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# Analysis of the Development of Rural Aqueduct Organizations in the Central Zone of Colombia: A View from Sustainable Livelihoods

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**Abstract:** Within the framework of sustainability analysis regarding the processes developed by man, water resources in rural scenarios have been a priority due to the impact generated by population growth and climate changes in tropical regions. In Colombia, the shortage of drinking water from aqueducts has become a problem especially in rural areas, even though its administration has been set and led by local community organizations. In this sense, in this research, the aim was to understand the dynamics of sustainable livelihoods in rural areas and their relationship with water resources in Boyacá, Colombia. For this purpose, surveys were carried out in two rural aqueducts in the municipalities of Boyacá and Oicatá paying special attention to the variables that affect human, social, technical, physical, natural, and financial capital. According to the results, the water supplied by community organizations directly affects the daily activities of family units, as well as the agricultural production systems. In addition, significant relationships were identified between human and financial capital, as well as social and technical capital; however, population increment and the accentuation of dry seasons have become a threat in these regions in Colombia. In conclusion, the analysis of the work developed by the organizations of rural aqueducts allows us to understand that water plays a fundamental role in the construction of society.

**Keywords:** community; water; agriculture; public services; climate change

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## 1. Introduction

Currently, in Colombia, agriculture represents an average of 17% of the gross domestic product—GDP [1]—generating employment for 4.8 million people in 2022 [2]. This shows a significant participation of the rural sector in the economic development of the country as it directly depends on the accessibility of water resources for the development of agriculture, playing a vital role, not only in productive activities, but in the development of daily tasks [3]. Population growth has caused the water supply to become a fundamental element to sustain the needs of modern life forcing the management organizations of water resources to work harder regarding the acquisition, storage, treatment, and distribution of the source. Such growth, in Colombia, has resulted in about 12 million people having inadequate access to drinking water, from which 3.2 million citizens belong to the rural sector [4]. This is also influenced by the requirements of food production, consumption,

the competitiveness of the agricultural market, and from consumers with high demands regardless of the critical context of climate change, environmental, and social tensions [5].

According to the National Farming Planning Unit from the Agriculture and Rural Development Ministry [6] Colombia is predominantly a rural country in its territorial extension with 30% of the national population being farmers mainly located in the departments of Boyacá, Nariño, Cundinamarca and Cauca. The rest of the country's population lives spread out in large urban centers, which are mostly the ones favored by the availability and quality of water resources [7].

Colombia is a country that stands out for its significant availability of water resources, both maritime and fresh water, benefiting its great biological and productive diversity. In this sense, Ref. [8] reports that the national territory has bodies of water that can supply populated and dispersed centers, estimating a water yield of 56 L/s-km$^2$ surpassing averages for Latin America at 21 L/s-km$^2$; and the world at 10 L/s-km$^2$. This water wealth has made possible the emergence of local management organizations throughout the national territory, with approximately 12 thousand aqueducts that were the result of community networking between friends, families, and neighbors. However, that number might increase to some 25,000 organizations that provide water and sanitation services but are not recognized due to the lack of formalization before state agencies [9].

For this reason, the construction of rural aqueducts involves not only financial and infrastructure capital, but elements associated with human–social development and its link with natural resources. According to [10], the role that the water source has around communities' development—especially in the rural sector—is associated with its sustenance capital. Such influence has been included in some papers that have studied elements of a particular phenomenon to describe its relationships with forestry systems [11], production [12], rural infrastructure [13], technology [14], and health [15]. However, livelihoods have not been considered as an aspect for also understanding the actors involved within the rural aqueduct associations. Previous researchers have not included elements like human, natural, financial, and infrastructure in the Colombian context.

In the case of the central region of Colombia, the existing aqueducts are part of the development benchmarks that evolved during the time of the Spanish conquest. However, in the countryside, the design and construction of aqueducts is recent and while they aim to cover the needs of drinking water service, they also represent challenges regarding geography, topography, and the distance among residents; therefore, accentuating the difficulties to access the resource. Despite this, the national government and private investments recently achieved the coverage of up to 84% of homes in the rural sector; however, this raises questions about the healthy use of the resource regarding domestic activities, crop production, livestock, mining, or commercialization [16].

Specifically, the freshwater bodies of the central area in Boyacá have been affected by the economic and social dynamics of the region, mainly due to deforestation, contamination by agricultural inputs, eutrophication, infiltration of wastewater, and population growth; therefore, changing the flow or quality of drinking water and elevating the frequency service suspensions [17,18]. This situation has generated changes in the usage dynamics, administration, and management of the resource. Such a view is presented by [19] regarding the administrative inconsistencies for the sustainable management of water; therefore, the social, human, environmental and financial development have been altered, affecting the livelihoods of rural farmer families [20].

Under that scope, the present research exhibits the first analysis around community organizations of rural water supply systems in Colombia proposing the hypothesis that sustainable livelihoods are an effective tool for understanding the dynamics developed around rural water supply users in central Colombia. It was also possible to identify that community organizations of rural water supply systems play a fundamental role in the development of the livelihoods of inhabitants of the region, since the availability of drinking water directly affects their well-being.

## 2. Materials and Methods

The present research included the environmental and social dynamics of rural aqueduct organizations through livelihood components based on proposed methodology by the Department for International Development [21]. Figure 1 depicts the method route including the participant aqueduct organizations along the livelihood capital.

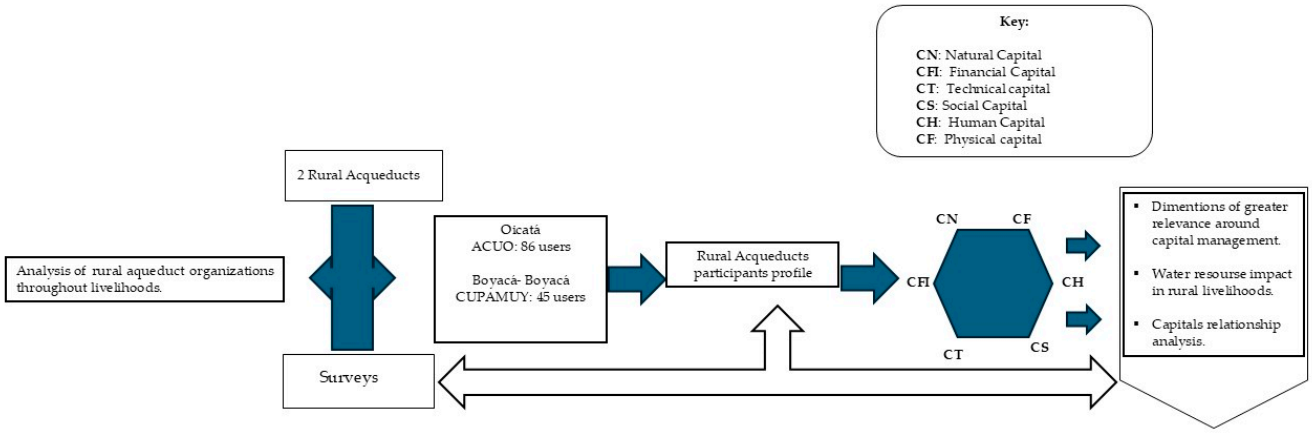



**Figure 1.** Research methodology diagram.

### 2.1. Study Area

The present research was carried out using a qualitative methodology with a case study approach, to understand the phenomenon of the particular context of the region [22], analyzing in depth the dynamics of rural aqueducts and their influence on livelihoods. In this sense, participants from the two communities were selected according to their social and political representativeness with respect to water resources.

Studied homes were located in two areas in the department of Boyacá (Colombia): Central, and Márquez (Figure 2).

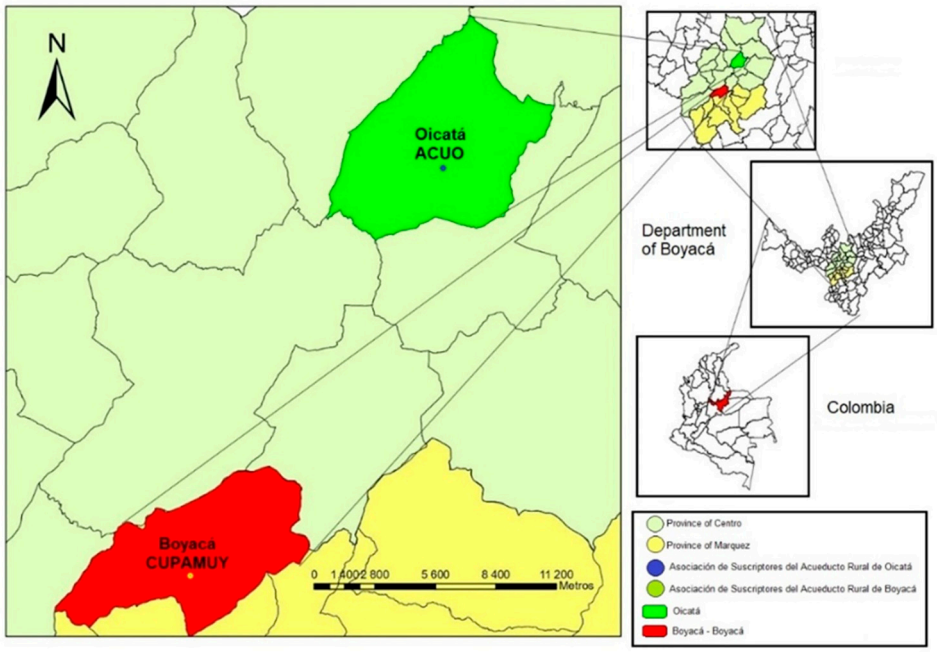



**Figure 2.** Location of the study area. Two defined areas that represent the Centro and Márquez province in the department of Boyacá, Colombia. In red: municipality of Boyacá. Green: municipality of Oicatá.

The community rural aqueduct organizations that were part of the research were the following:

Association of Subscribers of the Oicatá Rural Aqueduct (ACUO): The ACUO organization brings together users of the rural aqueduct and is located in the municipality of Oicatá, created with the purpose of providing a solution to a local problem associated with poor access to drinking water for the residents of the rural area of the municipality. Oicatá is characterized as a smallholder region—farmers with less than 3 hectares—for the development of agricultural activities [22]. The region leaves transactions close to COP 10,200 billion annually, even though there are no water sources that fully satisfy the needs of their production systems [23]. Despite this, ACUO supplies drinking water to nearly 3000 inhabitants and links approximately 744 users, from which 86 correspond to the sample of a finite population from four towns of the municipality.

Association of Subscribers of the Boyacá Rural Aqueduct CUPAMUY: the organization of users of the CUPAMUY aqueduct is located in the Rique village of the municipality of Boyacá in the department of Boyacá. The association benefits approximately 450 people through the involvement of 83 users, from which 45 are the sample of a finite population settled in the 4 towns of the municipality. This area is characterized by developing economic activities from agricultural activities and leaves transactions close to COP 21,000 billion annually [23].

### *2.2. Determination of Sample Size*

According to the total population from the ACUO and CUPAMUY aqueducts, the sample size was determined, using the formula for finite populations, as proposed by [24]. Then, it was possible to identify that the sample population for ACUO is 86 users, and for CUPAMUY it is 45 users (131 total), having a confidence level of 95% and a margin of error of 10%.

According to the sample population, users were selected randomly in the territory in each of the two municipalities to favor representativeness for the entire population.

### *2.3. Data Collection Methods and Tools*

Field work included questionnaires applied to users of the rural aqueduct associations, and open interviews were carried out for the key actors of ACUO and CUPAMUY. For this purpose, initial contact was made with the president of each association, and who had updated knowledge of the leaders and key people who were part of their organizations participating in the administration, management, treatment, and supply of water.

The type of capital taken as categories for analysis were measured in each family according to indicators (Table 1), which were weighted around incidence and rating between (1) one as the lowest regarding access to assets and three (3) as the greatest availability. Subsequently, for each capital, the scores were added and divided into the number of indicators. These averages were graphed in a pentagon, where the central point corresponds to zero access to assets and the external perimeter corresponds to maximum access [25].

For the analysis of livelihoods, multivariate criteria were used for the five capitals (Table 1), established as the following categories: human (H), social (S), natural (N), physical (F), financial (FIN), and technical (TEC). For this purpose, an analysis of the main component analysis was carried out, to identify the relationship between the categories and the linked families in the localities, following the methodology proposed by [26,27].

**Table 1.** Categories and degree of assessment of the livelihoods of users of rural aqueducts in two regions of the central zone of Colombia.

| Capital | Category | Concept | Range | Assessment |
|---|---|---|---|---|
| **Human capital** (H) | Knowledge | Access to knowledge. | Doesn't have | 1 |
| | | | Might have | 2 |
| | | | Does have | 3 |
| | Training | Access to management training. | Never | 1 |
| | | | Rarely | 2 |
| | | | Often | 3 |
| | | Access to technical and financial training. | Never | 1 |
| | | | Rarely | 2 |
| | | | Often | 3 |
| | Cooperation | Support networks. | Non- existent | 1 |
| | | | In process | 2 |
| | | | Present | 3 |
| | | Cooperation initiatives. | Non-existent | 1 |
| | | | In process | 2 |
| | | | Present | 3 |
| **Social capital** (S) | Socio-demographic | Population characteristics. | 1 to 5 members | 1 |
| | | | 6 to 10 members | 2 |
| | | | 11 or more | 3 |
| | | Basic needs satisfaction. | Very little | 1 |
| | | | Regular | 2 |
| | | | Good | 3 |
| | participation | Women's participation in rural aqueduct activities. | Does not participate | 1 |
| | | | Plans to participate | 2 |
| | | | Has participation | 3 |
| | | Participation of men in rural aqueduct activities. | Does not participate | 1 |
| | | | Plans to participate | 2 |
| | | | Has participation | 3 |
| | Conflicts | Conflict presentation. | Unknown | 1 |
| | | | Not presented | 2 |
| | | | It has happened | 3 |
| **Physical capital** (F) | Land access | Land ownership. | Rent | 1 |
| | | | Lease, society | 2 |
| | | | Own | 3 |
| | Private infrastructure | Quality family home. | No improvements | 1 |
| | | | Unfinished work | 2 |
| | | | Fully finished | 3 |

**Table 1.** *Cont.*

| Capital | Category | Concept | Range | Assessment |
|---|---|---|---|---|
| **Physical capital** (F) | Public infrastructure | Basic services: electricity, water, sewage, gas, and internet. | No basic services | 1 |
| | | | Some services | 2 |
| | | | All the services | 3 |
| | | Intermunicipal road conditions. | Bad | 1 |
| | | | Regular | 2 |
| | | | Good | 3 |
| | | Village road conditions. | Bad | 1 |
| | | | Regular | 2 |
| | | | Good | 3 |
| **Natural capital** (N) | Supply source conditions | Type of water source. | Source | 1 |
| | | | Reservoir | 2 |
| | | | Several | 3 |
| | | Pollution sources. | None | 1 |
| | | | Might happen | 2 |
| | | | Present | 3 |
| | | Availability of water resources. | Deficient | 1 |
| | | | Intermittent | 2 |
| | | | Enough | 3 |
| | | Quality of supplied water. | Bad | 1 |
| | | | Regular | 2 |
| | | | Good | 3 |
| | Supplying source biodiversity | Flora and fauna balance. | Low | 1 |
| | | | Medium | 2 |
| | | | High | 3 |
| | Water quality improvement | Presence of a drinking water treatment plant (PTAP) and/or disinfection. | None | 1 |
| | | | Disinfection | 2 |
| | | | PTAP | 3 |
| | Water resource management | Efficient resource use strategies. | Not present | 1 |
| | | | Unknown | 2 |
| | | | Present | 3 |
| **Financial capital** (FIN) | Fund availability | Resources received from contributions and/or donations. | None | 1 |
| | | | Sporadically | 2 |
| | | | Present | 3 |
| | | Resources received by the water service. | None | 1 |
| | | | Service reconnection | 2 |
| | | | Service payment | 3 |

**Table 1.** *Cont.*

| Capital | Category | Concept | Range | Assessment |
|---|---|---|---|---|
| **Financial capital** (FIN) | Financial Organization | Payment for the provision of the service. | Does not make payments | 1 |
| | | | Frequently make payments | 2 |
| | | | Make payments | 3 |
| | | Fund to carry out maintenance actions. | Not present | 1 |
| | | | Unknown | 2 |
| | | | Present | 3 |
| **Technical capital** (TEC) | Quality of service | Perception of service quality. | Deficient | 1 |
| | | | Acceptable | 2 |
| | | | High | 3 |
| | | Satisfaction regarding the water supply. | Very little | 1 |
| | | | Regular | 2 |
| | | | Good | 3 |
| | | Water quality risk index IRCA-Res 2115–2007. | High risk | 1 |
| | | | Medium risk | 2 |
| | | | Low risk | 3 |
| | | | Risk-free | 4 |
| | | Failures in the provision of the service. | Not present | 1 |
| | | | Frequently present | 2 |
| | | | Constantly present | 3 |
| | Measurement | Usage of water received by the aqueduct. | Industrial | 1 |
| | | | Agricultural | 2 |
| | | | Domestic | 3 |
| | | Use of alternative water sources. | Does not use | 1 |
| | | | Constantly | 2 |
| | | | Permanently | 3 |
| | | Operational meter on the property. | Does not have | 1 |
| | | | In process | 2 |
| | | | It has | 3 |
| | | Water consumption per family unit. | Up to 24 $m^3$ | 1 |
| | | | Up to 40 $m^3$ | 2 |
| | | | Over 41 $m^3$ | 3 |
| | Management | Costumers service office. | Does not exist | 1 |
| | | | In construction | 2 |
| | | | It exists | 3 |
| | | Compliance with legal requirements of the service provider. | Fails | 1 |
| | | | Improving | 2 |
| | | | Appropriate | 3 |

Source: own study.

### *2.4. Statistical Analysis*

The information was tabulated in an Excel® spreadsheet, software version 18.0. In the case of the data collected for the livelihood capitals, these were carried out in the MV pentagon, to identify the evolution scenarios around each of the contemplated capitals. Additionally, an analysis of the relationship that exists with each of the studied families and groups was carried out, using principal component analysis, R Software version 3.6.1, and the ggplot2, corrplot, and agricolae packages [28,29].

## 3. Results and Discussion

### *3.1. Characteristic Aspects*

This region of Colombia has been the main food pantry of the country as it has a wide diversity of micro climates, as well as significant cultural diversity, boosting primary economic activities as a fundamental factor for the region's gross domestic product (GDP).

More specifically, these two regions are characterized by their relevant agricultural vocation. In Oicatá, the production is predominantly potatoes (*Solanum tuberosum*), barley (*Hordeum vulgare*), oats (*Avena sativa*), bighead onion (*Allium cepa*), strawberry (*Fragaria*), apple (*Malus domestica*), and cattle farming for milk production. In Boyacá, the production consists of mainly potatoes (*Solanum tuberosum*), arracacha (*Arracacia xanthorrhiza*), corn (*Zea mays*), and types of broad beans (*Vicia faba*). For both locations, it demonstrates that agriculture is the main source of income.

Because of this, the configuration of family units conceive that labor activities from agriculture have a much more relevant role comparing working the land to permanence in an educational career [30]. It is important to highlight that the age group of 40 years and over is predominant in both associations ACUO and CAPAMUY, followed by the population between 11 and 20 years (Figure 3). In relation to the distribution by sex, it is evident that women predominate with 54.7% and 55.6% for Oicatá and Boyacá, respectively.

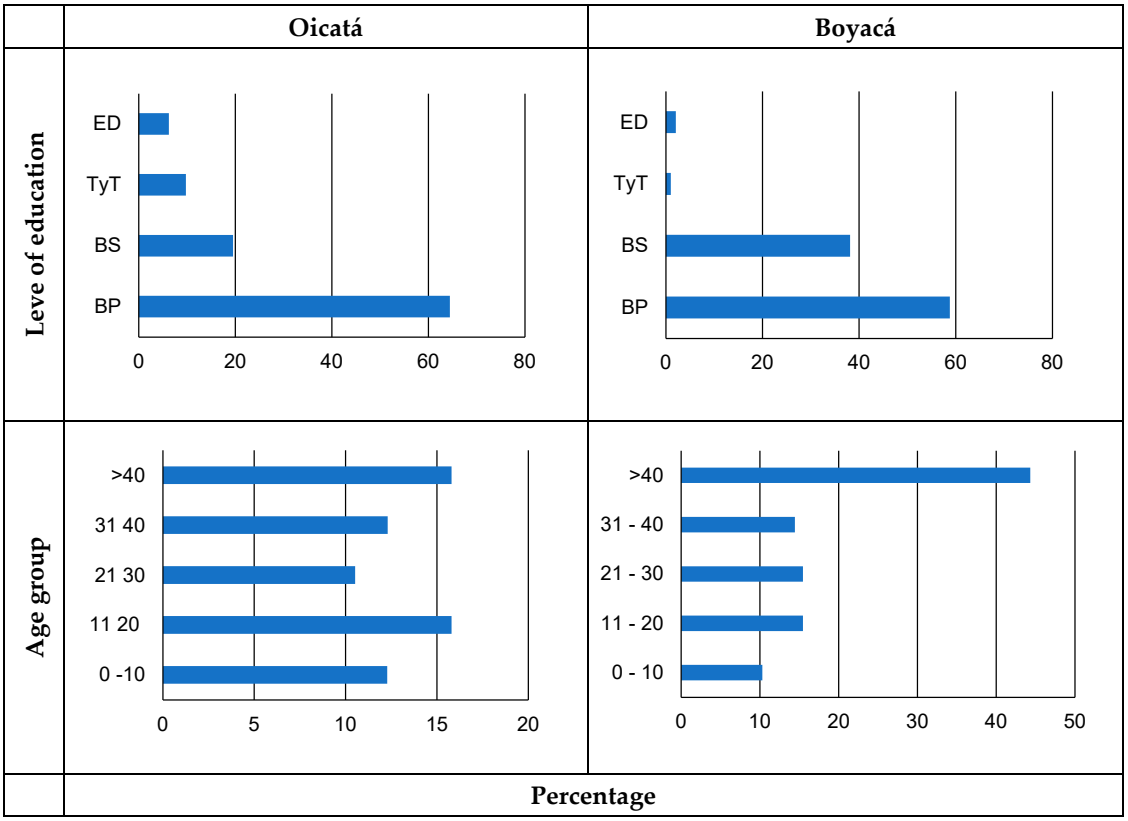



**Figure 3.** Characteristics of the users of the two rural aqueducts. (BP, basic education, BS, media education, TyT, technical and technological education, ED, higher education).

In relation to basic home services, it was observed that the aqueduct is the service to which people have the greatest access, followed by electricity. In the case of mobile phone connection, Oicatá stands out, while good condition roads, TV network, internet connection, and gas installation are the most critical services for users of this municipality (Table 2).

**Table 2.** Access to home services in users from both regions of the department of Boyacá—Colombia.

| Access to Public Services (%) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Municipality** | **Aqueduct** | **Electricity** | **Gas *** | **Telephony** | **Roads** | **TV** | **Internet** |
| **Oicatá** | 100 | 78 | 23 | 78 | 37 | 41 | 7 |
| **Boyacá** | 97 | 86 | 57 | 57 | 97 | 82 | 0 |

Note: * Propane/butane.

### 3.2. Livelihood Advances

Rates of livelihood capital show differences between the human and social capital aspects. This is the result of actions carried out by the communities around the aqueduct, and the use that is given for the development of economic and recreational tasks in the places of residence (homes and farms) (Figure 4). Furthermore, it is possible to show that the rural context in both municipalities is very similar in relation to the wealth of natural capital, and that it is mainly associated with agriculture of species like Laurel (*Litsea glaucescens*), Tuno esmeraldero (*Miconia squamulose*), Andean alder (*Alnus acuminata*), Arrayán (*Myrcianthes leucoxyla*), and Mortiño (*Vaccinium meridionale*) [31]. In addition, types of surface and underground water sources are highlighted [32], as well as the availability of financial resources that result from agricultural activities as the main economic activity and that have water resources as their protagonist.

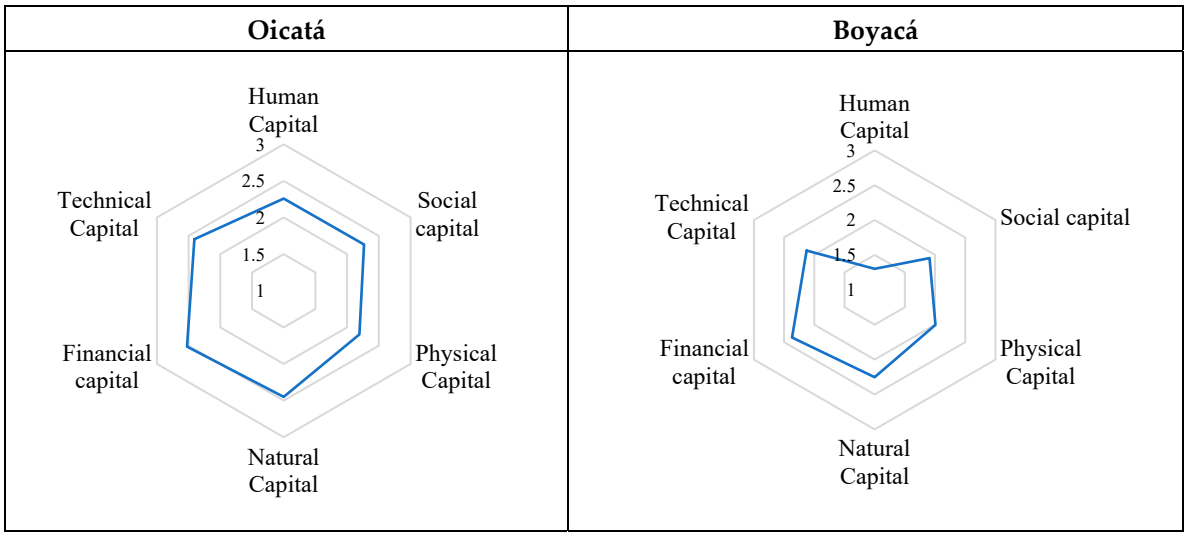



**Figure 4.** Indices of livelihood capital in users of two aqueduct organizations in the department of Boyacá—Colombia.

### 3.3. Multivariate Analysis

According to the principal component analysis (PCA), it is evident that the first two (Dim 1 and Dim 2) consolidate an accumulative variance of 65.4%; however, when including a third component (Dim 3), the cumulative variance was 78.5%, managing to discriminate its behavior on 131 users of the two aqueduct associations from both provinces in Boyacá. However, if a third component is added, the variance rises to 78% where variables such as technical, physical, financial, and natural capital are those that have the greatest impact on the variation rates from both groups (Figure 5). It is noteworthy that the studied users

have a greater correlation with the first two main components ($Cos^2$), showing that the associates present differential performances in the rates of livelihood capitals; despite being part of a same aqueduct association, life strategies are different regarding the availability, administration, and use of water resources

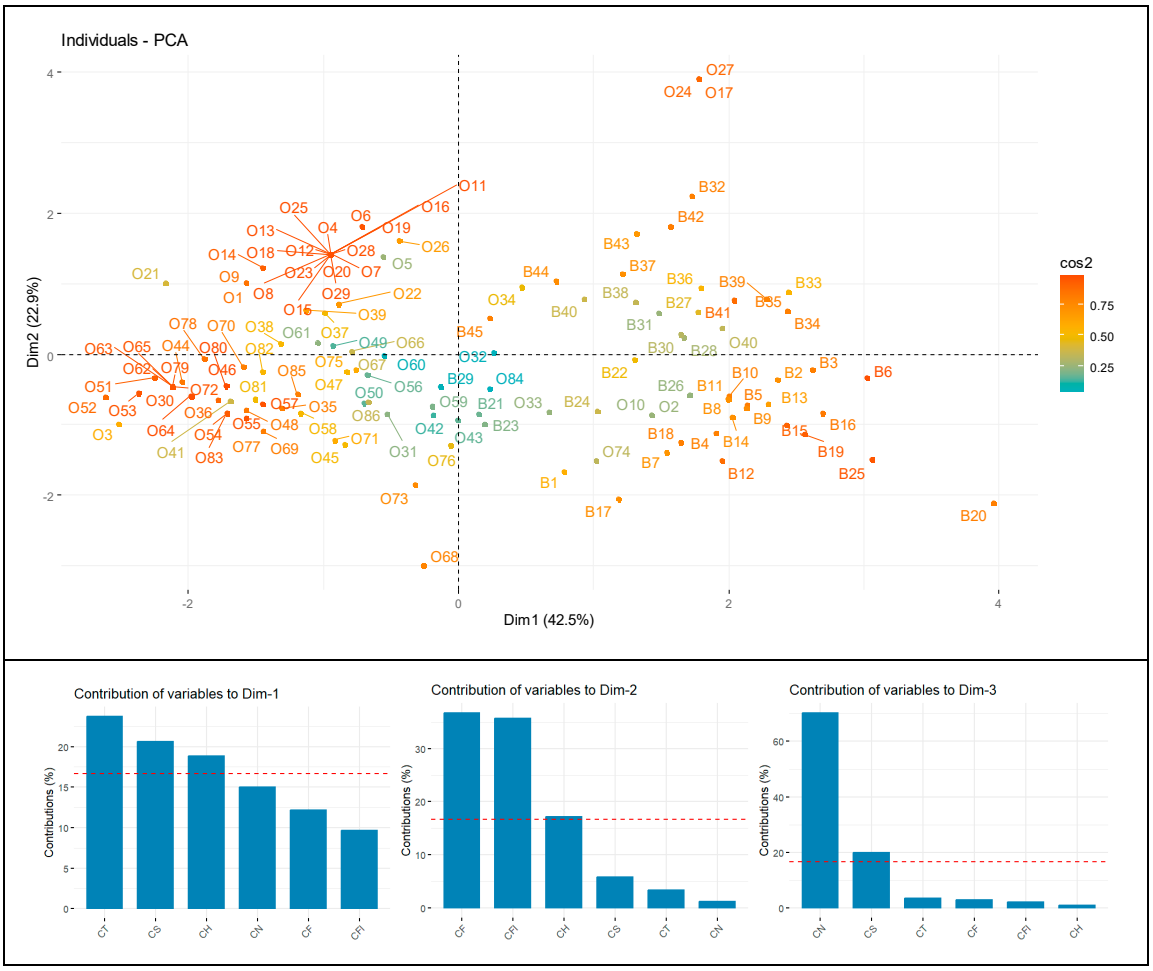



**Figure 5.** Correlation of the livelihood capitals of aqueduct users from two regions in the Department of Boyacá—Colombia. (CF: physical capital; CFI: financial capital; CH: human capital; CS: social capital; CT: technical capital; CN: natural capital).

Likewise, it is possible to show that the users who are part of the aqueduct associations show a distinctive pattern in relation to the livelihood rates according to the geographic area. For example, the Boyacá aqueduct shows a greater grouping of the blue points that represent the livelihood index of users according to the blue ellipse (more grouped points). In Oicatá, dispersion is wider represented by the brown ellipse with a larger radius (Figure 6A). In addition, it should be highlighted that the vectors associated with physical and financial capital had a greater relationship with the users of the Oicatá aqueduct, indicating high rates in their livelihoods. On the other hand, the third component (Figure 6B) highlights the efforts made by the users around the environmental capital, since a vector with a greater amplitude is evident when considering a third principal component (Dim 3).

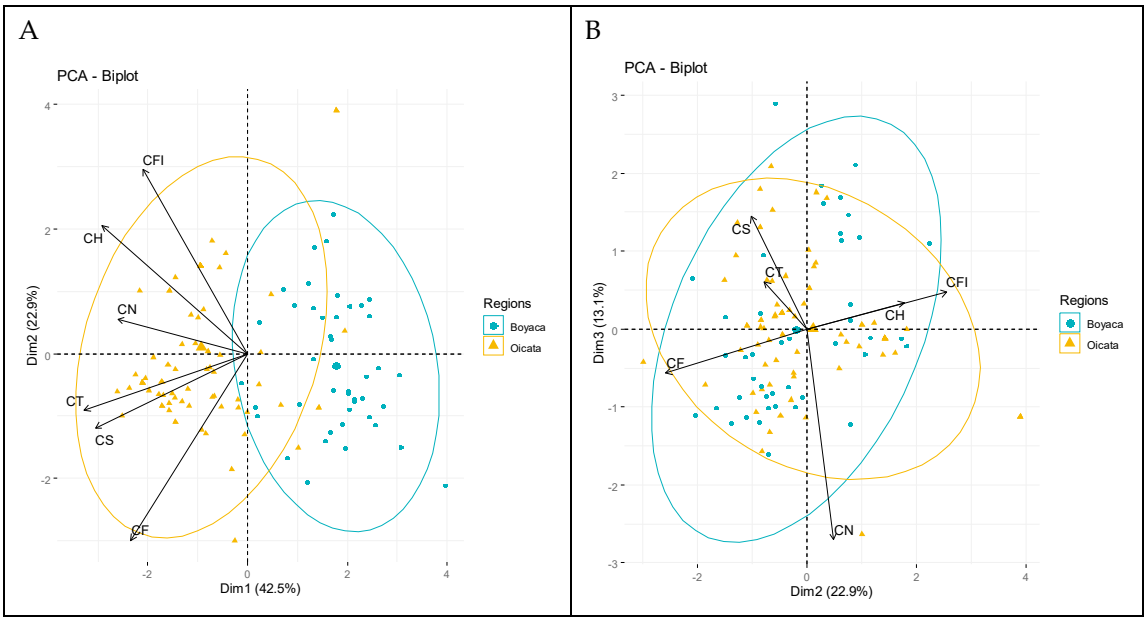



**Figure 6.** Analysis of principal components in Oicatá and Boyacá users. ((**A**), Component 1 and 2 relationships.), ((**B**), Component 2 and 3 relations), (**CF**, physical capital), (**CFI**, financial capital), (**CH**, human capital), (**CS**, social capital), (**CT**, technical capital), (**CN**, environmental capital).

### *3.4. Discussion*

According to the findings of the territorial analysis, it is worth highlighting that the central region of Colombia is characterized by its high diversity of species with nutritional interest, especially those around the daily provision crops, making it a diversified agricultural system. In this study, it was also identified that the majority members of the family gather around farming activities like plowing, planting, irrigation, and harvesting [33]. This information is supported by the Food and Agriculture Organization of the United Nations, who recognized women and children as having a fundamental role in food production, favoring rates for human rights around household nutrition and income acquisition that promote the financial well-being of family units [34].

In this sense, environmental capital becomes fundamental, especially regarding the availability of genetic resources (animals and plants), soil, and water, as vital factors for living well in rural areas [35]. According to [36], Colombia has shown that the lack of strategies and management of water for human consumption is commonly used for crop production, animal farming, or other traditional cultural uses, putting at risk the resource for the entire population of the region, due to excessive consumption in a few homes [37,38].

The households' income of families that are part of these rural aqueducts play a fundamental role as to access to basic needs; however, the average income for Oicatá users is USD 296.6 per month, while in Boyacá-Boyacá, it is USD 293 (dollar value as of 12/28/2023). This shows that there are no significant differences between the two populations, despite being below the legal monthly minimum wage established for the year 2023 by the Colombian government (USD 298.8).

The social analyses carried out in the central area of Colombia, especially those developed in the department of Boyacá, have allowed us to establish that this region is the result of an interaction between environmental and productive aspects, understanding that it is a smallholder region, with great agricultural products against other regions of the country [39]. However, municipalities like Oicatá often have problems due to the availability of water resources to maintain agricultural systems; therefore, the farmers take the alternative of establishing agricultural production using the water destined for human consumption, putting at risk the sovereignty of the resource and its availability for all users of the rural aqueduct.

The analysis of such means of sustenance outlines the reality of rural regions (especially those in peripheral areas around large population centers) to understand the social, economic, environmental, and political influence they have on the people from populated centers, as seen in the relationship between Oicatá (3047 inhabitants) and Tunja (187,286 inhabitants). It highlights the influence that the city of Tunja has on the quality of the water source of Oicatá, especially when understanding the impact that its proximity to the landfill and the release of wastewater could have in one of the most important water channels of the municipality [26].

Under this context, other problems arise, such as the lack of investment of resources to strengthen human capital and not having opportunities to access training, support networks, or cooperation initiatives. This situation is the result of the agricultural market, where the farmer is not recognized for his leading role in rural development, given the economic interest of the sector, which exceeds the expectations of the residents, and even the care of natural resources [40].

Regarding the natural capital, few differences were evident around the two regions. The low availability of the resource in both Boyacá and Oicatá shows that the administration of rural aqueducts—handled by their own communities—reveal a high level of resource management associated with strategies for use, quality, contamination, and water irrigation in association with inter-institutional alliances.

According to [41], Colombia is a country with rural areas that have a high level of vulnerability due to shortages of drinking water, which is why public institutions have designed a national policy for the comprehensive management of water resources (known by its acronym in Spanish, GIRH), allowing the associations and entities in charge of aqueducts to be more efficient around their governance.

Furthermore, the multivariate analysis show that families have differential actions regarding perception and management of water resources by understanding that water is fundamental for domestic chores and for establishing and developing agricultural systems, as evidenced by the contribution of technical capital in component 1 and 2 (Dim-1 and Dim-2). It is also worth highlighting that the family members' participation in the administration of the water resource, as well as the economic recognition for the service to the administrators of the aqueduct, offers a great diversity of positions within the PCA.

According to [42], a holistic way of understanding the relationship between users and the water resource is a multivariate analysis, as it allows us to understand the dynamics of the livelihoods of the populations in relation to the management of the resource; therefore, establishing routes of action that allow decision-making for prospective analyses regarding handle, administration, and identifying strengths and opportunities for improvement of the associates.

This analysis allows us to understand that aqueduct management can play a fundamental role in environmental education and water resource usage. Communication strategies within the organizations like meetings, financial reports, analysis of the impact of climate variability, and action routes associated with environmental risk management. Also, the quality of water resources for human consumption and adequate administration of water resources in homes are some of the main strategies that are developed in these two associations promoting efficiency of water supply, even for areas with a high climate risk index on drought periods [43].

It is worth mentioning that Oicatá presents a greater relationship with livelihood capitals as identified in PCA. Consequently, it is a municipality that has a high dispersion of associated families, due to the fact that the municipal aqueduct supply network is established in topographic areas with high slope, which directly affects the perception of the efficiency of the water resource by part of the users, and its impact on livelihoods. This situation is common in South American countries, where the influence of the Andes Mountain range modifies the connectivity strategies of the aqueduct network, as well as the quality of the water [44,45].

This natural capital continues to be the protagonist within the two regions. Both Oicatá and Boyacá are a reflection of the central region of Colombia, where the supply of water suitable for human consumption comes from areas with a high risk of deforestation or/or contamination due to commercial development and agricultural activities, that along with the flora diversity, mark a short route in relation to the conservation of ecological niches participating in the biogeochemical cycle of water [46], putting users and their role in the development of society at risk.

Furthermore, within the multivariate analysis, the direct correlation between human capital and financial capital, and technical capital and social capital, stands out. This behavior is the result of elements such as access to education according to the amount of economic income and the articulation of joint actions to strengthen the association of aqueducts regarding the water resource management processes as a philosophy of the aqueducts. This analysis agrees with [47,48], who spotted the strong relationship that exists within community organizations for water management and the social connections that arise from the supply of water, directly affecting human development and caring for natural capital towards the construction of social justice.

## 4. Conclusions

Community aqueduct organizations play a fundamental role in the construction of local and regional development, by directly influencing the capitals of livelihoods, especially in economic, social, and natural development. This is the result of participation processes that happen when choosing the leaders within the organizations, having an impact on the management of water resources, especially concerning the supply capacity, strategies established against shortages caused by climate change, and around the perception of resource management from the users who are part of the aqueduct.

The territories that are the most affected by the low availability of water resources due to the strong and periodic periods of drought have adopted contingency plans that address the low availability of the resource over time. However, situations such as the population growth and reduction in water resources—suitable for human consumption—generates a crisis around the appropriate development of the livelihoods of the users and residents of the municipalities of the central region of Colombia is compromised.

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