

Challenges and opportunities of collaborative management and university social responsibility of Adaptation to Climate Change in the community of Mangomarca (oasis of fog) in Lima, Peru

Rita J. Cabello-Torres, MSc¹, Eduardo R. Espinoza Farfán, DSc¹, Carlos A. Castañeda-Olivera, DSc¹, Edison A. Romero-Cabello², María C. Alegría-Arnedo, MSc²

¹Escuela de Ingeniería Ambiental, Universidad César Vallejo, Lima, Perú, rcabello@ucv.edu.pe, eespinozaf@ucv.edu.pe, carcalcaso@gmail.com

²Universidad Nacional Agraria La Molina, Lima, Perú, ediromero2000@gmail.com, calegria@lamolina.edu.pe

Abstract—The Mangomarca fog oasis in Lima is an important regulation and service system that is subject not only to the impacts of climate change, but also to land trafficking, illegal invasions, and pollution; which has generated serious environmental deterioration and loss of biodiversity. Due to this situation, the Cesar Vallejo University, within the framework of university social responsibility in accordance with its interest groups and service-learning, participates with the community and the Ecotourism Association of the area. The purpose is to preserve the Mangomarca ecosystem by seeking collaborative solutions and alliances that promote a better quality of life. An analysis of the system that today exerts actions and pressures on the Mangomarca fog oasis is made. Challenges due to the negative impacts caused by the covid-19 pandemic are identified and collaborative strategies for resilience to climate change are developed, in the context of sustainable development.

Keywords— climate change, ecotourism, social responsibility, biodiversity, Fog Oasis of Mangomarca

I. INTRODUCTION

The effect of climate change on fragile ecosystems has forced human beings to assume changes in the way of thinking and acting, there is a series of interrelated challenges that cannot be solved unilaterally [1]. It is important to include biodiversity [2] and direct efforts without neglecting the objectives of sustainable development [3]. The fog oases of Mangomarca, located between 11°59'51”S and 76°58'30”W, in Lima (Peru), is a source of different ecosystem services [4], and of temporary buffering, mainly in autumn and winter periods. Much of this ecosystem is located in the district of San Juan de Lurigancho and its main characteristic is its fragility, it is covered with ephemeral vegetation and permanent species that favor the development of biodiversity during the wet season [5], which gives rise to a large number of endemic species. In 2014, the fog oasis had an approximate area of

516.10 ha of natural cover [6] with intense vegetation above 400 meters above sea level [7]; however, for 2020 a reduction in vegetation cover of 7.6% has been calculated [8]. In addition, conflicts over land ownership did not allow its official legislation as part of the Oasis Zone of Coastal Fog of Metropolitan Lima, land trafficking, indiscriminate invasions and even the construction of a highway that reaches the top of the oasis of fog, has caused a strong pressure and a risk for its conservation. Tourist activities are developed through an association of the community surrounding the ecosystem since 2013, which has become the main defender of its protection. Figure 1 shows the factors and actors that directly influence its conservation.

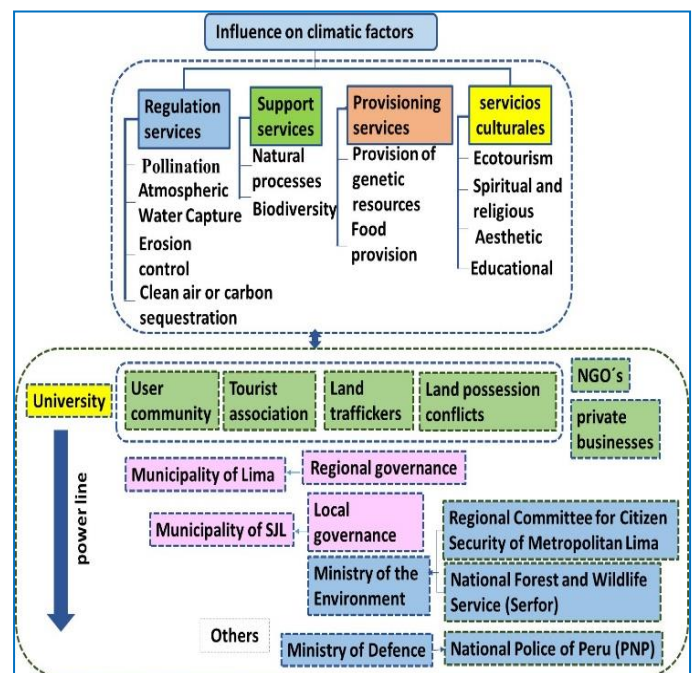


Fig. 1. Ecosystem services, pressures and actors that influence the fog oasis of Mangomarca

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Given this situation, the Cesar Vallejo University maintains a teaching-learning curriculum, which includes the participation of interest groups made up mainly of representatives of organized civil society, companies, graduates and authorities, among others; with the purpose of reviewing institutional policies and objectives and strengthening the profile of its graduates, in the face of current needs considering the objectives of sustainable development. The university becomes an academic actor with social responsibility and the ability to integrate the different groups related to the use of the fragile ecosystem of Mangomarca. The purpose is to contribute to promoting collaborative governance for adaptation to climate change and sustainable development, in the face of a critical situation marked not only by illegal activities in the area but also by the COVID-19 pandemic, which affects the most populous city from Lima. In this way, it is intended to develop innovative solutions with the active contribution of the actors involved [9].

The School of Environmental Engineering of the San Juan de Lurigancho campus has focused its attention on strengthening the capacities of organized society and the most vulnerable population that uses the Mangomarca fog oasis ecosystem. From this perspective, the teaching-learning, research and social responsibility processes were evaluated, based on the educational management processes developed by the university, translated into short, medium and long-term projects. The objective of this research was to analyze the challenges and opportunities of collaborative management and university social responsibility for adaptation to climate change in the community of Mangomarca (fog oasis) in Lima, Peru. For this, the factors that exert pressure on the Mangomarca ecosystem (figure 2), in the midst of climate change and the covid 19 pandemic, were analyzed based on the participation of the university in the group of actors. The future spaces that must be faced considering collaborative approaches to adaptation to climate change and nature-based solutions in balance with sustainable development are evidenced. In this analysis, cultural, institutional, political and natural aspects have been considered [10].

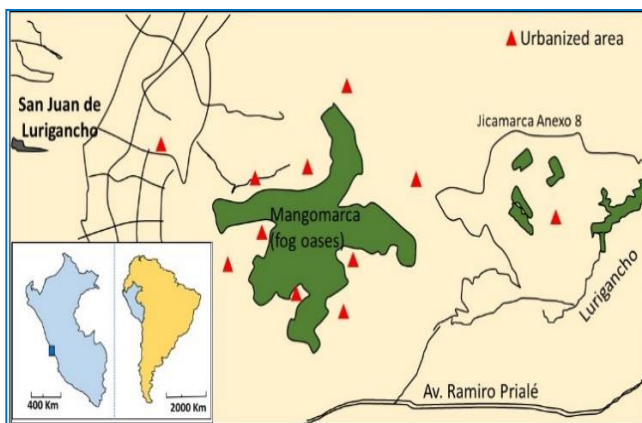


Fig. 2. Mangomarca fog oasis

A. Participants

First, the professors and students of each Professional School of the César Vallejo University meet periodically with the interest groups and, consequently, the University Social Responsibility in charge of the School of Environmental Engineering decided to strengthen the capacities related to Environmental Management. For this, the interest group analyzed the political, economic, sociocultural, technological and environmental variables and consequently, the teachers and students of the different subjects carried out a SWOT (strengths, weaknesses, opportunities, and threats) analysis, to propose a strategic vision of the most appropriate solution.

The participants directly involved in this research were the members of Civil Society, residents of the Mangomarca ecosystem, ecotourism association, who were interviewed by students from various curricular experiences such as: environmental management, pollution, soil treatment, biology, economic valuation, etc. The purpose of the study was explained in detail to each interviewee, respecting their anonymity and right to confidentiality.

The actors of interest are the General Directorate of Solid Waste Management of the Ministry of the Environment, the Environmental Quality Assessment Subdirector of the Environmental Enforcement Agency (OEFA), the presidency of the Peruvian Association of Sanitary and Environmental Engineering, the presidency of the ecotourism associations of Primavera and Mangomarca (fog oasis), as well as representatives of private companies and local governments and guests. Generally, the authorities directly involved are willing to collaborate with other institutions inside and outside the government, facilitating the implementation of actions for adaptation and protection of natural ecosystems [11].

B. Data acquisition and analysis

In 2019, a direct rapprochement began between the teachers and students of the curricular subjects of the San Juan de Lurigancho Headquarters, with the residents and the Oasis de Mangomarca Ecotourism Association, through the application of interviews and field visits. This interview was carried out before the Covid 19 pandemic began, to learn about the shortcomings, limitations, problems, qualities, benefits, linked to adaptation to climate change and the sustainable development of the community; with visions of collaborative governance and nature-based solutions. Once the preliminary information was collected, periodic workshops were organized between government actors, civil society and the university academic community. However, the covid 19 pandemic abruptly cut off all communication. When the pandemic situation presented the descent of the "wave" the workshops were resumed virtually, with the aim of analyzing the context of temporary recovery of the ecosystem and the strengthening of an ecological culture in the resilient inhabitants of the pandemic

and users. Likewise, documentary sources have been analyzed, especially related to nature-based ecosystem solutions [2, 3] and the challenges of collaborative governance for adaptation to climate change in the face of its negative impacts [10, 21,19]. Projects and conservation studies of fog oasis in Lima have also been analyzed [4, 7, 8, 24]. Another relevant aspect analyzed was the variation of vegetation and soil cover, due to urban expansion [12, 23]; studies on the resilience of ecotourism in the face of the covid-19 pandemic [15] and the urban political ecology of fog oases in Lima [16]. This has evidenced the situational state of the Mangomarca fog oases and the need for academic action within the framework of University Responsibility.

III. RESULTS AND DISCUSSION

A. Prioritization of multicriteria and strategies

The environmental situation of the fog oasis of Mangomarca is not exceptional in terms of environmental deterioration. The main components that compose it are described in figure 3.

From the field visits, carried out by teachers-students, review of current documents and the criteria of the specialists, the criteria shown in table 1 were determined:

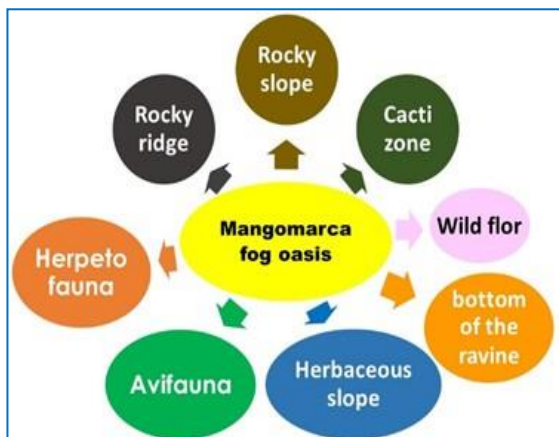


Fig. 3. Main characteristics of Mangomarca fog oasis

TABLE I. EVALUATION CRITERIA

Criteria	Description
C1	Degraded natural resources
C2	Deforestation due to felling of primary trees
C3	Biodiversity loss
C4	Imbalance in the food-ecological chain
C5	Soil erosion
C6	Fragmentation-isolation of populations
C7	Pollution (soil, air, water)
C8	Species migration
C9	Illegal hunting
C10	Land traffic
C11	Illegal land invasions
C12	Destruction of flora and fauna
C13	Unsuitable habitat

Under the multi-expert approach, the causal relationships of the criteria established in a range of importance (1-5), were resolved by applying the inverse matrix method, the results of which are shown below.

The results of this application defined the ranking of prioritized attributes C11, C3, C10; C12, C9, C13 and C8. Likewise, the application of the SWOT methodology, for the strategic planning of university action, resulted in table 2 and 3:

TABLE II. EVALUATION CRITERIA

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃
C ₁	1	1	0.2	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
C ₂	2	1	0.2	0.3	0.3	0.3	3	3	0.3	0.2	0.2	0.2	0.3
C ₃	5	5	1	5	5	5	5	0.3	0.3	5	5	5	5
C ₄	2	3	0.2	1	3	5	3	3	3	0.2	0.2	0.2	0.3
C ₅	3	3	0.2	0.3	1	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3
C ₆	3	3	0.2	0.2	3	1	4	0.3	0.3	0.2	0.2	0.3	0.3
C ₇	4	0	0.2	0.3	3	0.3	1	0.3	0.3	0.2	0.2	0.2	5
C ₈	3	0	3	0.3	3	3	3	1	0.3	0.2	0.2	0.2	4
C ₉	3	3	3	0.3	3	3	4	3	1	0.2	0.2	0.2	0.3
C ₁₀	5	5	0.2	5	5	5	5	5	5	1	0.3	4	0.3
C ₁₁	5	5	0.2	5	5	5	5	5	5	3	1	5	5
C ₁₂	5	5	0.2	5	5	3	5	5	5	0.3	0.2	1	5
C ₁₃	5	3	0.2	3	3	3	0.2	0.3	3	3	0.2	0.2	1

TABLE III. SWOT RESULTS

STRENGTHS	OPPORTUNITIES
Institutional alliances provide constant support, in addition to government, business and society.	Reduce exposure to climate hazards
Support from teachers, university students and volunteers for the benefit of the Mangomarca ecosystem.	Options to promote the development of ecotourism.
Diversity of scientific research about the foggy oasis of Mangomarca.	Climate change provides research opportunities.
Ecotourism incentive.	Conservationist interest on the part of educational institutions, NGOs and the state.
Mangomarca is a bank of genetic resources	Options to promote sustainable development.
Entrepreneurship-ecobusiness	Climate change offers new alternatives and develops the capacity to adapt
WEAKNESSES	THREATS
The covid 19 pandemic limits face-to-face participation	Changes in natural structure, resources and biodiversity due to climate change
Budget Priorities	Land invasion in the foggy oasis of Mangomarca.

Integration of objectives at the national level	Presence of Solid Waste Informal pig farming
	Little tourism in the dry months.
	Lack of environmental culture of tourists
	Disaster risk from climate change
	Unstable political and economic environment

B. Research and Social Responsibility

Research on the physical changes of the ecosystem carried out between 2000 and 2022, showed a rapid deterioration, with loss of soil (143.8 Ha), of vegetation cover (273.7 Ha) and loss due to urban expansion (97.5 Ha) [12]. The investigations are carried out within the formative cycles, and in the final cycles. An estimate of the economic value of the ecosystem service for carbon storage of aerial, underground and necromass biomass for the actual total area (475.74 Ha), assigned a monetary value of annual income of 205423 US [13], which shows the economic performance of the ecosystem.

On the other hand, the level of involvement of environmental engineering students and their teachers in the field of social responsibility has allowed the development of a series of activities that respond to the establishment of a short-term strategy. For example, signage and visiting routes for tourists, development of awareness workshops in the community surrounding Mangomarca, workshops with the participation of central and local representatives, as well as NGOs. It has been tried to create an ecological awareness and culture, whose strategy includes collaborative education with society. This is because universities around the world are increasingly aware of their responsibility to empower their students and society to actively reduce and embrace climate change [14].



Fig. 4. Group of volunteers in different short-term actions, such as route signs, ecosystem protection notices, reforestation.

C. Collaboration process of the actors involved in the protection, conservation and adaptation to climate change

Climate change adaptation activities included workshops to approach vulnerable communities, but sporadic during the covid 19 pandemic. It is important to note that in Lima, the Peruvian capital, the fragility of the Mangomarca ecosystem deserved special attention, not only because of climate threats. but also anthropogenic that accelerate its degradation and loss of biodiversity [15]. Despite the efforts to conserve the Mangomarca ecosystem by the Ecotourism Association made up of residents of the area, external threats have turned out to be very strong. The institutional approach of the University and aware of its institutional strength that favors joint actions with the community, has been evolving in support of collaborative governance, from planning, program execution, to evaluation. To reach this conclusion and build resilience or adaptation to change, in 2018, teachers and students contacted the members of the Ecotourism Association, and the local population, through organized dialogues and interviews, as well as field visits, giving rise to the elaboration of short, medium and long term strategies.

Consequently, the approach generated a link and trust with this group of actors, for which meetings and workshops were organized with the participation of different representatives of the central, regional and local government, as well as NGOs, etc., this made it possible to raise the main problems that threatened Mangomarca, to strengthen the priority criteria in the face of external climatic and anthropic threats. The first stages focused on establishing consensus, not on managing private benefits, the students and teachers got involved with the Association and the neighbors, initiating a sense of shared responsibility in the process. In addition, training courses linked to community entrepreneurship have been started, such as the development of eco-businesses based on the transformation of solid waste, into soil quality improvers such as compost or biochar, the latter included in the purification of water. . Other aspects involved are the management of orchards and nurseries in times of pandemic, among other concepts that can improve their conditions of ecotourism services.

D. Analysis of the human-nature relationship, local governance and government policy

The analysis of the man-nature relationships that cause the degradation of ecosystems confirms the application of a linear approach of political-economic organization that has been very limited, with repercussions on the community and its living conditions. Corruption in state investments in housing, sanitation, energy dominate the state, weakening local governance [16]. Political instability, as well as accelerated and uncontrolled urban growth, have generated severe urban impacts on natural ecosystems and the services they offer [17]. The district of San Juan de Lurigancho, where part of the Mangomarca fog oasis is located, is no stranger to this situation and has 1,117,629 inhabitants [18]. This situation is

associated with land trafficking, illegal invasions, brings with it pollution processes, which associated with climate change are producing drastic changes in the ecosystem and lead to habitat loss and environmental degradation [19]. Currently, it is the local communities that have implemented ecotourism as a tool to protect the environment and improve their economic income. This capacity shows a trend towards sustainability since not only the local economy is promoted, but the development of local culture is strengthened, confidence and identity as a brand are increased, improving the conservation and protection of the ecosystem [15].

E. Collaboration process of the actors involved in the protection, conservation and adaptation to climate change

1) Illegal urban growth and local responses:

Lima is the capital of Peru and attracts more residents seeking to improve their quality of life, migrants in search of a better life. Many citizens, without access to housing subsidies, migrate en masse to the capital from rural areas and illegally occupy areas for urban settlements unsafe from natural hazards [20]. In some cases, land trafficking is legalized through conjunctural or disguised policies, impacting the ecosystem of Mangomarca, with improvised houses on the slopes and sandbanks on the outskirts of the city [21]. These conflicts have exposed acts of corruption in the local and national system [22]. The covid 19 pandemic, has caused an unexpected departure of citizens who returned to their provinces due to lack of food and work, this allowed a certain recovery of Mangomarca, however, a gradual return to normality does not mean any guarantee of recovery of the ecosystem.

2) Land trafficking and ecological degradation of the fog oasis of Mangomarca:

Land trafficking is the main factor in the degradation of the Mangomarca ecosystem, due to the loss of soil and plant cover, which alters the natural system, preventing ecological and evolutionary processes [16]. Local authorities intervene sporadically to eradicate illegal invasions, but given the existence of acts of corruption, these activities find legal support, which leads to the degradation of the ecosystem.

In Peru, this activity is considered an environmental crime (Law No. 29263) and is typified in article 313, indicating that any person who alters the natural environment, modifying the landscape with buildings or cutting down trees, will receive a custodial sentence. The support of the university, through its teachers-students-volunteers, is a fundamental support that not only provides labor, to improve certain physical aspects, such as signaling routes, or ecological alerts, reforestation, etc.

Alliances are also promoted, with representatives of entities, thanks to the initiative of the Mangomarca Ecotourism Association, as a spokesperson for alerts to the community. The local and environmental impact caused by land trafficking with tenures, makes legal procedures difficult by forming illegal settlements, reducing the coverage of fog oases and therefore restricting the provision of ecosystem services that were previously offered [23]. This situation allows an informal land market, where poor families pay for said land, even in high-risk and unhealthy areas [4]. Finally, this economic corruption turns into political power, preventing the authorities from being able to react and maintaining poor urban planning [22].

3) Ecotourism and its alliance with the University:

Community ecotourism not only helps improve the economy of low-income coastal communities, but can also engage their active participation in the conservation and adaptation to change of ecosystem services that could be generated by climate change, applying nature-based solutions.

This includes local municipal collaboration and local entrepreneurship in waste management, generating environmentally sound infrastructure to accommodate tourism, hotel development, and market access [2] (Seddon et al. 2020). Since the conceptual model of ecotourism embraces the community resilience model and the social network perspective [15], the Mangomarca ecotourism association is expected to develop alliances with other fog oasis ecotourism associations in Lima. This collaborative alliance keeps alive the purpose of inserting the fragile ecosystem of Mangomarca in the set of fog oases recognized by the regional government of Lima.

As mentioned above, on the one hand, covid 19 generated a certain recovery of the Mangomarca ecosystem, while fatally affecting the local community and therefore the organizations. The ecotourism community and association have developed an unbalanced resilience between the pandemic and the accelerating impacts of climate and anthropogenic change.

It is evident that community ecotourism has been adapting to the temporary effects of the pandemic, thanks to its capacity for self-management, but with respect to the local community, made up of a great diversity of migrants, cohesion has not yet been achieved, this has generated, a weak cultural identity, not fully committed. However, the ecotourism association has proven to be a powerful engine whose social relationships allow it to see the positive aspects of adversity [15]. It is important to overcome this gap, sustain and expand the social relations of these actors who are part of the community, to generate a vision of adaptation to climate change in the context of sustainable development with solutions based on the natural environment of the Mangomarca ecosystem.

4) Climate change, challenges and opportunities:

The fog oasis of Mangamarca represents a greenish ecosystem in winter, due to the accumulation of fog whose humidity feeds plant development, in addition to providing a life zone for harriers, kestrels, owls and other animals [24]. The Mangamarca ecosystem is steep, it does not exceed 600 meters above sea level, and the local government has considered it a fragile ecosystem by the Ministry of Agriculture (RDE N° 153-2018-MINAGRI-SERFOR-DE) and a protection zone of the landscape (Ordinance 1081-2007-MML) by agreement of the council 041-MSJL of the Municipality of San Juan de Lurigancho [18]. Despite the various campaigns organized in the short term, and the efforts of certain inter-institutional alliances, an effective and integrated plan for the protection of the ecosystem and adaptation to climate change in the context of sustainable development has not yet materialized.

The new nature-based solutions approach to climate change adaptation proposed by Seddon et al. (2020) [2], propose exclusive designs to provide measurable benefits for biodiversity, considering this aspect, efforts can be directed towards robust and resilient designs that mitigate the urgent challenges of climate change and biodiversity loss. However, it also implies a collaborative governance challenge [10], that leads to the implementation of long-term public policies, although the route is vulnerable to failure due to cultural, institutional and political factors. However, the will to maintain a synergistic circuit that provides an effective response to the anthropogenic components of pollution, land trafficking, etc., as well as to the pandemic and climate change, requires shared responsibility and trust (see Figure 5).

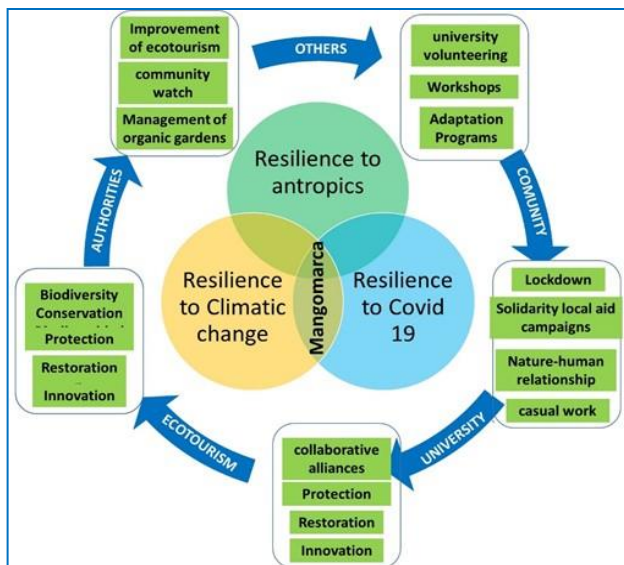


Fig. 5. Conceptualization of solutions based on nature and collaborative governance

The university, through its faculty-student body, plays an important role as an actor of integration between the academic, social and innovative-business nexus, which strengthens local governance by contributing to the conservation of this oasis of fog, always faced with various formal and informal barriers.

However, even externalities such as political and economic instability, anthropogenic aspects, put pressure on resilience to climate change. Despite this, the opportunity to strengthen alliances through the academy deserves special attention, since it has the capacity to integrate the various actors. Social responsibility feeds the university vision to propose new strategies in accordance with the balance between nature and human beings, especially in favour of the most vulnerable.

IV. CONCLUSIONS

An analysis has been carried out of the system that today exercises actions in the management of the Mangamarca fog oasis, and of the role that the university exercises in the actions of adaptation to climate change in times of the covid 19 pandemic aimed at the local community, especially the Ecotourism Association, which has become the bastion defending the conservation of this fragile ecosystem. Consequently, it is necessary to develop strategies considering solutions based on nature and a collaborative governance that finds a great challenge, due to the potential for corruption that exists among officials in favor of land trafficking and weak regulatory compliance that allows illegal invasions, without leaving aside the impacts exerted by climate change that result in the loss of biodiversity. The university is a crucial actor with the capacity to integrate the actors, driven mainly by social responsibility where teachers and students of the different training stages generate trust and involvement in the search for solutions in the context of sustainable development.

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