Andean Rural Resilience: Water infrastructure and social organization Colca Valley case study

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Abstract: Resilience is known as the capacity to adapt or resist adverse situations. In rural territories it is observed that this capacity is based on social capital. In this sense, this research analyses ancestral practices and their relationship with the hydraulic infrastructure known as "irrigation canals" from the perspective of risk and disaster management. The methodology developed presents the case study of the Colca Valley, where 10 population centers exposed to the risk of natural disasters and with a direct relationship to a water source were selected. Data was collected using Geographic Information Systems, where urban population centers, agricultural areas and irrigation canals were located. Semi-structured interviews were also carried out to obtain testimonies of the reciprocity activities with respect to the hydraulic infrastructure from Irrigation Organizations and Rural Communities. As a result, the network of irrigation canals constitutes the backbone of the Colca Valley from the point of view of agricultural activity. The social organizations present a clear hierarchical structure and reciprocity activities related to the hydraulic infrastructure established for generations, such as the cleaning of canals, ceremonies for the birth of springs and payments to the gods. In conclusion, the construction of Andean rural resilience is based on ancestral activities based on reciprocity and redistribution.

Keywords: Rural resilience; Andean resilience; hydraulic infrastructure, social organization, colca valley

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Resumen: La resiliencia se conoce como la capacidad de adaptarse o resistir a situaciones adversas. En territorios rurales se observa que esta capacidad se fundamenta en el capital social. En este sentido la presente investigación, analiza las prácticas ancestrales y su relación con la infraestructura hidráulica denominada “canales de regadío” desde la gestión de riesgos y desastres. La metodología desarrollada presenta el estudio de caso del valle del Colca, donde se seleccionaron 10 centros poblados expuestos a riesgo de desastre natural y con relación directa a fuente hídrica. Se realizó un levantamiento de datos con Sistemas de Información Geográfica, donde se localizan los centros poblados urbanos, las áreas agrícolas y los canales de regadío. Así también se realizaron entrevistas semiestructuradas donde se obtuvieron testimonios de las actividades de reciprocidad con respecto a la infraestructura hidráulica desde Organización de Regantes, Comunidades Rurales. Como resultado se obtiene que la red de canales de regadío constituye una columna vertebral del Valle del Colca desde la actividad agrícola. Las organizaciones sociales presentan una clara estructura jerárquica y actividades de reciprocidad relacionada a la infraestructura hidráulica establecidas por generaciones como limpieza de canales, ceremonia de nacimiento de manantiales y pago a los dioses. En conclusión, la construcción de la resiliencia rural andina se fundamenta en actividades ancestrales basadas en la reciprocidad y redistribución.

Palabras clave: Resiliencia rural; resiliencia andina; infraestructura hidraulica, organizacion social, valle del colca

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1. Introduction

The resilience studied in rural territories is based on the capacity of rural communities to adapt, overcome or resist adverse situations. This is the case of communities located around Andean territories, i.e. close to the chain of volcanoes in the Andes mountain range, which, according to the World Bank, have been studied for their evident social capital. Social capital is defined as the set of real or potential resources linked to the possession of a network of institutionalized relationships of mutual knowledge and recognition, as a collectively owned capital in the form of gratitude or trust. This approach makes it possible to recognize the potential drivers of Andean rural resilience.

Based on the position of Chelleri at al., (2016) where it is argued that development models that create resilience expand social networks to link communities with all levels of government. Furthermore, Stadel (2008) formulates indicators that help to measure the resilience of rural territories that start from the understanding and valorization of Andean knowledge to the identification of the potential and limitations of the physical and human environment, the culture of the community through its social principles of reciprocity, or the identification of local strategies and external agents for the social, economic and political development of the community, this research concludes that Andean rural resilience has to be based on the pillars that comprise the values of cohesion and traditional Andean practices. In this sense, one of the traditional practices of the Andean community is the cleaning of irrigation canals, such canals have been built in pre-Inca times, hence the importance of studies based on this infrastructure.

The analysis in this article is based on quantitative and qualitative data. The quantitative data were managed with the GIS mapping method by linking secondary data sources obtained from maps with local and national level information. The qualitative data were obtained from structured interviews carried out in the village of Yanque in the Colca Valley, from 28 February to 10 March 2023. The interviews were carried out with the main actors and authorities involved in the communities and in the activity *Escarbe de Acequias* (a name recognized by the inhabitants of Yanque, which will be used as such from now on for the writing of this research), including the: President of each Peasant Community, President of the Irrigation Commission, Water Councilors, being for the Anansaya Irrigation Commission the Huarancante and Ticlla canals and for the Urinsaya Irrigation Commission the Mismi and Sifón canals. The interviews were carried out using a structured questionnaire based on three levels of theory: disaster risk management, disaster risk management and its relationship with resilience, and finally, the cleaning of canals or the digging of irrigation ditches. The interviews made it possible to recognize the social organization that has enabled the rural Andean resilience of the Colca Valley's hydraulic infrastructure.

The following sections of this article will begin with a presentation of the theories focused on three subheadings, Andean rural resilience, hydraulic infrastructure and Andean social capital, and finally the network of irrigation canals and their impact on rural resilience. Then the materials and methods used are explained, which allow the visualization of the relationships between the exposed hydraulic infrastructure and the representative Apus of the Yanque District, as well as the relationship between the exposed hydraulic infrastructure, the Apus and the community actors, and the organigram with the internal relationships of the community actors involved in the digging of irrigation ditches. Finally, the results lead to conclusions that highlight the importance of the analysis of Andean hydraulic infrastructure. It should be noted that technical studies have been carried out on road infrastructure or roads, which allow accessibility between communities, but the infrastructure related to irrigation canals, which are fundamental for agriculture and therefore for the socio-economic development of Andean communities, does not present the same degree of interest. Therefore, the study of these millenary practices such as the digging of irrigation ditches must be hierarchized and structured in terms of their social and collective behaviors in order to be recognized and financed at both national and local level. Especially in territories where rural resilience and the increase of social capital are evident.

A. Andean Rural Resilience

One of the first definitions of resilience is based on the ability to cope with unexpected hazards after they have manifested themselves, learning to recover (Wildavsky, 1991) or buffering of a system to absorb measurable disturbances before a system changes its structure by changing variables (Holling et al, 1996). Later studies (Mallak,1998; Van der Linden,2015) defined resilience as social and individual capabilities and as the ability of an individual or an organization to quickly design and implement positive adaptive behaviors that match the immediate situation, while enduring minimal stress. From the rural setting, Scott (2013) and Heijman, Hagelaar, Heide (2007), introduce the term rural resilience as the ability of a rural region to adapt to changing external circumstances, maintaining its standard of living, through a constant interplay between ecological, economic and cultural resilience, through the concepts of diversity and sustainability.

Specifically, in a study on resilience in the Andes (Sietz and Feola, 2016), resilience in the Andes was evaluated based on the theory of learning, adaptability and transformability, allowing the study of alternatives and opportunities for rural communities. On the other hand, several studies (Wilson, 2012; Scott, 2013) establish resilience factors in rural environments such as: diversity, connectivity and development models, where diversity is the variety and heterogeneity of the components and functional relationships that shape the socio-ecological systems, which allows responding in different ways to climate change and adaptation to new phenomena that occur today, generating alternatives for resistance, recovery or transformation systems (Vallejo- Rivas et.al., 2015). Connectivity, is the relationship between nature and the strength of socio-ecological connections and interactions (Murra, 1975; Troll, 1968). According to Chelleri at al., (2016) development models that can build resilience by creating or expanding socio-ecological networks link communities and the environment at the level.

Stadel (1995, 2000, 2008) formulates indicators that help measure resilience in rural territories such as: (i) Understanding and valuing Andean knowledge ii) Understanding the harmony of the environment and society through the Andean cosmovision iii) Identifying the potentialities and limitations of the physical and human environment iv) Identifying the culture of the community through its social principles of reciprocity v) Identifying local strategies and external agents for the long-term social-economic and political development of the community, concluding that Andean rural resilience has to be based on pillars comprising Andean cohesion values and traditional practices, as well as locally controlled and sustainable forms of adaptations in a genuine way and with the cooperation of external actors. Rural resilience in Andean contexts, therefore, responds to adaptive capacity and the diversity of connectivity with each other or with external actors.

B. Hydraulic Infrastructure and Andean Social Capital

Social capital is defined by Bourdieu (1986) as the set of real or potential resources that are linked to the possession of a network of more or less institutionalized relationships of mutual knowledge and recognition, as a capital of collective property in the form of gratitude or trust; through the membership of social actors to a certain class or group. On the other hand, several studies (Coleman, 1990; Portes, 1998) define social capital by its function, as a combination of different entities, arising from closed and interconnected groups that foster behavioral norms, and demarcate group boundaries through symbols, language and identity, which are derived from the social roles of education and family; where kinship is the strongest form of social capital, because it is rooted in stable, dense and non-permeable relationships that are appropriable in other social contexts. More recent studies (Putnam, 1993a, 1993b, 2000, Portes, 1998 Bhandari, H., & Yasunobu, K. 2009) indicate that social capital is a public good that exists in the relationships between people; it is specifically described as the capital based on goodwill, companionship, sympathy and social relationships between those who compose a social unit in communities and networks of relationships that exist within and between social groups that give rise to pro-social norms of reciprocity, cooperation and trust.

The Organization for Economic Co-operation and Development (OECD) defines social capital as the networks of together with shared norms, values and understandings that facilitate cooperation within or between groups. The World Bank (WB) defines social capital as the institutions, relationships and norms that shape the quality and quantity of a society's social interactions. From academic positions (Cheshire, Esparcia, & Shucksmith, 2015; Masterson et al., 2014; Putnam, 2000; Wilson, 2012, Bhandari, H., & Yasunobu, K. 2009), social capital is based on trust, norms and informal networks, where social relationships are built through interactions such as social norms, values, beliefs, trust, obligations, relationships, networks, friends, affiliations, civic engagement, information flows and institutions that foster cooperation and collective actions for mutual benefit that contribute to economic and social development, as well as trust, reciprocity, common rules, norms and public commitment.

C. Irrigation canal network and its impact on rural resilience

Irrigation canals are a type of infrastructure responsible for the conduction and distribution of water collected from a natural storage source such as rivers, streams, wetland drains, etc. (Centro de Estudios y promoción del desarrollo -DESCO). Most of the irrigation canal networks in Peru were built in pre-Inca times, hence the importance of the studies carried out based on this infrastructure. Although most studies focus on Andean communities, research topics have been based on the rational use of irrigation water, according to the ecology of these communities, who seek to optimize their production and the use of water in irrigation canals (Fernández, R. V., & Gutiérrez, C. E.,1986, Stensrud, A. B.,2019). In addition, another group of works, (Fernández, et.al., 1986; Mendoza R. R., 2010; Wernke, S. A., 2006) are based on the diversity of festive ceremonies and rituality around the cult of water. However, the relationship between agriculture, rituality and Andean rural resilience has been studied in a general way. For example, irrigation canals are a fundamental part of the agricultural economic process in the Colca Valley and are considered one of the most important hydraulic infrastructures in the territory. Thus, the inhabitants practice communal cleaning and maintenance work, commonly called *Yarqa Aspiy* or ditch digging, which bring together a system of communal work among irrigation users, and developed according to their agricultural calendar, and festive ritual between the months of July and August.

2. Materials y Methods

A. Case study, The Colca Valley

The Colca Valley is located in the province of Caylloma, in the department of Arequipa in Peru. The province's main scenery is the Colca Canyon, which has a depth of 4160 m, and is the fourth deepest canyon on the planet. It is worth mentioning that "Colca" comes from the words Collaguas and Cabanas, two ethnic groups that lived along the Colca River and around the canyon. Caylloma, whose name comes from one of the local villages, has a surface area of 11 990.24 km² and borders the department of Cuzco to the north, the provinces of Camaná and Arequipa to the south, the department of Puno to the east, the province of Castilla to the west and the province of Condesuyos to the north-west.

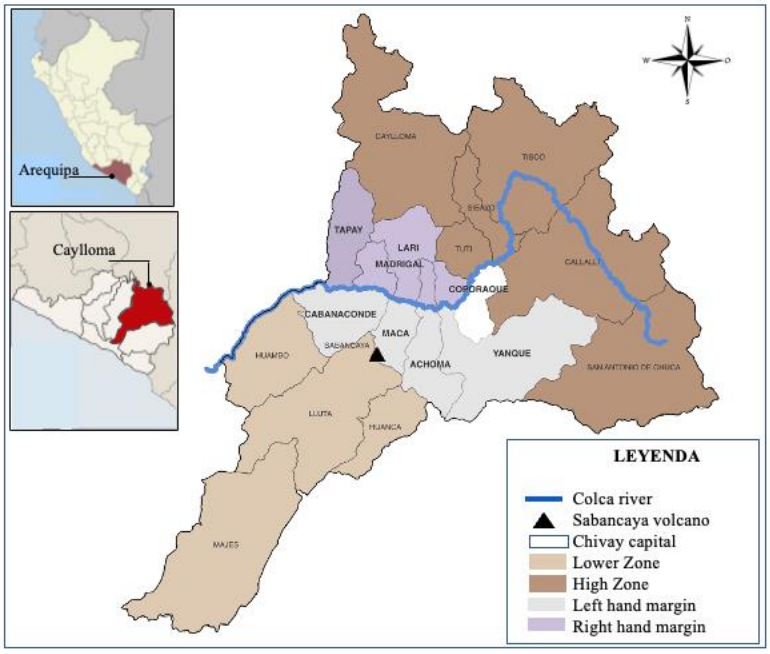
The current Andean social organization in the Colca Valley responds to a political, economic and family division, politically it is made up of twenty districts (AUTOCOLCA - Law N° 28537) within the province of Caylloma, organized in four zones, based on the banks of the Colca River and its altitude, such as: (i) the Ampato zone or low zone made up of the districts of Majes, Huambo, Lluta and Huanca (900 to 3,322 m. above sea level), (ii) the high zone made up of the districts of Tuti, Sibayo, Callalli, Caylloma, Tisco and San Antonio de Chuca. (ii) high zone comprising the districts of Tuti, Sibayo, Callalli, Caylloma, Tisco and San Antonio de Chuca (3700 to 6000 m.a.s.l.). (3700 to 6000 m.a.s.l.), (iii) the Left Bank conformed by the districts of Chivay, Yanque, Achoma, Maca, Cabanaconde and Tapay (2400 to 5000 m.a.s.l.); (iv) the Right Bank, formed by the districts of Tapay, Coporaque, Ichupampa, Lari and Madrigal (2400 to 5000 m.a.s.l.) (See Figure 1).

The second form of organization within the Colca Valley is the economic one, made up of a total of 24 independent and recognized peasant communities (Agencia Agraria Caylloma, 2023) within 17

districts, in charge of managing communal lands (registered and recognized by D.S. N° 008-91-TR) and regulated by the General Peasant Communities Law (Law Nº 24656). N° 008-91-TR) and regulated by the General Law of Peasant Communities (Law Nº 24656), where the presidency of the peasant communities usually varies between two years or more, depending on the statutes approved within each peasant community and where in turn there is another group of associations of independent economic activities conformed mostly by community members such as the Associations of Artisans, Alpaqueros, Cattlemen and the Board of Users (Agencia Agraria Caylloma, 2023), depending on their altitude and economic activity, The Caylloma Users Board is regulated by ANA and the Water Resources Law (Law N° 29338), in charge of the maintenance of the hydraulic infrastructure, water distribution and collection of water tariffs, Currently within the Colca Valley it is made up of 31 irrigation commissions in 15 districts, which in turn contemplates the same division of the Colca River banks as AUTOCOLCA, it has around 103 springs, 62 canals and 74 reservoirs (Mejía, Mejía and Vásquez, 2022).

The hydraulic system in the Colca Valley comes from the main water sources such as snow-capped mountains and springs, so most of the hydraulic infrastructure is within the entirety of each district or shared with each other because they have the same source due to their geography, organized according to their geographical altitude, divided into three zones, such as: (i) the high zone is formed by the districts of Sibayo, Tuti, where there is limited agriculture,(ii) in the middle zone is formed by the districts of Chivay, Coporaque, Yanque, Maca, Achoma, Ichupampa, Lari and Madrigal , (iii) the low zone conformed by the districts of Cabanaconde, Tapay and Huambo, highly agricultural zones.

Figure 1. Location of the Province of Caylloma



Source: The Authors

B. Data Collection

The data collection for this research is based on three sources of information. The first source of information is obtained from the analysis of data with a geographic information system (GIS), using information from maps of public institutions at the national level, where rivers and canals are shown. The second source of information is obtained from the analysis of data from maps of public institutions at local level, such as the municipality of Caylloma and the documents of the Agrarian Agency of Caylloma. The third source of information is obtained from interviews with the inhabitants of the Yanque population center in the Colca Valley (see Table 1).

C. Data Processing

The data processing is based on two phases. The first phase is related to the GIS mapping where the first and second data source is processed and the second phase depends on the field work where the data collected from the semi-structured interviews conducted in the village of Yanque are processed (See Table 1).

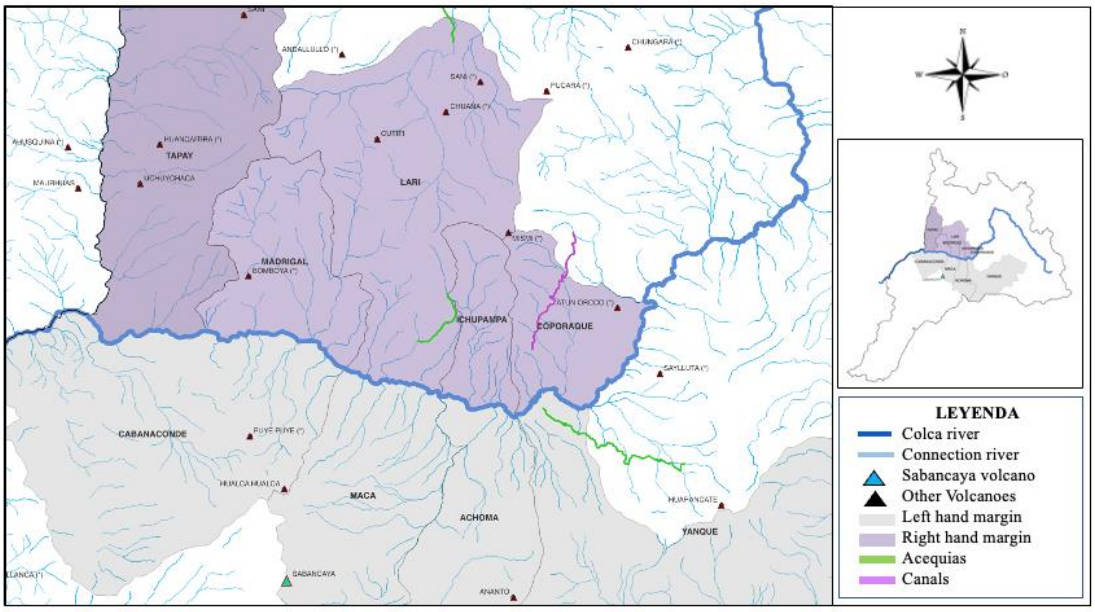
Table 1. Data collection

Phases	Source *Tip of Source*	Method	Sample
I	**Source 1** *Secondary*	GIS mapping	Map of National Public Institutions
	Source 2 *Secondary*	GIS mapping	Local Public Institutions Maps and Documents
II	**Source 3** *Primary*	Semi-structured interviews	Population of the village of Yanque

Source: The Authors

The first phase is based on GIS mapping with secondary data sources from the maps of national and local public institutions and the documents of the Caylloma Agrarian Agency. From these data, the relationships between the population centers and the hydraulic infrastructure exposed to natural disaster hazards are visualized, taking the proximity to the Sabancaya volcano as a danger trigger. Therefore, the exposed population centers are those located on the right bank of the Colca River, which are Cabanaconde, Maca Achoma and Yanque. In addition to these four population centers, the one that constitutes the hydraulic infrastructure of irrigation ditches, as shown in Figure 2, is the population center of Yanque. In this sense, the second phase of the information processing focuses on the collection of interviews with the inhabitants of the Yanque population center.

Figure 2. Relationship between population centers and exposed water infrastructures



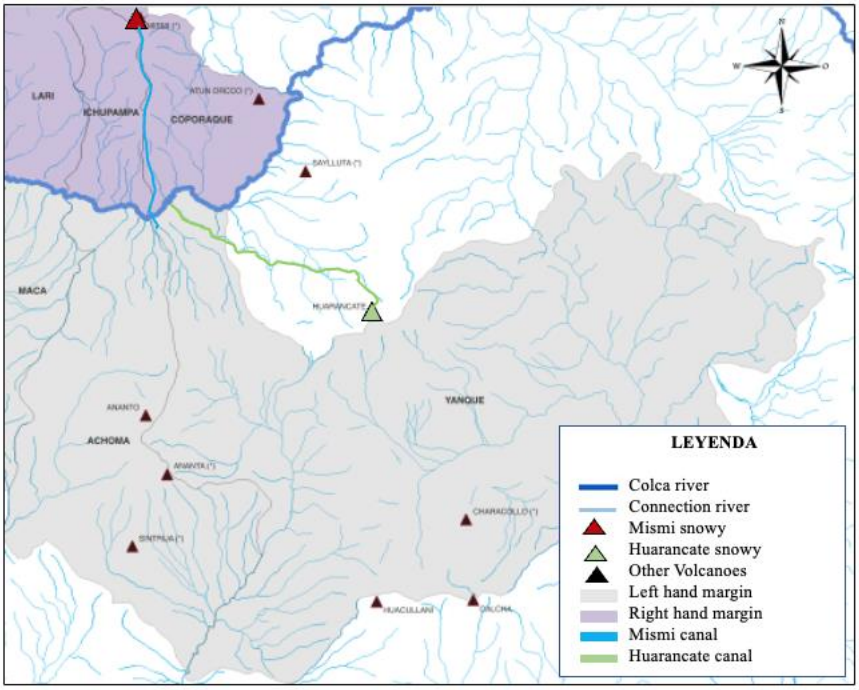
Source: The Authors

3. Results

In the town center of Yanque there are two Apus, which are the highest hills on each of the banks of the Colca River. These two Apus are: Mismi snowy, corresponding to Yanque Urinsaya and Huarancante snowy corresponding to Yanque Anansaya; both snow-capped mountains are sources of the main irrigation channels (See Figure 3).

From the interviews conducted on 28 February, 01, 02 and 10 March 2023 in the village of Yanque with the main actors involved in the ditch digging activity, two findings are reported. Firstly, the interviewees recognize four irrigation canals and that the ditch digging lasts between 4 to 5 days of cleaning. The Sifón and Mismi canals take approximately 1 to 2 days to clean. The Huarancante canal lasts approximately 3 days for cleaning and the Ticlla canal lasts 1 day and is currently the canal where most community members participate. Secondly, the actors involved in the digging of irrigation ditches were prioritized and organized: the president of each Peasant Community, the president of the Irrigation Commission, and the Water Board members, with the Huarancante and Ticlla canals for the Anansaya Irrigation Commission and the Mismi and Sifón canals for the Urinsaya Irrigation Commission (see Table 2).

Figure 3. List of exposed hydraulic infrastructure and the representative Apus of the Yanque population center.



Source: The Authors

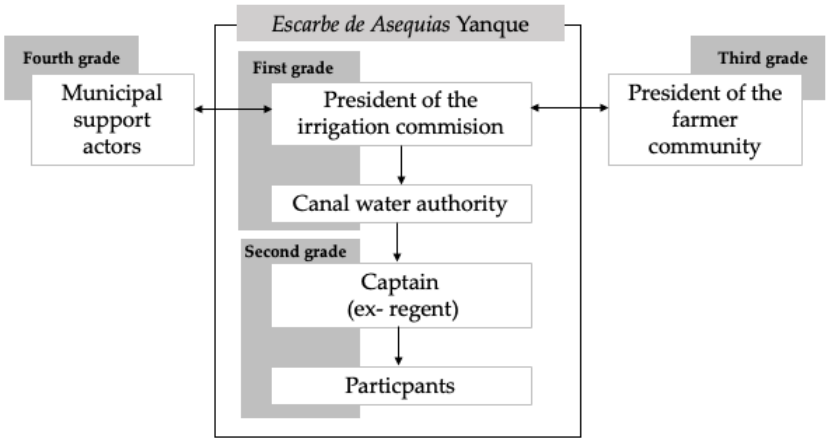
Table 2. Relationship of exposed hydraulic infrastructure, the Apus and the actors of the community of the Yanque village center

Yanque Anansaya	Yanque Urinsaya	Number Community Actors
President Community Farmer		1
President of the Irrigation Commission		1
Water Councilor of the *Canal Huarancante*	Water Councilor of the *Canal Mismi*	2
Water Councilor of the *Canal Ticlla*	Water Councilor of the *Canal Sifon*	2
	TOTAL	**5**

In addition, from the processing of the interviews, the degrees of participation of the actors involved were identified. In the first level, the main actors are those who organize the ditch digging activity, such as the presidents of the irrigation commissions and the water councilors of each partiality. In the second level, these are the participants or users of each irrigation commission. In the third level, these are the actors who are in continuous communication with the irrigation commission,

but who do not participate in the organization of the activity, such as the president of the Irrigation Commission. At Fourth Degree, they are the external actors who know or are former participants of the activity (See Figure 4).

Figure 4. Organizational chart and internal relations of the actors involved in ditch digging



Source: The Authors

From the first level of participation, according to the interviews, we can discern that this group of actors are the main organizers of the activity of the Escarbe de Acequias, as well as of the equitable distribution of water to all users and of the water reserve, with positions recognized by the Yanque population center in each part of the community. They have a more committed stance regarding natural hazards, as they directly affect their production and each user's source of economic income. In the case of natural phenomena, the role of this type of actors consists of organizing together with the users activities for immediate solutions during the natural phenomenon (such is the case of frosts and droughts), which are often limited by various factors such as technical and economic factors. At the same time, they recognize that the organization and strengthening of this is not only based on providing solutions to problems of natural phenomena, but also to social, economic and political problems that affect their community.

Por otro lado, del segundo grado de participación se sustenta que los actores participantes de la actividad del Escarbe de Acequia tienen una participación anual. Cabe destacar que una de las entrevistas, correspondiente al genero femenino que las actividades asignadas a las mujeres eran diferentes a los varones, sin embargo, la percepción de importancia de la actividad es la misma. Además, los entrevistados indican que uno de los peligros naturales que más afecta tanto a la comunidad como a su actividad agrícola es la sequía, pues hay temporadas en el que la lluvia es poca y el reparto de agua precedido por el regidor es limitada.

The third level of participation groups together the actors who are community authorities, but do not participate in the organization of the ditch digging activity, being the presidents of the communities with a two-year term of office, democratically chosen by the Yanque community members. It should be emphasized that most of the community members are users. These authorities directly represent and look after the interests of the communities and are in constant communication with the irrigation users' commission, as they have a common goal, which is to encourage improvements for their communities and for Yanque. Finally, the fourth level of participation includes external actors, who do not currently belong to the users' commission, but live in Yanque, former water councilors, people who have provided technical assistance to Yanque through non-governmental organizations such as DESCO. This type of actors, as is the case of the former water councilor, indicates the old practices of canal maintenance and the active participation of the users.

4. Discussion and Conclusions

Within the reviewed theory, it can be concluded that resilience in rural Andean contexts, comprises the capacities for adaptability and diversity, based on relationships, norms and trust of social capital, practices that are currently present in the Colca Valley, through the practice of the activity of digging ditches in the hydraulic infrastructure of the area, due to the social-economic impact, through the organized and regulated distribution of communal work in cohesive societies. The social organizations present a clear hierarchical structure and reciprocity activities related to the hydraulic infrastructure established for generations, such as the cleaning of canals, ceremonies for the birth of springs and payment to the gods. In conclusion, the construction of Andean rural resilience is based on ancestral activities based on reciprocity and redistribution.

Disaster response and risk mitigation policies consider neither the irrigation infrastructure nor the hierarchy of the population at the time of response, only the hierarchical structure established in their housing or residential spaces, leaving aside the space dedicated to agriculture. It is therefore questionable whether this policy response capacity does not recognize the perfect binomial between housing and agriculture, which is determined in a rural environment.

Technical studies of infrastructures in rural Andean territories are mostly carried out in terms of feasibility and accessibility; however, infrastructures related to irrigation canals, which are fundamental for agriculture and therefore for the socio-economic development of Andean communities, do not have the same degree of interest for the sustainable development of Andean communities. For this reason, the study of these age-old practices, such as the digging of irrigation ditches, must be prioritized and structured according to their social and collective behaviors in order to be recognized and financed at both the national and local levels. Especially in territories where rural resilience and increased social capital are evident.

This research shows the importance of broadening knowledge of the organizational dynamics of the different population centers of Andean communities or those areas where ancestral coexistence is still maintained and their relationship with the territory, in order to deepen studies and understanding of the different social capitals and their scope within different fields such as territorial planning.

Acknowledgments: To the National University of San Augustin. To the research project "Urbanismo De Emergencia, Patrones De Reasentamiento De Poblaciones Vulnerables Del Valle Del Colca, En Torno Al Volcán Sabancaya".

References

1. Batabyal, Biswas, Godfrey. (2004). A Dynamic and Stochastic Perspective on the Role of Time in Range Management. Microeconomic Theory eJourna, 69-75.
2. Bhandari, H., & Yasunobu, K. (2009). What is social capital? A comprehensive review of the concept. Asian Journal of Social Science, 37(3), 480-510.
3. Bourdieu, P. (2011). The forms of capital. (1986). Cultural theory: An anthology, 1(81-93), 949.
4. Bowlby. (1984). Attachement et perte. Paris: PUF.
5. Chelleri, Minucci, Skrimizea. (2016). Does community resilience decrease social–ecological vulnerability? Adaptation pathways trade-off in the Bolivian Altiplano. Regional Environmental Change, 2229–2241
6. Cheshire, L., Pérez, J. E., & Shucksmith, M. (2015). Community resilience, social capital and territorial governance. Ager: Revista de estudios sobre despoblación y desarrollo rural= Journal of depopulation and rural development studies, (18), 7-38.
7. Coleman, J. S. (1990). Foundations of social theory. Harvard university press.

8. Fernández, R. V., & Gutiérrez, C. E. (1986). Sistemas de riego y organización social en el valle del Colca: caso Yanque. Allpanchis, 18(27), 179-202.
9. Heijman, Hagelaar, Heide. (2007). Rural resilience as a new development concept.
10. Holling. (1996). Engineering Resilience versus Ecological Resilience. Engineering within Ecological Constraints, 31-43.
11. Mallak. (1998). Measuring resilience in health care provider organizations. Health Manpower Management, 148-153.
12. Chi, D. L., Masterson, E. E., Carle, A. C., Mancl, L. A., & Coldwell, S. E. (2014). Socioeconomic status, food security, and dental caries in US children: mediation analyses of data from the National Health and Nutrition Examination Survey, 2007–2008. American journal of public health, 104(5), 860-864.
13. Mendoza, R. R. (2010). Sistemas de riego y ritualidad andina en el valle del Colca/Irrigation Systems and Andean Ritualism in the Colca Valley. Revista española de antropología americana, 40(1), 197-217.
14. Murra. (1975). Formaciones económicas y políticas del mundo andino. Lima: Instituto de Estudios Peruanos IEP.
15. Portes, A. (1998).Social Capital : its origins and applications in modern sociology.Annual Review of Sociology.24(1):1-24
16. Putnam. (1993a). Making democracy work. Civic traditions in modern Italy. Princeton, NJ: Princeton University Press.
17. Putnam. (1993b). "The prosperous community. Social capital and public life". The American Prospect, 13: 35–42
18. Putnam. (2000). Bowling alone: The collapse and revival of American community. New York: Simon and Schuster Paperbacks
19. Scott. (2013). Resilience: a conceptual lens for rural studies? Geography Compass, 597-610.
20. Sietz, Feola. (2016). Resilience in the rural Andes: critical dynamics, constraints and emerging opportunities. Regional Environmental Change, 2163-2169.
21. Stadel. (1995). Perzeption des Umweltstresses durch Campesinos in der Sierra von Ecuador. En Umwelt und Gesellschaft in Lateinamerika (Marburger Geographische Schriften (págs. 244-265). Marburgo.
22. Stadel. (2000). Ciudades medianas y aspectos de la sustentabilidad urbana en la región andina. Espacio y Desarrollo, 25-43.
23. Stadel. (2008). Vulnerability, Resilience and Adaptation: Rural Development in the Tropical Andes. Pirineos, 15-36.
24. Stensrud, A. B. (2019). The formalisation of water use and conditional ownership in Colca Valley, Peru
25. Troll. (1968). The cordilleras of the tropical Americas: aspects of climatic, phytogeographical and agrarian ecology. Colloquium Geographicum, 15-16.
26. Vallejo-Rojas, Ravera, Rivera-Ferre. (2015). Developing an integrated framework to assess agri-food systems and its application in the Ecuadorian Andes. Regional Environmental Change, 2171–2185
27. Van Der Leeuw, Aschan-Leygonie. (2005). A long-term perspective on resilience in socio-natural systems. En Micro Meso Macro: Addressing Complex Systems Couplings (págs. 227-264). World Scientific Publishing.
28. Van Der Linden, Maibach, Leiserowitz. (2015). Improving Public Engagement With Climate Change: Five "Best Practice" Insights From Psychological Science. Perspectives on Psychological Science, 758–763.
29. Wernke, S. A. (2006). The politics of community and Inka statecraft in the Colca Valley, Peru. Latin American Antiquity, 17(2), 177-208.
30. Wildavsky. (1991). Searching for safety; Social Theory and Social Policy. Oxford: New Brunswick.
31. Wilson. (2012). Community Resilience and Environmental Transitions. London: Routledge.