Neutrosophic Sets and Systems {Special Issue: Neutrosophy and Plithogeny: Fundamentals and Applications}, Vol. 69, 2024

University of New Mexico

Cognitive Mapping in the Study of Agricultural Orality in the Apagua Community

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Abstract. This research explores the application of neutrosophy to understand and address the inherent complexity in the oral transmission of knowledge in family agriculture. It leverages its ability to handle contradictions and ambiguities, facilitating a richer analysis of agricultural practices and social interactions. Orality, as the primary form of communication in these communities, is essential for the transmission of agricultural and cultural knowledge. This research highlights how orality acts as a vehicle for the preservation of collective identity and the transmission of ancestral knowledge. The study used Fuzzy Cognitive Maps (FCM) to describe the causal relationships between different variables of interest. Fieldwork was conducted between October 2023 and January 2024, using semi-structured interviews to capture the oral narrative of the farmers in Apagua. The analysis of the FCM showed that the components of cultural preservation and knowledge transmission are the most influential. This study demonstrated that neutrosophy is an effective tool for analyzing the complex dynamics of oral knowledge transmission in family agriculture. The conclusions underline the interdependence between knowledge transmission, social relationships, adaptation to changes, and cultural preservation.

Keywords: Ambiguity, information transmission, neutrosophy, FCM.

1. Introduction

Orality in family agriculture often involves narratives and knowledge that are both contradictory and complementary. Communities may have different interpretations and practices that coexist, which can be difficult to analyze with traditional binary approaches. Neutrosophy allows for effectively addressing these contradictions, offering a framework that accepts and works with ambiguity.

The transmission of knowledge through orality is highly subjective and varied [1]. Neutrosophy, with its ability to handle indeterminacy, is particularly suited to analyze how different individuals or groups may interpret the same facts differently, allowing for a richer and deeper analysis of social and cultural interactions.

In family agricultural communities, knowledge is passed from generation to generation, often in ways that are both traditional and adaptive to new circumstances [2]. Neutrosophy helps to integrate these diverse perspectives without prioritizing one over another, facilitating a more inclusive and holistic approach.

In the implementation of policies and programs aimed at improving family agriculture and preserving oral culture, neutrosophy enables the evaluation of the effects of such policies not only in terms of success or failure but also considering neutral or indeterminate outcomes, which can lead to more precise and effective adjustments.

By explicitly recognizing areas of uncertainty and neutrality, neutrosophy facilitates dialogue between different parties or groups with opposing interests within the community. This is crucial in environments where decisions about agricultural practices and knowledge transmission need to consider the voices of multiple stakeholders [3].

Applying neutrosophy in the socio-communicational analysis of orality and family agriculture provides a robust framework for understanding and addressing the complexity inherent in these systems. It facilitates a deeper and more nuanced understanding of community dynamics, which is essential for formulating development strategies that are sustainable and culturally respectful.

The community of Apagua was established on January 11, 1939, and is located in the Canton of Pujilí in the province of Cotopaxi. It is situated at an altitude of 4200 meters above sea level. A notable aspect of Apagua, which makes it relevant to the current research, is that 70% of its economically active population is involved in agricultural activities such as planting and harvesting potatoes, melloco, and beans, among other products. The population of Apagua is approximately 1500 people, most of whom are between the ages of 20 and 65. Additionally, it is important to mention that the inhabitants of the community speak Kichwa.

The name Apagua is associated with the production of a variety of potatoes called 'Apagua', introduced and cultivated by Augustinian religious in this area. These religions were dedicated to cattle ranching and the cultivation of agricultural tubers, involving indigenous companions in the work of this estate.

It should be noted that communication is intrinsically linked with orality, as through words experiences directed at others are transmitted and expressed; language acts as a medium for the transmission of thoughts and the strengthening of socialization between thinking and speaking [4]. Accordingly, oral communication plays a key role in the exchange and preservation of the customs and traditions of indigenous cultures, thus establishing orality as a fundamental basis for the preservation of knowledge that shapes collective identity within cultural groups.

In the communicative sphere, indigenous peoples have transmitted their information through oral language, through which, by means of conversations, information is transferred from generation to generation, preserving important events for the peoples without the need to resort to writing. Thus, the way in which peasant conversations that refer to traditional practices can be scientifically analyzed becomes relevant [5].

Among the elements to be considered, it is possible to identify that orality is classified into two parts (Figure 1):

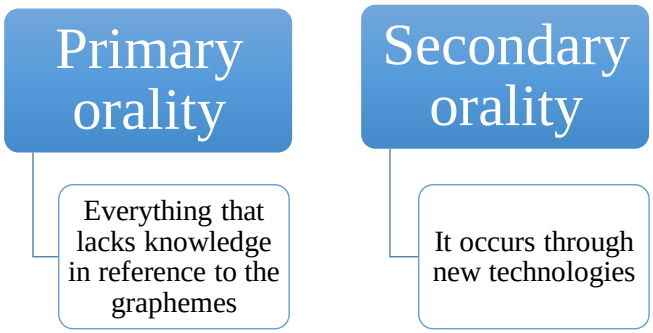

Figure 1: Classification of orality. Source: own elaboration

In this scenario and after reviewing the literature, it has been identified that various studies consider orality as the primary form of communication, as it allows the transmission of information in various ways. In the Latin American context, the process of orality has been analyzed using certain research parameters in relation to the recovery of speech as an effective strategy, not only for the reconstruction and preservation of ancestral traditions but also as a mechanism that facilitates dialogue about social and cultural trends [6].

In this same context, oral tradition plays a fundamental role in shaping a dynamic and creative culture. The exchange of stories creates a social space in which all elements that make up the identity of a group are shared and valued, avoiding exclusions or marginalization.

From the above, it can be seen that orality is linked to the essence of each people, as it allows preserving knowledge that is often also related to ancestry and the cultural heritage of the peoples, thus forming a cultural heritage that is maintained in families and transmitted from generation to generation. In this sense, the ancestral knowledge transmitted through orality gives meaning to the actions of social subjects and allows shaping a conception of present and future [7], [8].

In the case of Andean communities, stories, beliefs, knowledge, customs, and traditions that are loaded with meanings are involved. These narratives are part of the cultural heritage of the communities and, within the research conducted, there was an interest in identifying how knowledge related to agriculture is transmitted through orality.

The main objective of this study is to analyze how neutrosophy can be applied to understand and address the complexity of the oral transmission of knowledge in family agriculture in the community of Apagua. This approach seeks to capture the richness and variety of interpretations and agricultural practices that are transmitted from generation to generation, especially in contexts where contradictory and complementary narratives coexist.

2 Materials and methods

2.1 Fuzzy Cognitive Maps

Fuzzy Cognitive Maps (FCMs) extend over the range [-1, 1] to indicate the strength of causal relationships, see [9]–[11]. They describe the strength of the relationship using fuzzy values. FCMs allow for expressing causal relationships between variables, where each edge is associated with a weight in the set, where 0 indicates no causal relationship between the variables, -1 indicates an inverse causal relationship (if one variable increases, the other

decreases, and vice versa), and 1 indicates that there is a direct causal relationship (both variables increase or both decrease).

These three values do not capture the uncertainty that exists in these causal relationships, which is why Fuzzy Cognitive Maps emerge, where a gradation is introduced to the previous set of weights defined in the continuous interval [-1,1]. An FCM can be represented through a weighted directed graph. An adjacency matrix is constructed from the values assigned to the arcs generally in a numerical form [12].

In FCMs, there are three possible types of causal relationships between concepts:

- Positive causality ($W_{ij} > 0$): Indicates a positive causality between the concepts C_i and C_j, meaning an increase (decrease) in the value of C_i leads to an increase (decrease) in the value of C_j.
- Negative causality ($W_{ij} < 0$): Indicates a negative causality between the concepts C_i and C_j, meaning an increase (decrease) in the value of C_i leads to a decrease (increase) in the value of C_j.
- Non-existence of relationships ($W_{ij} = 0$): Indicates the absence of a causal relationship between C_i and C_j.

In this article, the calculation will proceed as follows:

1. Selection of relevant causals.
2. Elaboration of the adjacency matrix.
3. Static analysis: calculations are made for the absolute values of the adjacency matrix:
   - Outdegree, denoted by od(v_i), is the sum for each row of the absolute values of a variable from the fuzzy adjacency matrix. It measures the accumulated strength of the existing connections in the variable.
   - Indegree, denoted by id(v_i), which is the sum for each column of the absolute values of a variable from the fuzzy adjacency matrix. It measures the accumulated incoming strength of the variable.
   - The total centrality or degree of the variable is the sum of od(vi) with id(vi), as follows:

$$\text{td(vi)} = \text{od(vi)} + \text{id(vi)} \quad (1)$$

Finally, the variables are classified according to the following criterion, see [13]:

a) *Transmitter variables* are those with $od(v_i) > 0$ and $id(v_i) = 0$
b) *Receiver variables* are those with $od(v_i) = 0$ and $id(v_i) > 0$
c) *Ordinary variables* satisfy both $od(v_i) \neq 0$ and $id(v_i) \neq 0$

They are ranked in ascending order according to the degree of centrality.

When a group of individuals (k) participates, the adjacency matrix is formulated through an aggregation operator, such as the arithmetic mean. The simplest method consists of finding the arithmetic mean of each of the connections for each expert. For k experts, the final FCM adjacency matrix (E) is obtained as [14, 15]:

$$E = \frac{(E_1 + E_2 + \cdots + E_k)}{k} \quad (2)$$

2.2 Methodology

Fieldwork within the community of Apagua was conducted from October 2023 to January 2024. We operated under a qualitative approach, as we were interested in observing phenomena in their natural environment before analyzing them. We applied semi-structured interviews to consider oral narrative as an object of study within the research.

The criteria considered for the interview participants were as follows: male and female farmers aged between 24 and 70 years (Figure 2), engaged in agriculture and originating from Apagua.

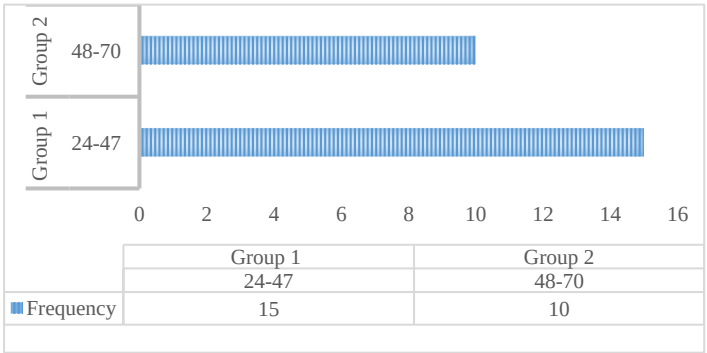

Figure2: Age groups. Source: own elaboration.

The topics covered in the interview script focused on four categories (knowledge transmission, social relationships, adaptation to changes, and cultural preservation). We highlight that during this process, the Pallamukuy Organization, affiliated with the Indigenous Peasant Movement of Cotopaxi (MICC), assisted us in establishing contact with community representatives, which allowed us to conduct interviews with various actors who have experiences and knowledge related to agriculture.

Once access to the community was obtained, interviews were conducted in the sectors of Corralpungo, Chilca, Milin, Redrován, Conucto, and Agua Centro. The interview script was structured through four categories and nine subcategories, which allowed for a deeper analysis of orality and family agriculture in the community of Apagua (Table 1).

Table 1: Categories and subcategories, interviews with farmers from the Apagua community, Pujilí canton, Cotopaxi province. Source: own elaboration.

Category	Subcategory
Knowledge Transmission	1a. Transmission of agricultural knowledge. 1b. Family stories in teaching agricultural techniques. 1c. Main sources of information on agricultural experiences and knowledge.
Social Relationships	2a. Interpersonal relationships between families. 2b. Verbal interactions and collaboration among families.
Adaptation to Changes	3a. Adaptation of new tools and machinery. 3b. Successful adaptation experiences.
Cultural Preservation	4a. Preservation of cultural identity. 4b. Stories that highlight the importance of maintaining traditional agricultural practices.

Once the interviews were conducted, open coding was developed to analyze the corresponding variables. This activity belongs to the analytical process where the researcher must identify basic concepts related to the text while discovering the same characteristics and dimensions through the narratives of the interviewees. After this process, the most important and representative fragments were selected and redundant data from each category were removed to avoid theoretical saturation. Subsequently, the responses obtained in the survey were combined with the results of the application of the fuzzy cognitive map for a more comprehensive assessment.

3 Results and Discussion

Once the corresponding analysis was conducted for each category, we proceeded to present the most relevant results in each of the areas previously outlined that structured the script of the research:

Category 1. Transmission of Knowledge.

The transmission of knowledge contributes to human personal and social development and establishes relationships with other individuals. Disseminating and sharing experiences through language is an activity that continues not only in indigenous communities but in any daily activity or geographical situation.

Testimonies identified that orality plays a very important role in ancestral communication, as it presents a path that allows the construction and transmission of agricultural knowledge through the voices of the actors themselves, such as our ancestors.

According to the results of the interviews, it is highlighted that agriculture in the Andean world is passed from generation to generation, as from an early age parents share activities linked to agriculture (land preparation, planting, and harvesting) with their progenitors.

For this reason, within the analyzed context, it is considered appropriate to explain and take children to agricultural activities together with their parents, as a result, they acquire knowledge that allows preserving wisdom and improving implemented techniques.

In agricultural activity, several processes are also required, such as the application of fertilizer in the soil after using the plow or after 'tolar'. Within this context, practices that have been used for a long time in the community within the planting process become important.

After the planting period, the harvest proceeds, of different products such as potatoes, beans, melloco, oca, mashwa, barley, carrot, beet, cabbage, and onion, these products are still maintained in the families of the Apagua community.

Through this dialogue, an important aspect that was highlighted was the collective minga, a tradition that consisted of unpaid work for a community or family. It is mentioned that "it has been like a kind of party for example the planting of potatoes after planting has been almost culturally like a wedding where guinea pigs, chickens, a lamb are killed."

Moreover, after planting they usually meet to share their products and at the same time engage in conversation with other individuals (neighbors), where they used to tell their stories, experiences, and anecdotes of their ancestors, there is much knowledge, much wisdom, through orality, grandparents share various stories about the proper process for planting and harvesting products in the chacras (family orchards).

Therefore, it can be seen that orality is very important in the transmission of knowledge, as it gives meaning to social activities through various interactions.

As already mentioned, orality has been from the beginning the first system of human expression, which gives us access to a cultural world full of knowledge, therefore, it is necessary to emphasize that history can also be told from the experience of the social actors of the community.

Another relevant aspect is that the community members of Apagua feel concerned to see that these stories and knowledge are being lost, since, not being written or disseminated in any physical or digital format, they run the risk of being forgotten, since currently within the community there is a minority of older adults who can still transmit their knowledge to new generations.

Therefore, orality is just as relevant as written forms of expression, in the case of orality the capacity to delve into both individual and collective memory takes on importance, which aids in the exchange of knowledge, this particularity can be enhanced by writing to safeguard knowledge.

Category 2. Social relations

While it is true that social relationships constitute a fundamental basis within the daily life of social groups, these interactions can involve various aspects. In the case of our research, for example, we identified that there is a direct link between orality, festivities, and agriculture.

Social relationships are differentiated by considering the level from which they are observed, such as interactions, organizations, and society. Therefore, the externalization of relationships as events suggests relationships are understood as interactions; however, in any case, structure and events are always co-present.

On the other hand, the family nucleus is the cultural support where the basic rules and norms of coexistence emerge, allowing the acquisition of skills for relationships and emotional control. In this sense, within the testimonies, and the result of interviews, it was found that most affirm that they still share these pieces of knowledge, stories, or tales from their grandparents to their children, grandchildren, and neighbors.

Another important aspect of social relationships is coexistence, solidarity, and reciprocity, which have been fundamental elements for agricultural work. The community of Apagua has traditions of Makita Mañachi (reciprocity) and Randy Randy (solidarity), these festivities are related to the community dynamics since previously to ask neighbors for help with planting and harvesting, they had to bring them some items like machica, potatoes, guinea pigs, and wedding gifts to formally ask for help. This activity serves as a symbol of showing respect towards the family and strengthening community bonds. These aspects directly influence the strengthening of the Andean people through community coexistence.

Therefore, it is important to highlight the relevance of orality within the family as it allows for articulating the collective dynamics with different field activities. Within this scope, it is worth noting the role of the women of the Pakarimuy organization who promote strengthening strategies for family agriculture. This organization aims to maintain its customs and traditions through orality; hence they have sought to spread the importance of the community's knowledge through media and digital platforms.

Therefore, social relationships go hand in hand with orality and communication, as they are the fundamental basis for all kinds of activities, organizations, and planning. Throughout our research, we identified how this is reflected in agricultural activities and that from generation to generation has allowed obtaining good production and at the same time maintaining a bond with the community.

Category 3. Adaptation to changes

In the context of family farming, each community has particular characteristics regarding soil preparation, seed selection, planting, and harvesting. This knowledge involves skills and experiences accumulated over generations, which allow for the improvement of agricultural practices. The way of life of people in the countryside has been crucial for production through the traditions of the taitas and mamas. This has led to the continued maintenance of ancestral knowledge and improvements with the implementation of machinery, fertilizers, and fertilizers.

It can be seen that the tractor is a very helpful tool for agriculture, but it is equally harmful to the soil since being heavy machinery, and exerting strong pressure on it tends to wear it out. It was mentioned that, in the past, there was a yoke, where they worked in mingas, performing the same activities as their grandparents. Also, the previous use of horses, donkeys, and mules, which were used to plow the soil, extract the grains, and take them to

the fairs, but this activity lasted several days and weeks. Currently, there are machines to shell corn and a threshing machine for barley. This has been an important contribution to agriculture because it speeds up the work of the farmers.

After analyzing several interviewees, it is evident that although innovation is a help for humans, the majority of the inhabitants of Apagua prefer to continue working in the traditional way, with manual labor, with the hoe and organic manure from animals, thus preserving the ancestral knowledge, since their ancestors always mention that the preservation of Pachamama is important for good living.

Category 4. Cultural preservation

Cultural preservation ensures that ancestral knowledge is kept for future generations, as through stories, tales, and myths, various traditions, customs, and festivals in honor of Pachamama have been generated. In this sense, all human beings experience community coexistence in terms of individual well-being and development (social, personal, economic) to improve quality of life.

In the Andean context, the diverse and ancient culture of the communities has been a reference for the exchange of knowledge through different festivals such as Inti Raymi (festival to the fertility of Mother Earth), Kulla Raymi (cult to the fertility of Mother Earth), Kapak Raymi (royal festival dedicated to germination) and Pawkar Raymi (festival to Pacha Mama).

Communities must continue maintaining these types of festivities, where they can interact not only with their relatives but also with people from other cities different from their culture. This helps to continue strengthening identity, and a sense of belonging, and at the same time interweaving customs and traditions.

To conclude, it is necessary to recognize that orality plays a very important role in the transmission of agricultural knowledge, as it facilitates communication, and promotes development, and social bonding. That is why, currently, in Apagua, family meetings have been chosen, including neighbors to maintain this agricultural knowledge to this day.

Following the line of the basic elements of the study, the experts analyzed the dimensions previously evaluated, from the point of view of the causal relationships between them. The development of the study is shown next in Figure 3, Tables 2 and 3.

Table 2: Adjacency matrix. Source: own elaboration

	Knowledge transmission	Adaptation to changes	Cultural preservation	Social relationships
Knowledge transmission		0.45	1	0.34
Adaptation to changes	-0.33		0.13	0.46
Cultural preservation	1	-0.39		0.7
Social relationships	0.19	0.3	0.28	

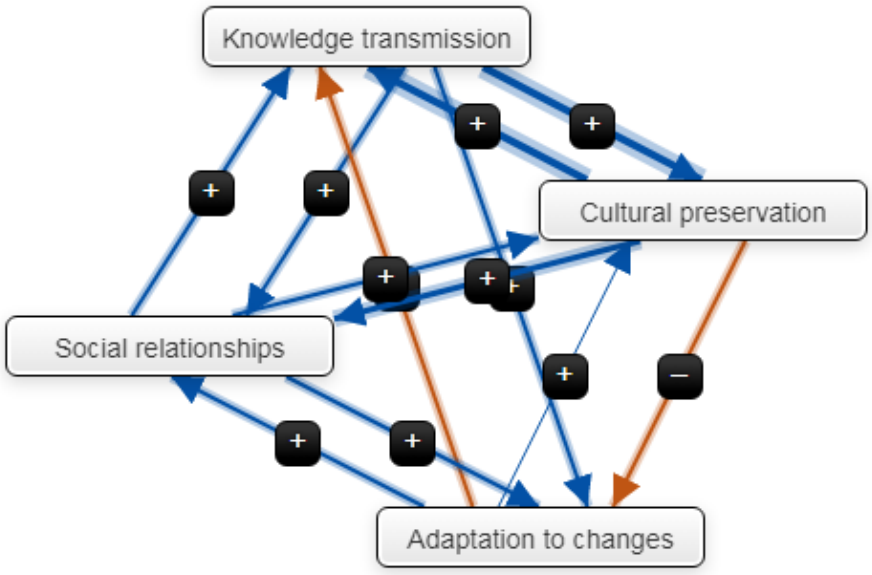

Figure 3: Fuzzy Cognitive Map. Source: own elaboration.

Table 3: FCM centrality analysis. Source: own elaboration.

Components	Indegree	Outdegree	Centrality	Type
Knowledge transmission	1.52	1.79	3.31	ordinary
Social relationships	1.5	0.77	2.27	ordinary
Cultural preservation	1.41	2.09	3.5	ordinary
Adaptation to changes	1.1400000000000001	0.9200000000000002	2.0600000000000005	ordinary

The interpretation of the centrality analysis reveals that Cultural Preservation and Knowledge Transmission are the most influential components, suggesting that interventions or policies focused on these aspects could have a broad impact on the network. Social Relationships, although relevant, seem to act more as receivers of influences than as transmitters, which can be significant when considering social intervention strategies. Adaptation to Changes requires more support or reinforcement to increase its capacity to influence the network, especially if the goal is to improve the resilience of a community or system.

Focusing on the interaction between both research efforts, the survey results were combined with the FCM to observe how they reflect and interconnect in terms of knowledge transmission, social relationships, adaptation to changes, and cultural preservation (Table 4).

Table 4: Fusion of methods. Source: own elaboration.

Category	Survey	FCM
Knowledge Transmission	Orality is highlighted as a crucial medium for the transmission of agricultural knowledge and ancestral practices in the Apagua community. The importance of generational interaction for the preservation of ancestral knowledge is emphasized.	This component is central in the matrix and shows a significant relationship with Cultural Preservation. Strengthening the oral transmission of knowledge is an effective way to preserve culture and improve social relationships in the community.
Social Relationships	Festivities and coexistence in agricultural activities strengthen social relationships and are essential for the transmission of knowledge. Orality facilitates cohesion and the strengthening of community ties.	It is influenced by other factors but has less external influence. Promoting activities that involve orality in a community context increases the influence of social relationships on other cultural and adaptive aspects.
Adaptation to Changes	There is a preference for maintaining traditional agricultural practices despite the introduction of modern technologies, reflecting resistance to change that affects the land. Technological adaptation is valued as long as it aligns with ancestral practices and respect for the land.	It has moderate influences on other components and vice versa. Interventions that seek to promote adaptation must consider ancestral knowledge and the needs of the community, integrating technologies that respect practices and the land.
Cultural Preservation	Culture and ancestral practices, such as festivals and planting according to the lunar calendar, are vital for community identity. The transmission of these knowledge and cultural practices is at risk due to a decline in oral transmission between generations.	This component has the highest degree of influence on other components and significant centrality. Reinforcing cultural preservation through formal and non-formal education can ensure the continuity of these ancestral practices and knowledge.

Combining these findings reveals the interdependence between knowledge transmission, social relationships, adaptation to changes, and cultural preservation. The most effective strategy for sustainable intervention would be one that not only addresses each of these components in isolation but seeks to strengthen them holistically, recognizing and leveraging their interconnections.

4 Conclusion

This study has demonstrated the richness and complexity of oral knowledge transmission in the community of Apagua, an essential nucleus in Andean family agriculture. The use of neutrosophy and Fuzzy Cognitive Maps (FCMs) has enabled a deeper and more nuanced analysis of the cultural and social dynamics that characterize this community.

The narratives and experiences shared orally between generations are fundamental for preserving ancestral techniques and knowledge. These practices are transmitted not only as practical instructions for agriculture but also as stories and anecdotes that reinforce cultural identity and social cohesion. Neutrosophy proved to be an effective framework for analyzing the complexity and contradictions inherent in these narratives, allowing for a more nuanced understanding of how knowledge is transmitted and evolves within the community.

Social relationships in Apagua are intrinsically linked to agriculture and orality. Festivities and collective agricultural activities, such as the minga, strengthen these ties, facilitating the exchange of knowledge and experiences. Orality not only serves to transmit technical information but also to maintain and reinforce networks of solidarity and reciprocity. The use of fuzzy cognitive maps revealed that, although social relationships are influenced by other cultural and knowledge factors, their capacity to influence other aspects is less direct. Enhancing these relationships through community activities could increase their effect on other cultural and adaptive aspects.

In Apagua, there is a clear preference for maintaining traditional agricultural practices despite the introduction of modern technologies. This resistance to change reflects a deep respect for the land and a valuation of ancestral practices that align with the care and preservation of Pachamama. Interventions to encourage adaptation must integrate these perceptions, using technologies that respect traditional practices and the land. Adaptation should not be imposed but should arise from dialogue and the integration of ancestral knowledge with appropriate innovations.

The preservation of culture and ancestral practices is crucial for the community identity of Apagua. The transmission of knowledge and cultural practices is at risk due to a decline in oral transmission between generations. Strengthening cultural preservation through formal and informal education can ensure the continuity of these practices and knowledge. The analysis showed that cultural preservation has the greatest degree of influence on other components, highlighting the importance of interventions focused on this aspect to have a broad impact on the community's network of knowledge and practices.

This study underscores the need for an integrated and respectful approach to intervention and development in Andean indigenous communities like Apagua. Neutrosophy and fuzzy cognitive maps have provided a rich and detailed perspective that allows for understanding and working with the complexity of orality and family agriculture, paving the way for more effective and culturally coherent policies and programs.

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Received: February 22, 2024. **Accepted:** June 12, 2024