the intervention of organizations outside it, which triggered conflicts over the management of the resource: the first, with Mariana de Jesús citadel in 1936 and the second, with Central University of Ecuador in 1955 (Jácome, 2018).

The Commune currently has an internal water management system for human consumption, which is managed by a group known as the "Water Board of the Santa Clara de San Millán Commune" (Pacheco, 2019). This system and the operation of the Board is based on the Regulations to the Organic Law on Water Resources, Uses and Development of Water (LORHUyA) (Presidencia de la República del Ecuador, 2014), which establishes that the Drinking Water and Sanitation Management Boards (JAAPS) are non-profit community groups whose purpose is to provide public drinking water service in rural or peri-urban areas, where the municipal Autonomous Decentralized Governments (GAD) have not been able to achieve it through their public companies. It should be mentioned that these organizations have administrative, financial, and managerial autonomy to fulfill their functions, which usually include an effective and efficient service for their beneficiaries (Martínez and Abril, 2020).

Likewise, it is worth mentioning that water management is also related to changes in land use that modify the local environment and contribute to increase variability related to Climate Change (Yánez et al., 2011, 2012), one of its negative effects is seen in groundwater that does not reach the usual re-

charge time; therefore, groundwater and nearby surface flows decrease, significantly affecting the availability of the resource (UNESCO, 2015).

In this sense, institutions such as the Intergovernmental Panel on Climate Change (IPCC) promote guidelines to face this change, considering different environmental factors. According to the IPCC (2019), it is essential to maintain a maximum temperature increase below 2 $^{\circ}C$ with respect to pre-industrial levels until 2050. With the current level of greenhouse gas emissions, it is believed that an increase of 1.5 $^{\circ}C$ will be reached in the period 2030-2052; not exceeding this limit must be one of society's short-term objectives. Failure to achieve this goal would generate a scenario that could endanger life as we know it on the planet.

Because of this, it is important to create strategies at the local level that enable adaptation and at the same time contribute to mitigating the effects of climate change, through responsible water use, in which the environmental, economic, and social components are combined (Gallo and Jiménez, 2019; MAE, 2017). Water co-management involves the participation of all stakeholders and requires a multi-criteria analysis to maintain a sustainable and efficient system (Rivera, 2016); in addition, it should be considered that water is a main element for food sovereignty and economic development.

The aim of this research is to propose a management alternative in which ideas are harmonized around the appropriate co-management of water (between community and public actors) as a tool to adapt to contemporary scenarios of Global Climate Change.

2 Materials and Methods

2.1 Area of study

Gómez (2009) mentions that Santa Clara de San Millán Commune can be considered an ancestral commune, with direct descendants of the "Quitu-Cara" indigenous ethnic group. However, it was barely recognized as a social organization with territorial autonomy in 1911; currently, the Municipality of the Metropolitan District of Quito (Consejo Metropolitano de Quito, 2014) establishes that it is recognized as a Commune with its respective legal and government autonomy, known as Cabildo.

Geographically, the Commune is located to the west of Quito, Ecuador (Figure 1), on one of the slopes of the Pichincha volcano, in an altitudinal range between 2800 to 3250 masl, with an average temperature of 12 $^{\circ}C$ and an average annual precipitation of 1488.2 mm (INAMHI, 2017).

The ecosystems in the surroundings of the Commune include a eucalyptus forest (*Eucalyptus globulus* Labill.) and shrubby paramo in higher areas (with vegetation corresponding to the genera: *Baccharis, Monnina, Chuquiraga, Puya, Cortaderia, Oreopanax, Gynoxis, Diplostephium, Monticalia,* among others) and paramo brush (mainly *Calamagrostis, Festuca, Castilleja, Azorella, Hypochaeris, Valeriana, Gentiana, Stellaria, Bartsia*), in which two water sources are located, which are managed and used for human consumption by the Commune Board (Pacheco, 2019).

By 2010, this commune had a population of 10287 inhabitants (INEC, 2010); its main economic activity constitutes commerce, especially in the lower zone; the economic-productive dynamics changes in the upper zone, observing the development of agricultural activities mainly destined for self-consumption (Pacheco, 2019).

2.2 Methodology

The field information and mainly the bibliographic information was organized in ATLAS.ti version 7 (https://atlasti.com/). This program made it possible to generate semantic networks for each subtopic of interest. In the case of maps and other geographic information, ArcGis ArcMap version 10.4.1 was used (https://desktop.arcgis.com/es/arcmap/). For the characterization of the Commune and its JAAPS, the information proposed by Pacheco (2019) was used, who mentions a technical-participatory methodological model, in which most of the information is collected by applying a Community Participatory Diagnosis, using techniques such as: talking maps, surveys and interviews, construction of historical timelines, SWOT matrix.

Figure 1. Aerial photography and referential maps of the location of Santa Clara de San Millán Commune.

Regarding the construction of the legal content, it was generated from the analysis of the legal regulations in force in Ecuador regarding water management, including the competencies of each key actor; the order determined by the Kelsen Pyramid (Muñóz, 2017) was applied as a legal hierarchy instrument. The issue of adaptation to Climate Change was addressed under the ecosystemic approach proposed by Yánez et al. (2012) for the Metropolitan District of Quito.

To generate the water co-management proposal, the recommendations of the Fund for Water Protection (FONAG, 2020) were followed, which include, among other actions: describing the current state of the resource and establishing short-term goals based on lines of action such as the generation of hydroclimatic and water quality data, characterization of participation, strengthening governance, restoration of degraded areas, management of conservation areas, training activities and environmental education.

The proposals of Perugachi and Cachipuendo (2020) were also considered, who mention that to manage water it is important to establish a commonwealth, i.e., cooperation between public administration and communities, and not only attend to a technocratic and centralist view. Therefore, community participation in the co-management of water resources, the creation and/or strengthening of grassroots social organizations, the analysis of organizational capacity, the description of endogenous and exogenous factors that could weaken community management, the combination of technical and community knowledge, as well as the increase of governance and governability were considered.

3 Results and Discussion

3.1 Legal basis as an instrument for proper water management in Ecuador

The management and handling of water resources has always been a controversial issue; in Ecuador, the first approach that proposed access to drinking

water as a right for people's health occurred in the Political Constitution of Ecuador in 1998 (Martínez and Abril, 2020). The Constituent Assembly of Montecristi (2007-2008) began with a discourse of rights, not only of people but also of the environment, establishing the protection and treatment of water resources as a significant element; this environmental approach was confronted with the classic discourse of exploitation (oriented primarily to the present needs) without guidelines for real sustainability. Despite this, Ecuadorians approved the 2008 Constitution of the Republic of Ecuador, establishing the bases to prevent the privatization of water and to promote its adequate management with a multidisciplinary approach of various actors (Acosta and Martínez, 2010).

In the first place, the Constitution establishes that access to water is a fundamental human right, especially to drinking water; it prohibits water hoarding and privatization; it refers that the State is responsible for providing drinking water services in the country and mentions that the authority in charge of water management will plan, regulate, and control its use (Asamblea Constituyente, 2008).

The LORHUyA, which is the main regulatory body regarding water resources, establishes two unique forms of administration, public and community, and establishes the different levels of management (State, single water authority, decentralized autonomous governments "GAD's", public companies and JAAPS), related among themselves (Figure 2). It regulates and controls the management, authorization of use, conservation, restoration, and exploitation, and ensures the collective rights of the Communes, Communities, Peoples and Nationalities in the active participation with respect to water (Presidencia de la República del Ecuador, 2014).

Additionally, the organic codes, in this case the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD, 2010, updated to 2019) and the Organic Environmental Code (COA, 2017). The COOTAD generates the relevant competencies at each of the government levels from the general to the specific, including the provincial, cantonal and parish; the water resource is mentioned in this Code, which establishes that the GADs are responsible for the proper integrated management of watersheds and the provision of drinking water as an essential service for the life of the inhabitants of urban, peri-urban and rural areas, including the active and coordinated participation of community organizations, represented by the JAAPS. The COA, for its part, emphasizes the processes of evaluation, control and monitoring of the quality and quantity of water in the water bodies, in addition to establishing the environmental obligations and responsibilities of the GADs with respect to the treatment and recovery of the resource.

Finally, Ministerial Agreements 0031 and 0194 (Secretaría Nacional del Agua, 2017, 2018), establish the independence of community organizations such as the JAAPS in the management of water, through the image of legal personality to which they can access through a process with the single water authority. Once generated, the social organizations are free to have an internal regulation that does not need to be approved by the governing body, likewise, their authorities will be chosen internally without the influence of the MAAE and it is complemented with an instruction for the strengthening of the processes of the community organizations to the water authority. Figure 2 shows in a summarized and hierarchical way the main actors related to water management in Ecuador.

3.2 Water management in different spatial approaches: an approach to urban, rural, and peri-urban areas

Water management for domestic use has different models, depending on the spatial and territorial reality. In urban and peri-urban areas, the participation of public companies or their concessions is much more common; in rural areas, it is generally the JAAPS who intervenes, normally regulated by community action/opinion and other actors such as local action Non-Governmental Organizations; however, they are rarely advised by a public company. Urban areas, due to the constant increase of their population, need a large amount of vital liquid to satisfy their basic needs, thus requiring greater economic and technical efforts in the management and distribution of water. To address each of these realities, different cases are presented to demonstrate their structure and operation.

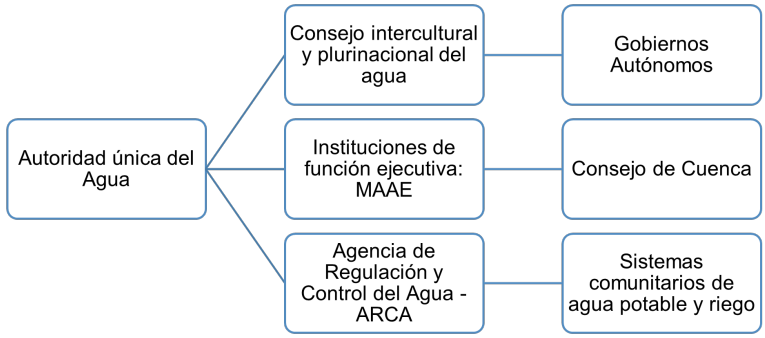

Figure 2. Hierarchy of actors engaged in water management
Source: LORHUyA

To refer to **urban areas**, it is necessary to establish the meaning of urban: according to the RAE (2021) it is defined as "belonging or related to the city". Capel (1975) in a classic idea mentions that the following elements should be included to characterize this concept: population size and density, the appearance of the urban core, including the dynamics of buildings and infrastructure, economic activity, and way of life, preferably based on a non-agricultural economy; likewise, the human population should be mentioned as an important factor, including its heterogeneity, the "urban culture" and the degree of social interaction.

The general rule in terms of water collection in the Andean zone of Ecuador is to do it in watersheds located at a considerable altitude, where water quality facilitates its treatment, since pollution sources are less common in these areas with less anthropic influence; however, it is worth mentioning that agricultural activities, especially burning and grazing, are gaining more space in Ecuador's paramo (Chuncho and Chuncho, 2019). In short, the activities that prevail in the drinking water service in public enterprises are: collection, conduction, storage of raw water, treatment, and conduction of treated water to the distribution center. Drainage and wastewater treatment are part of this management process, forming a cycle. According to Peña et al. (2016) the urban water cycle involves all these actions, including those aimed at preserving the resource.

Cities like Quito, such as Bogotá, Colombia's most populated center, are also supplied by main systems that get water from micro-watersheds. There, *Empresa de Acueducto y Alcantarillado de Bogotá* "EAB" is in charge of providing the service to the community (Peña et al., 2016).

Regarding **rural areas**, the RAE (2021) defines them as "pertaining or related to the life of the countryside and its labors"; among other authors, Larrubia-Vargas (1998) mentions that times the word "rural" in ancient was completely associated with the agrarian. Nowadays, it would be difficult to mention that only activities associated with agriculture are the only ones that take place in rural areas. Something striking in the rural area is that the natural component predominates over the artificial structural, likewise the population density has relatively low values and the economic flow is considered to be small, which can cause a greater number of social inequalities and a lifestyle that can be considered simple.

Water management in rural areas of Ecuador is mainly carried out through the model of community organizations, whose work is generally not sufficiently visible; local actors share interests and a vision more rooted in nature. Water Boards or JAAPS are created to manage the resource; this type of organization has less complex water systems than urban ones that consist of water collection, raw water conduction, raw water treatment, mainly by chlorination, and distribution to home

networks (Pacheco, 2019). The predominant difference between public and community systems is the treatment of raw water, being more technical in public networks, where methods such as screening, coagulation-flocculation, sedimentation, and filtration are used (Chulluncuy, 2011).

A negative aspect in community networks is the conduction process of raw and treated water, which is done through ditches or canals, a situation that leads to a decrease in water quality due to cross-contamination by not having a total cover in the circulation of water to its partial and final destination (Pacheco, 2019).

According to Perugachi and Cachipuendo (2020), the responsible entity is *Empresa Pública de Agua Potable Pesillo-Imbabura* with the support of community participation, which is structured by 5 actors: 2 corresponding to the GADs, 2 from the JAAPS and a president of the association. The community and people disagree with it since they had the idea of autonomously managing the resource.

Finally, the term **periurban** is not coined by the RAE. However, the word can refer to the processes of territorial organization, whether orderly or unorderly in large cities (Mansilla, 2018). The peri-urban area is often related with the periphery and with poverty; for Vieyra et al. (2018), this social condition has a multidimensional and multifaceted approach; in this way, the peri-urban area is understood as an area of accelerated transformations of the territory, which cause a physical expansion of the city, generating economic and socio-environmental impacts, and a gap between the city center and the periphery. There is another similar term to characterize these zones, which is rururban space, defined by Cardoso and Fritschy (2012) as a hybrid between urban and rural dynamics; De Mattos (2002) has called it part of the "metamorphosis" of cities.

Water management in a peri-urban area such as the one addressed in this study (Santa Clara de San Millán) is represented by the Commune, its rural socioeconomic characteristics, but also by the fact that it is adjacent to the north-central area of the city of Quito. This community manages the water resource in its territory, through a water system for human consumption, which consists of catching water, ditches, and PVC pipes for transporting raw water, pressure breaker chambers at different points, raw water purification area and PVC pipes for transporting treated water to houses (Figures 3 and 4).

In addition, JAAPS works in the Commune, which is annually assigned by the Cabildo to conduct this work. The Board consists of a committee chosen annually by the partners to provide the service, which has a single cost for each beneficiary; it is important to mention that several partners benefit from the service provided by the Board and by the EPMAPS (Empresa Pública Metropolitana de Agua Potable y Saneamiento de Quito).

Among the main strengths observed in the local water management are the participation and teamwork of the committee and the members, the cooperation activities that are carried out from time to time for the maintenance and cleaning of the system. On the other hand, weaknesses correspond to some technical and economic aspects that need to be characterized and improved, such as: inadequate dosage of calcium hypochlorite in the chlorination of raw water, pipes in risk areas due to potential mass movements, leaking pipes, debts of the beneficiaries of the service, universal single charge without taking into account the value of actual consumption per beneficiary, among others, aspects that should be improved to promote the long-term sustainability of the system (Pacheco, 2019).

3.3 Adaptation to Climate Change and water co-management and the natural landscape at the community level.

It is estimated that South America, among other regions, would have devastating consequences in an accelerated climate change; one of the risks is the melting of glaciers in the Andes Mountains and changes in high Andean ecosystems (Yánez, 2009; Yánez et al., 2011), which would decrease the amount of drinking water by people in the region; the acceleration in glacier melting dates back to 1976 when Ecuador had 60 km^2 of glaciers in the mountain range (Francou et al., 2013); according to Cáceres (2010) the loss of them has been 38 % in approximately 30 years.

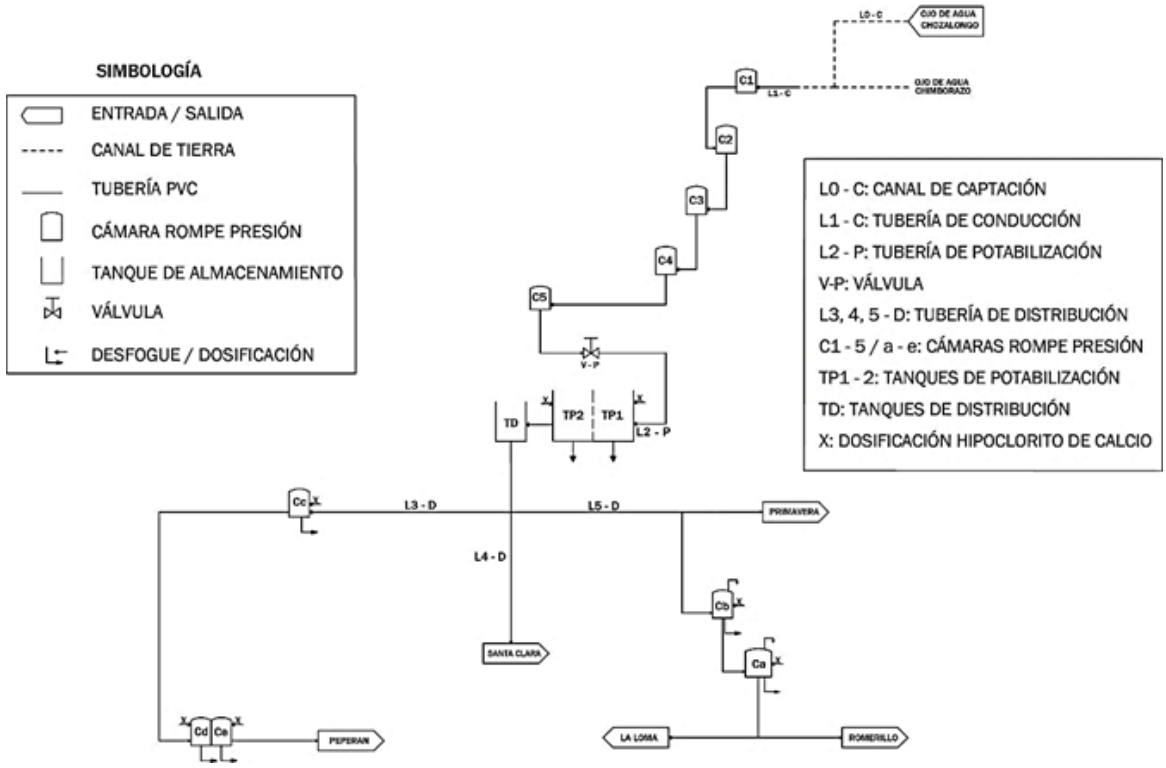

Figure 3. Diagram of the water system at Santa Clara de San Millán commune.

Other negative effects of climate change must also be considered: decrease in precipitation, sea level rise, loss of biodiversity, droughts, extreme heat waves, floods, among others (ONU, 2015). In this scenario, the efforts made by governments in the formulation of development plans are important, as they present mitigation and adaptation tools. Other ways to address the phenomenon are international agreements, especially those involving emissions control and the generation of compensations to those harmed (UNESCO, 2018).

Therefore, adaptation to climate change requires management tools (methodologies and regulations) based on an ecosystemic approach, with active community participation. According to Magrin (2015), one of the most complex options for climate change adaptation is that based on ecosystems, as it requires cooperation of different organizations and actors. In this study, it is more feasible since the inhabitants of the Commune are willing to preserve the natural ecosystems in the area.

In this sense, Delgado et al. (2015) and Gómez-Ruiz and Lindig-Cisneros (2017) state that such management and preservation instruments should enable communities and organizations to focus on meeting their needs and maintaining ecosystem services, using, among other tools, ecological restoration in the areas when appropriate.

Therefore, in the area of this research, it is recommended the gradual replacement of the eucalyptus forest by a forest with native species that would generate greater ecosystem benefits (including water) than monospecific forests with introduced species (Cordero Rivera, 2011; Anchaluisa and Suárez, 2013; Faries and Ríos, 2019), it is especially necessary in resilient peri-urban areas. Therefore, we consider that the forest of the commune requires landscape restructuring to improve its current conditions.

In this scenario, the concept of adaptation through co-management is paramount, and the prioritization of actions is essential for the development of communities and participatory management, especially in terms of water and forest/moorland resources.

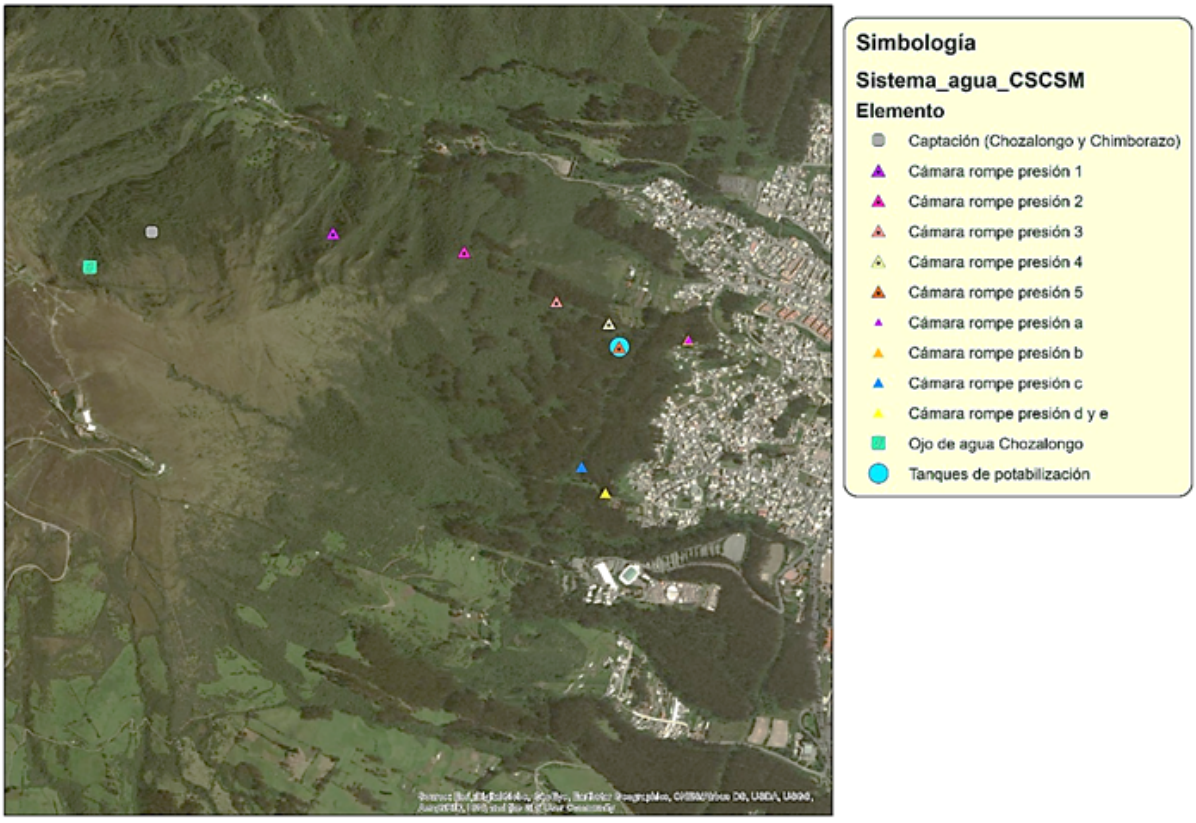

Figure 4. Location map of the water system at Santa Clara de San Millán commune. Adapted from Google Earth, 2020.

There are interesting models that can be applied in the commune, like the one proposed by Barazorda and Pérez (2014) and Saborío et al. (2019) in similar environments in a context of climate change, who combine landscape management activities and reasonable and rational water management.

The water co-management model to be applied in the commune must be holistic, enabling an adequate interaction between human rights and water management, and cannot be discriminatory; therefore, it must include different age and gender groups as key management actors. Dialogue and cooperation must be generated to move from a potential conflict in the management and use the resource to an agreed solution. Similarly, joint work between JAAPS and EPMAPS should be balanced in each of the management competencies, including environmental sanitation. The strengthening of internal capacities should be based on shared work, including the ancestral and territorial knowledge of the people in the commune, in addition to the experience and technological knowledge of the members of the public company (FONAG, 2020; Perugachi and Cachipuendo, 2020).

Another axis of management should be the participatory governance of the resource, that would evaluate a fair price for the service, including expenses related to planning, mitigation of climate change effects in the area, monitoring, provision of water-related services, system maintenance, effective internal communication, and administrative costs (WWAP, 2019). Two cross-cutting elements to consider in all phases would have to do with avoiding inefficient management actions and corruption events, elements that can lead to an increase in the system's internal vulnerabilities and inadequate water management.

Finally, regarding environmental sanitation, water purification, when necessary, can appeal to three options: the use of technology through Wastewater Treatment Plants; the application of Oxidation Lagoons; solutions based on the dynamics of water in the ecosystem and its natural purification in the corresponding micro-watershed (García, 2021; Lafortezza et al., 2018; Scott et al., 2016). In rural and peri-urban communities, the second and third options are the most successful due to the economic-operational capacities of the JAAPS.

4 Conclusions

Proper water management by human beings at all levels of government, from local to regional, is one of the main tools that will enable proper adaptation to climate change.

Currently, the most common management models are based on a poorly connected work between key actors in a location, whether urban, rural or peri-urban. Regarding the Santa Clara de San Millán commune and other similar ones, it is noteworthy that the proposal generated enables articulating, under legal, technical and communication aspects, the necessary processes for a participatory management of the water resource present in the area. The strengthening model from grassroots organizations, in this case the Board, would allow the creation and improvement of the capacities of people involved.

In this context, we consider that adaptation to Climate Change scenarios based on ecosystems and communities is the best way to establish and develop measures that allow achieving a real adaptation to this change, significantly reducing the vulnerability of the population in this and other similar communities.

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