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ORIGINAL RESEARCH

Assessing Economic and Shared Social Values of Forest Conservation to Improve Water Availability: A Case Study of the Protected Forest Reserve of El Quinini, Colombia

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Abstract
Most of the rural population of developing countries depends on forest ecosystems; consequently, there is a myriad of trade-offs that jeopardize the ability of the forest to produce goods and services. To maintain the current forest cover and offer opportunities to improve rural livelihoods, more attention has been paid to the development of strategies to assess the plurality of values associated with ecosystem services. Stated preference methods have served to asses non-market values of ecosystem goods and services; nevertheless, they have been criticized for their inability to reflect social values and the limited stakeholder´s participation in the selection of attributes for valuation. The aim of this study was to asses shared social values associated with water provision to further integrate them as attributes for contingent valuation. The study was conducted in a small community in central Colombia. Shared social values, the values held in common by forest owners, were assessed through application of problem tree and participatory mapping techniques; and the willingness to pay method was used for economic valuation.
Results showed that forest owners expressed their shared social values as three projects to aimed at enhancing the health of the forest in the reserve: environmental education, forest restoration, and agroforestry. The contingent valuation indicated that despite the very low income of forest owners (US$251.32 per month), there was a high support (74%) to pay an extra US$ 1.84 per month in the water bill to implement the projects. Our study presented a systematic procedure that combines methodologies to assess the multiple ways in which forest ecosystems are important to people. Ecosystem services have collective significance that can be assessed in small local communities to enable participation in policy making.

Keywords Ecosystem services · Shared values · Participatory mapping · Contingent valuation · Deliberative decision making · Forest governance

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Introduction

Tropical ecosystems are essential to ameliorate the adverse effects of climate change due to their capacity to remove carbon dioxide from the atmosphere (D'Annunzio et al. 2015); nevertheless, high levels of poverty still persist in countries with vast areas of tropical forest forcing the economic sectors to rely heavily on agriculture, mining, and timber extraction in such a way that the remaining forest cover is in danger. Over the past few decades, an increasing number of policies to protect the tropical forest have been developed. Sustainable forest management (SFM), defined by United Nations as "a dynamic and evolving concept [that aims] to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations" (UN 2007), has been adopted as a policy framework for monitoring forest stewardship, to fight deforestation, and to overcome poverty. However, around the world SFM has proved to have different levels of success to accomplish these goals (Cheng et al. 2019).

Due to the large number of tradeoffs involved and the multiple ecosystem services compromised when managing the forest, the contribution of SFM to improve the well-being of forest dependent communities remains a challenge. To this extent, economic and social valuation have become essential components of SFM in order to inform policy making and to help ensure its contribution to poverty alleviation (Burke et al. 2016; Costanza et al. 2014; Ives and Kendal 2014; Pearce et al. 2003; Rice et al. 2001).

The traditional non-market valuation methods, often used to assign monetary values to ecosystem services, provide relevant information for the efficient allocation of the resources and to develop market strategies for management and conservation. However, they have been criticized due to their inability to reflect social values (Cadman and Maraseni 2011; Dryzek and Pickering 2017; Lo and Spash 2013a; Rawlins 2008; Wellens and Jegers 2014) and the value incommensurability associated with some environmental services (Parks and Gowdy 2013). Assessing social values of ecosystem services not only serves to complement the economic valuation but also informs decision makers on the relation of social groups with nature. Likewise, identifying social needs and perceptions is important to understand tradeoffs and to avoid potential social conflicts associated with the ways that stakeholders benefit from ecosystems (Caballero-Serrano et al. 2017; Rodriguez et al. 2012).

The terms social, cultural, community, shared, and local values have been indistinctly used to denote values that people collectively hold (Fish et al. 2011) and that can be transmitted over time (Mayett-Moreno et al. 2017); they are conceptions of common goods or wrongs about a topic and are formed and expressed through social interactions (Parks and Gowdy 2013). Kenter et al. (2015) presented a detailed review of the meaning used in the literature for the concepts of shared values, social values, and shared social values; in addition, the authors presented a theoretical framework that includes five dimensions (value concept, provider, intention, scale, and elicitation process) and seven types of shared values (transcendental, cultural/societal, communal, group, deliberated other-regarding values, and value to society) that serves to guide the path for further research on ecosystems valuation.

Likewise, Christie et al. (2012) presented a review of the challenges to apply monetary and non-monetary methods to value ecosystem services in developing countries; the authors concluded that there are some practical, methodological, and epistemological challenges that need to be addressed to allow more accurate valuation. Among those challenges, the authors mentioned language barriers, respondents´ lack of scientific understanding, low local research capacity, local people subsistence economies that do not allow them to define a market price, differences in spiritual and cultural values, lack of social context and value, and political pressures.

Therefore, one of the most salient recommendations to improve the robustness of these methods is the incorporation of participation and deliberation into the ecosystem services valuation (Christie et al. 2012; Langemeyer et al. 2018; Martín-López et al. 2014; Parks and Gowdy 2013). In this regard, the deliberative monetary value (DMV) model arose as a means to reconcile the total economic value (TEV) approaches with the participatory techniques (Lo and Spash 2013b; Spash 2007). One of the earliest reports that attempted to mix social and economic methods was done by Macmillan et al. (2002) who compared willingness to pay (WTP) and group-based methods to value the non-market benefits of goose conservation; they found that giving participants the opportunity and time to discuss allowed them to consider household budgetary implications and reevaluate their WTP; consequently, they could make more informed decisions.

Although the DMV promises to minimize the lack of public participation in economic valuation, Bunse et al. (2015) argued its potential to improve valuation of ecosystems services. In an in-depth review of DMV theoretical and empirical studies, Bunse et al. (2015) presented some of its limitations, such as issues of participants' representation as well as the assumption that DMV only discusses monetary values of ecosystem services, forgoing the potential of deliberation to elicit social values as key components of ecosystems services valuation. Deliberation is instrumental in developing countries to assess both economic and shared social values of ecosystem services, people rely on the ecosystems to fulfill their needs usually through a strong communal sharing of good and services. In deliberation, people present, exchange, and reflect on issues that matter most to them, revealing their opinions and shared social values (Irvine et al. 2016; Stern and Fineberg 1996).

Nevertheless, both contingent valuation and DMV methods suffer another methodological issue, they exclude people´s preferences before valuation; traditionally, scenarios to be valued are assumed and designed by the specialists forcing people to provide a value for something that may have no inherent meaning to them (Abdullah et al. 2011; Armatas et al. 2014; Christie et al. 2012; Jeanloz et al. 2016; Parks and Gowdy 2013; Sauer and Fischer 2010). As a result, the traditional methods of non-market valuation are not sufficient to value ecosystem services. Studies have suggested that there is a need to incorporate participatory and deliberative methods into valuation to capture the value that people collectively assign to ecosystem services that support their livelihoods; this would help to enhance the robustness of valuation. Although, in the past few years there has been an increasing number of studies that estimate the non-monetary value of forest ecosystem services; some limitations still persist: there is a low number of studies in countries with high biodiversity, in particular mountain forests, and there are few studies at the local level (site specific management units) that have been shown to be costly due to the use of sophisticated techniques that have been applied (Acharya et al 2019) which varies in relation to the country and the resources available (Arias-Arévalo et al. 2018; Boukherroub et al. 2018; Christie et al. 2012). In developing countries where technological resources are scarce, rural stakeholders do not have high technical knowledge, and investment on these types of studies is not a priority; there is a need to use simple, yet rigorous methods that allow stakeholders to engage in deliberation and acquire more knowledge to enhance valuation of ecosystem services.

This study aimed to assess shared social values of water provision and further integrated them as attributes of contingent valuation. We hypothesized that transcendental shared values, a type of shared social values defined by Kenter et al. (2015) as "conceptions about desirable end states or [behaviours] that transcend specific situations and guide selection or evaluation of behavior", could be elicited through deliberative forums in which forest owners express their desirable future based on their own assessments of land use change. We also hypothesized that by including those values in the contingent valuation method, stakeholders could assign a monetary value to something that is significant to them. To elicit shared social values the problem, tree and participatory mapping (PM) techniques were used, forest owners analyzed the problem of water scarcity and interpreted the use of their territory in the past and present to frame their desired future. The PM technique helped participants to characterize their reality in relation to water scarcity and identify solutions to improve the health of the forest and its associated water supply (the expected outcome). The solutions (henceforth projects) proposed by the community represent forest owners´ shared social values for water provisioning services. Those proposed projects were then used as attributes for contingent valuation to examine forest owners' willingness to pay for them.

This study, therefore, contributes to overcoming some of the limitations of the valuation of forest ecosystems services reported by Acharya et al. (2019). It was conducted in a small forest community in Colombia, the second most biodiverse country in the world. In addition, it addressed some of the limitations of traditional non-market valuation methods when applying them in developing countries as mentioned by Christie et al. (2012). The challenges of language barriers and local research capacity were overcome since the researchers and facilitators are from the same country and speak the same language of the participants. The epistemological challenge related to social context and values that assumes that social values are expressed as the sum of individual preferences was addressed by using participatory methods that allowed participants to reflect on the problems, exchange ideas, and express their shared social values. Finally, the limitation of forcing respondents to value attributes that are not familiar to them was overcome by including shared social values as attributes for contingent valuation.

Methodology

Study Area

The Republic of Colombia is the second most biodiverse country of the world, it hosts more than 50 thousand species of plants and animals. Due to its rich biodiversity, that has been well-known for decades, a set of laws, rules, and regulations have been issued since the 1950s to manage the forest cover of the country; a summary of the forest legislation and administration can be found in Rodriguez et al. (2018). The National Code of Renewable Natural Resources and Protection of the Environment of 1974 (Código Nacional de Recursos Naturales y Protección del Medio Ambiente -CNRN-, Decreto 2811 de 1974) allows to declare reserve areas of public or private property for the establishment, maintenance, or rational use of the forest (Republica de Colombia 1974). Although the CNRN had legal mechanisms for protection, some did not have regulations until 2010 when the government issued Decree 2372 of July 1, 2010. This Decree defines seven categories of protected areas that conformed the National System of Protected Areas of Colombia (SINAP for its Spanish Acronym). Forest Protected Reserves, as one of those categories, is defined as: a geographical space in which the forest ecosystem maintains its function, although its structure and composition has been modified. The decree also states that the natural values associated with these areas are subjected to preservation, conservation, sustainable use, restoration, education and recreation; it also states that these areas can be of public or private ownership. Due to some gaps in legislation related to forest reserves, the economic projects related to subsistence have been developed in forest protected reserves, even in national natural parks. To overcome this complexity, the sustainable use of natural resources has been enforced and several initiatives have been implemented to avoid the expansion of agriculture and other land uses in protected areas.

Colombia is considered one of the countries with the greatest surface water supply[1] in the world. According to the Natural Water Evaluation of 2014, the estimated national water yield is 56 liters/second/km^2, which exceeds the world average yield of 10 liters/second/km^2 and the average yield of Latin America of 21 liters/second/km^2 (IDEAM 2015). Despite this richness, only 73 % of the rural population has access to municipal water systems. High costs of building infrastructure in remote areas along with depletion of forest cover hinder the right of human populations to obtain fresh water for their daily activities. Community empowerment has been considered one of the national strategies to ameliorate the lack of fresh water supply in rural areas. Community empowerment is conceived from a perspective of capacity development and sharing knowledge; usually communities have their own uses, traditions, local customs and arrangements that have worked for them to manage natural resources. Therefore, the task of technical assistance is to integrate the knowledge of the communities with newer scientific knowledge to promote the sustainable management of services at the community level (Ministerio de Vivienda 2021).

The National Institute of Renewable Natural Resources and Environment (INDERENA for its Spanish acronym) was in charge of regulating the management of natural resources, and by this power it declared (in 1987) the natural area of "El Quinini" as a Forest Protected Reserve. This decision obeyed to a petition of the

[1] Surface water supply refers to the volume of continental water, stored in surface water bodies (rivers, streams, lakes, reservoirs, and springs) in a given period of time. It is quantified through runoff and water yields (liters/second—km2) in defined spatial units of analysis in the hydrographic zoning of Colombia.

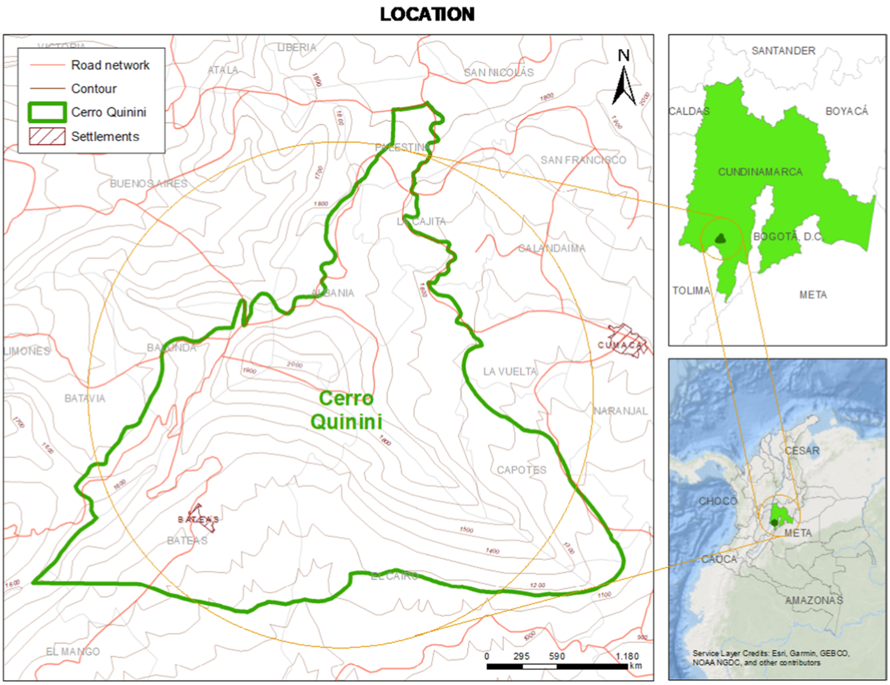

Fig. 1 Location of the forest reserve el Quinini

forest owners to protect the highest part of their territory, where most of the water-heads are located, from construction of a road and a telecommunication tower (as stated in the "acuerdo 0029 del 5 de mayo de 1987", INDERENA). The El Quinini is located in the central part of Colombia, its extent is 1947 ha with elevations ranging between 950 and 2150 m a.s.l. According to the last regional survey, 60% of the reserve is covered by premontane moist forest (PM-mf), 35% by premontane dry forest (PM-df), and the remaining 5% is covered by lower montane moist forest (LM-mf). Within the reserve there are several headwaters that serve as tributaries of two rivers, Panches to the west and Pagüey to the south (Cundinamarca 2005). The reserve contributes to an ecological connectivity with three other reserves that are part of the biological corridor between the Andes and the Valley of Magdalena.

The jurisdiction of the reserve is under three municipalities, Tibacuy (80%), Viotá (10%), and Nilo (10%), that are administered by the state of Cundinamarca (Fig. 1). Studies in the region have shown that 95% of the reserve has been altered by anthropogenic activities, in particular agricultural practices, the PM-mf and PM-df have suffered changes in their structure and size, jeopardizing their rich diversity and water availability. In addition, there is also a water deficit because of the decrease in precipitation that now ranges from 800 to 1000 mm per year. The majority of the population of the reserve are adults who base their income on agriculture; a large portion of the younger population has migrated to the city of Bogotá, 75 km away. According to national statistics, 90% of the land is privately owned (DANE 2014). Six localities comprise the forest reserve, Albania, Bateas, Capotes, La Vuelta, Ocobo y Palestina, all of which have their own water systems; however, the service does not reach 100% of the population of the localities due to geographical distances between the main distribution pipes and households.

To minimize forest degradation that hinders water availability for the inhabitants of the reserve who are mainly settled in the low slopes of the reserve, the forest owners in collaboration with local authorities want to explore the possibility of implementing a fee for forest conservation that will be paid with the water bill. However, as explained in the previous section, one of the disadvantages of contingent valuation is that participants have to decide from attributes that are not familiar to them. Therefore, it was important to ask forest owners how they want to see their territory and what projects they want to implement to maintain forest cover.

Materials and Methods

A mixed method approach was designed to accomplish the research goal. The study was divided into three stages; the first stage was designed to identify the main reasons associated with water scarcity and to elicit shared social values. A review of literature and revision of official cartography[2] of the reserve were done prior to visiting the reserve, fifteen field visits were conducted to build rapport with forest owners and to identify biophysical aspects of the study site. Using a snowball approach, 16 key forest owners were identified to participate in a focus group in which problem tree and the participatory mapping (PM) techniques were applied.

The second stage sought to incorporate shared social values into the contingent valuation method as attributes of willingness to pay for the projects proposed in stage 1. Finally, the third stage was dedicated to calculating the market-based costs of the three projects in order to make comparisons and inform decision makers (Fig. 2).

Stage 1: Past, Present and the Future of My Territory

To identify the main reasons associated with water scarcity, we used the problem tree technique; although the technique is typically used to identify a problem, for this study we used it as tool to facilitate dialogue among forest owners and to make a visual scheme that was more understandable to them. Sixteen participants were asked to identify reasons for why water availability was diminishing. Once they had a list, they were requested to place the main reason in trunk of the tree, then the roots of the tree represented the causes and the branches the consequences. The information from the tree scheme gave forest owners insights about projects needed to improve water availability.

The PM is a participatory rural appraisal tool used to understand how people collectively see their territory and integrate its parts. This tool allows communities to

[2] Refers to the cartography made by environmental authority of the region

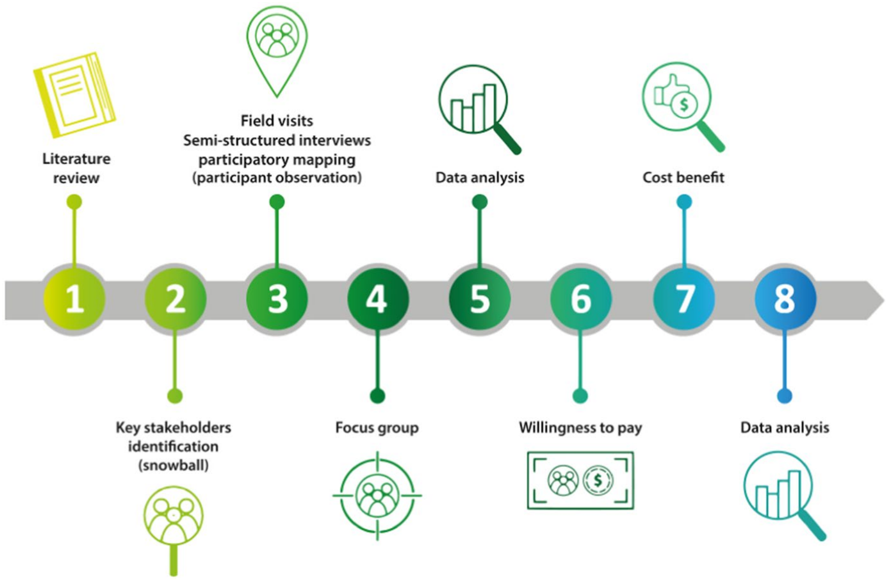

Fig. 2 Methodological Process

show the elements of their territory that are important to them, such as cultural traditions, geographical boundaries, economic activities, and some elements that are not included in official nor digitalized maps. The process of drawing the maps has value in itself since participants join in a dialogue and create a common understanding of their territory while characterizing their socio-cultural activities and express their needs and aspirations (Chambers 2006). Conventionally, this technique is used for people to represent their activities in the present; however, for the purpose of this study we wanted participants to represent their territory in the past, present, and future, for transgenerational comparisons. A sketch of the reserve was drawn on transparent paper; then, participants were asked to include aspects of their territory as they see it in the present (Fig. 3). To recreate the past, on another transparent paper, and participants were requested to incorporate those aspects of their territory that they remembered[3] since 1987 when the land was declared a Forest Reserve. In the next step the present and past maps were overlapped, and participants were able to observe how their territory has changed. Later, participants deliberated and reached consensus on how they want to see their land in the future, 20 years from now, that information was place in another sketch. Due to the perceived change of the landscape and its relation to water scarcity, stakeholders identified what projects would be necessary to meet their desired future.

[3] The instruction was also to include what their parents or grandparents mentioned to them

Fig. 3 Example of map drawn by forest owners

Stage 2: Willingness to Pay for Community´s Shared Values

To estimate the value of the water provisioning ecosystem service, the contingent valuation method was used. This is a widely used method for estimating the value of goods and services that don't have inherent market prices; traditionally, the method uses surveys to directly ask consumers how much they would be willing to pay for specific environmental services under given conditions. The term willingness to pay is defined as the difference between consumers' surplus before and after adding or improving a given ecosystem service attribute. The survey for this study was designed to assess people´s willingness to pay to implement the three projects identified in Stage 1; according to forest owners those projects would guarantee forest cover for water provision. Economic theory suggests that an individual's demand for a good is a function of the price of the good, the prices of substitute and complementary goods, the individual's income, and the individual's preferences, usually measured by the individual's socioeconomic characteristics and perceptions. Based on a review of literature and considering the economic theory, we included income, cost of water bill, occupation, age, educational level, locality, perception about the reserve, sources of water, what they consider to be the major problem of the reserve, and preference for the activity as variables that may affect forest owners, willingness to pay to establish a given activity (Cahui-Cahui et al. 2019; Gonzalez-Alcolt et al. 2016; Gunatilake et al. 2007; Solikin 2014; Villegas-Palacio et al. 2016).

From a population of 378 families that obtain water from streams that are located in the forest reserve of El Quinini[4], a random sample of 113 families was drawn. The survey contained three sections: demographics, information about participants´ knowledge of the reserve, in particular the sources of water; and the respondents' willingness to pay for the three projects proposed in Stage 1. The main valuation questions were:

1. Would you be willing to pay to implement (*ad projects here*) to improve the health of the forest and thus increase water availability?
2. Considering your household income and expenditures, would you be willing to pay (*add bid here*) in addition to your current water bill to implement these projects?

The starting value provided to participants for the bids was based on their own water bill. Participants were asked to choose among four bids that ranged from \$0.36 to \$2.18 dollars/month (\$1000 to \$6000 Colombian pesos). When a participant answered NO to the willingness to pay question, we asked his/her reasons for that answer. In addition, we provided the possibility to indicate other ways to contribute, rather than money, to implement the projects. To estimate the probability of an individual willingness to pay, we used a logistic model assuming that the probability to pay is related to X_i, a vector of explanatory variables that may influence participant´s decision (Eqs. 1–3).

Stage 3: Market-Based Cost of Forest Conservation

To scale up the projects proposed by stakeholders and to be able to assign their market prices, the information from the sketches obtained in Stage 1 were transferred to a digital map using ArcGIS 10.3 and QGIS 2.14.7. We used the municipality zoning plan to determine potential areas to establish the projects based on forest owners´ preferences and to estimate the cost of their implementation. All market prices were taken from the national statistical service of Colombia, the net present value was estimated at a 5% discount rate with 20 years for the implementation of the projects.

Results

Results From Stage 1

Interviews with sixteen forest owners and the field visits gave the first elements for a diagnosis of the study site; some biophysical problems were identified from field

[4] The total population of the reserve is of 1513 inhabitants approximately; however, only 1135 take water directly from the reserve. The average number of people per household is of three, which makes for approximately 378 families who use the water of the reserve.

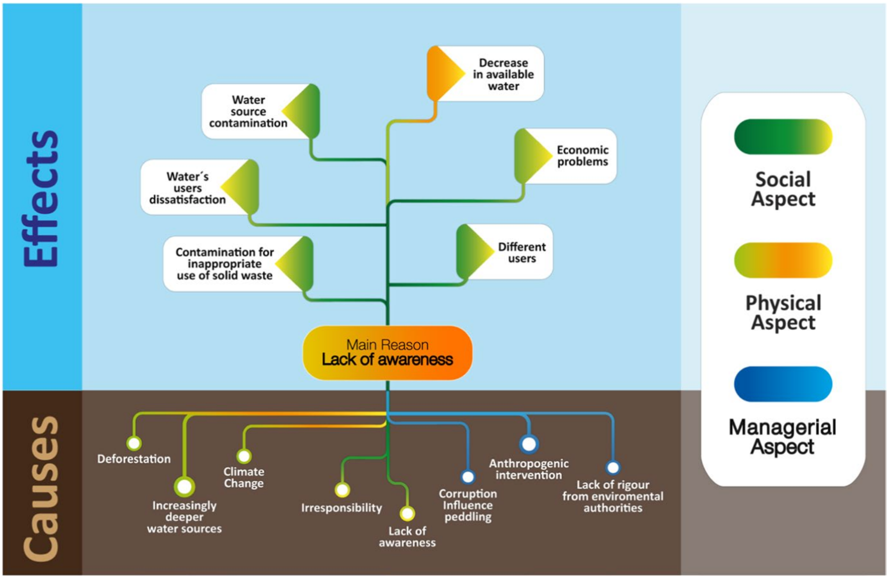

Fig. 4 Tree scheme

visits including: erosion at the base of the mountains during the rainy season, uncontrolled tourism, logging, expansion of agriculture, and dry water-heads.

To organize the information obtained from the tree schemes drawn by the forest owners and to be consistent with the principles of sustainability, we differentiated three aspects: social, biophysical, and managerial (Fig. 4).

The main reason associated with water scarcity identified by the participants was the lack of awareness of the importance of preserving the forest, this lack of awareness also causes climate change, people taking water from deeper water sources, and deforestation. From the managerial point of view, lack of awareness also causes corruption, lack of enforcement from the authorities to comply with the laws, and the introduction of heavy machinery for agriculture. Water pollution, economic problems, and dissatisfaction were the effects identified due to the lack of awareness. In summary, forest owners perceived that all of the events that are associated with water scarcity are the result of lack of awareness.

During deliberation, forest owners expressed dissatisfaction with the reserve visitors due to uncontrolled campfires, trash along the riparian zones, and excessive use of water from the streams. This group of forest owners reached consensus on the need to enforce environmental education as a tool to increase awareness and consequently to solve the problem of water scarcity; forest owners claimed that the water-heads are diminishing because people cut the trees to establish their crops not knowing that the area is a forest reserve that has restrictions for its use. Forest owners believe that, if all stakeholders (themselves, tourists, and environmental authorities) within and around the reserve have knowledge of the impacts of their actions, the reserve would be in a better condition to provide water. During the discussion, the problem of corruption was addressed, forest

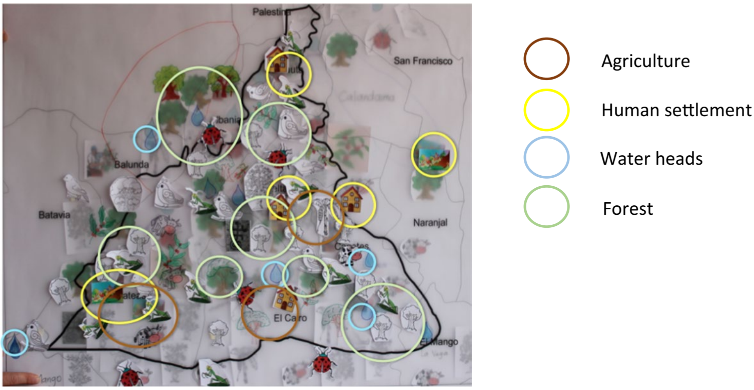

Fig. 5 Future map drawn by forest owners

owners complained of the lack of compliance with regulations due to the permissiveness of environmental authorities; however, they did not identify any solutions to combat corruption.

Results from participatory mapping showed the present, past, and future. The present-map drawn by forest owners (Fig. 3) depicts socio-economic activities such as cattle, mining, tourism, roads, and coffee plantations; and the cultural connection to the land was extolled denoting their sense of belonging to the land. It also showed water-heads, forested areas, more diversified agriculture (such as plantain, banana, sugar cane, and potatoes) that that had been, but are no longer, practiced in the highest altitudes of the reserve.

Fig. 5 shows how forest owners perceive their future based on their own assessment of their territory during the past and the present. Forest owners expressed their desire to protect waterheads and to establish forests in areas with not agriculture or cattle (abandoned land) and to implement some agroforestry systems in their already used for agriculture.

To better illustrate changes in the territory and to estimate the costs of the projects, we transferred the information from sketches to electronic maps into a GIS. The past - present map drawn (Fig. 6) shows areas with forest cover in the past and present (areas with no changes in forest cover), areas with no forest in the past nor in the present (areas with other uses), areas that did not have forest in the past but there is forest in the present (areas converted from other uses to forest), and areas that were modified from forest to other uses (areas from forest to other uses). It is important to clarify that since agriculture and livestock are for subsistence, there are also patches of natural forest in those areas. Other uses are agriculture, livestock and housing.

After discussion and reflection, the forest owners proposed three projects: forest restoration with native species, establishment and enhancement of agro-silviculture systems, and environmental education as projects needed to enhance forest health, and therefore water availability. Forest owners showed an enthusiasm to work with and participate in the implementation of the projects.

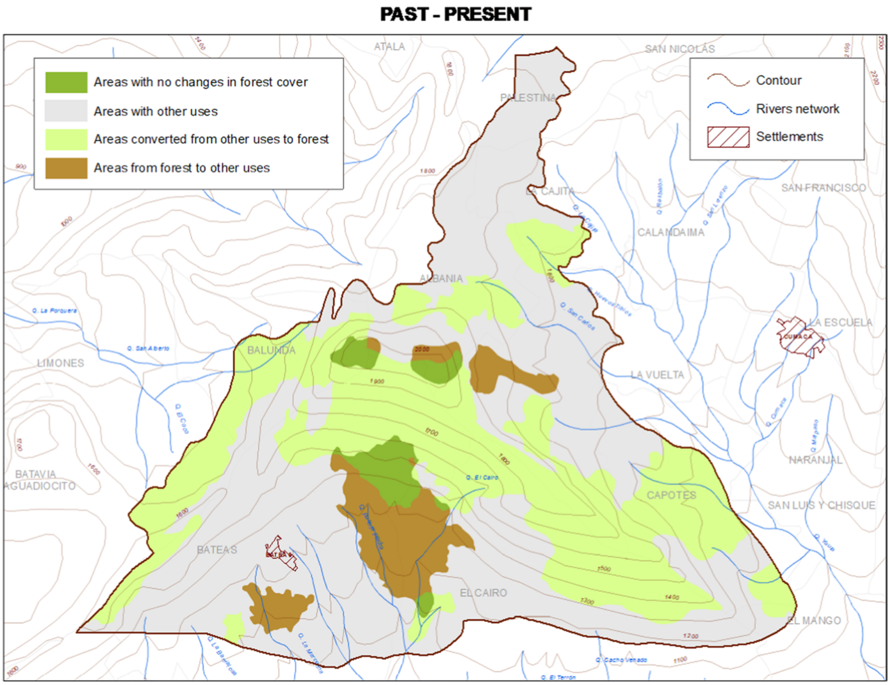

Fig. 6 Social mapping outcome (PAST - PRESENT)

The information from the tree scheme gave forest owners insights about the projects that are needed to improve water availability.

The present-future map drawn by the forest owners illustrated their desire to have more forest at the highest altitudes, they also want to combine conservation and agriculture activities. To locate the areas where the projects can be established, the actual use of the territory was obtained from official maps (Fig. 7), then we located areas that forest owners indicated suitable to established the projects; Fig. 8 shows areas that can be transformed from other uses to forest and where forest can be enriched.

Results From Stage 2

From the analysis of the survey, we obtained information on demographics (Table 1 in the Supplemental Materials). The average size of a family unit is three people with one person employed. The major economic activity of the inhabitants is agriculture, land ownership is mostly private with some exceptions, and property size per household is less than 5 ha. About 82% of the participants reported to have a monthly income of \$218.70 US dollars that was less than the minimum salary for Colombia in the year 2015 (\$251.32 dollars). Those who reported to have a greater income were had their own business or were government employees.

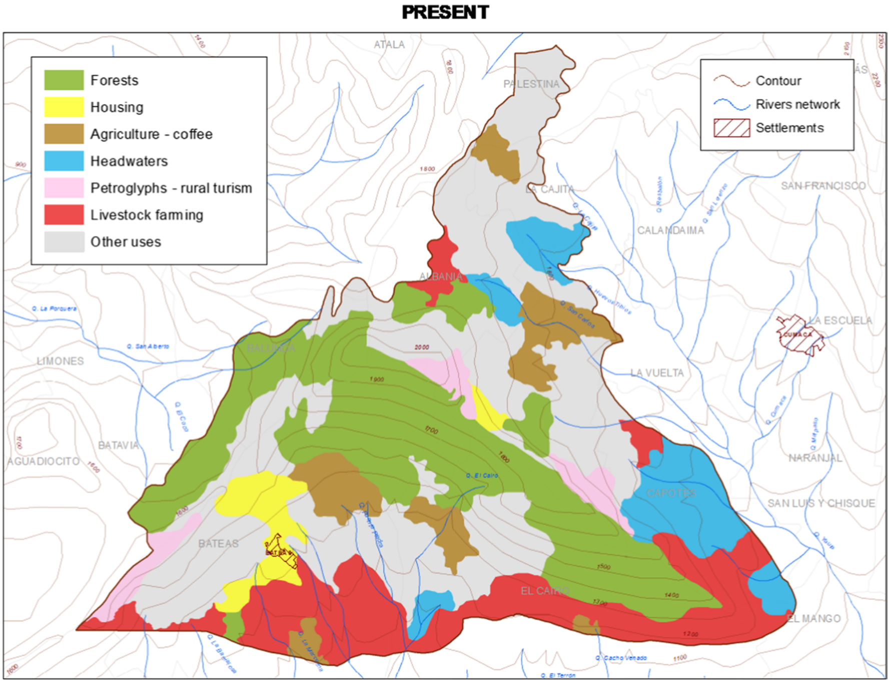

Fig. 7 Current use of the territory

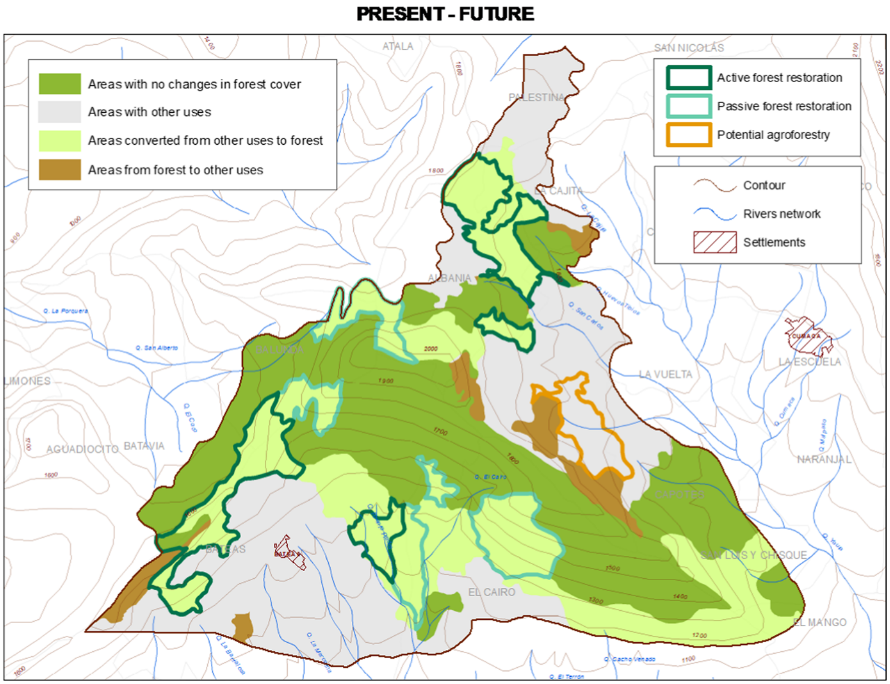

Fig. 8 Social mapping outcome (PRESENT - FUTURE)

Regarding the water bill, (Table 2 in the Supplemental Materials) shows the monthly cost of water service by locality. The locality with the highest cost of water, La Vuelta, is the only locality with water meters. On average each family was willing to pay $ 1.84 per month, in addition to the current water bill, to implement the three projects (scenarios) proposed.

To estimate the probability of an individual's willingness to pay for the projects needed to enhance the health of the forest for water availability in the Cerro Quinini, we used a logistic model assuming that the probability to pay is related to X_i, a vector of explanatory variables that may influence participant´s decision (Eqs. 1–3).

$$P_i(WTP = Yes) = \propto + \beta X \quad \text{that can also be expressed as} \tag{1}$$

$$P_i(WTP = Yes) = \frac{1}{1 + e^{-(\alpha + \beta X_i)}} \tag{2}$$

The linear expression of this model is:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \propto + \beta X_i \tag{3}$$

P = probability β = parameters, they measure the change of the probability of being willing to pay when the independent variables change.

We used SAS® 9.1 to estimate the model and respective statistics, the variables included in the model were:

- *Locality (LOC) referring to the locality where the respondent live*: Albania, Bateas, Capotes, La Vuelta, Ocobo, and Palestina;
- *Age (AGE)*;
- *Educational level (EDLEV)*: None, elementary, secondary, technical, professional, and other;
- *Occupation (ECONAC)*: Unemployed, coffee farmer, fruit farmer, cattle ranching, own business, and other;
- *Income in dollars (INC)*: Less than 220, between 221 and 364, between 365 and 547, and more than 547
- *Perception about the importance of the reserve (PER)*: No important, a little important, important, very important, and no answer
- *Major problem of the reserve (MPR)*: Pollution, deforestation, construction of electricity plants, erosion, lack of awareness, uncontrolled tourism, none, don't know, and other
- *Preference for activity to implement (PFSM)*: Forest restoration with native species, environmental education, agroforestry, all, and none.

First, we examined the explanatory variables that were statistically significant at $p<0.05$, and measured the effect of the significant variables with the odds ratio (exp β), which indicated that with an increase of one unit in the explanatory variable that participants will be willing to pay as much as the odd ratio shows, while keeping the other variables constant. Due to the small sample size some of the variables predicted perfect WTP, WTP=1. Then, we used the exact logistic regression method to check the results. However, the results of the exact logistic regression corroborated the results obtained from the logistic model. Using both methods, the variable PER was statistically significant in its ranking 4 (important), result are shown in Tables 3 and 4 in the Supplemental Materials. Then, the model for the willingness to pay is shown in Eq. 4.

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = 1.272966 - 1.139434 * PER = 4_i \tag{4}$$

Table 4 in the Supplemental Materials shows the odds ratio value for the variable PER, the ranking 4 (perception of the reserve as important) was significant at $p < 0.05$. However, its odd ratio is less than 1. This indicates that an individual whose perception of the reserve is important (rank 4) is willing to pay 3.6 more times than others.

We further included in the model more variables that may predict the amount of an individual's willingness to pay, WB = how much is the water bill and SOW = Source of water. Results are shown in tables 5 and 6 in the Supplemental Materials.

An individual who obtains water from a natural well (ceteris paribus) is willing to pay 39 more times to others. Since the odd ratio of WB is equal to 1 the variable could be dropped from the model, then, the equation that best predicts the willingness to pay is shown in Equation 6.

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = 3.662551 - 2.4178 * SOW2 - 4.068016 * SOW3 \tag{6}$$

Results from Stage 3

We transferred the information from participatory mapping to a Geographical Information System (GIS), we compared people´s view of their territory in the future with the actual use of the territory using the municipality zoning plan (Fig. 7) to localize the areas where the projects could be implemented (Fig. 8).

Two types of forest restoration were identified, active and passive; active restoration is characterized by the direct intervention and their the management; while, passive restoration is characterized by removing the stressors that cause degradation and further isolating those areas to allow natural recovery (McIver and Starr 2001). For this study, we identified 168 ha to be subjected to active restoration and 134 hectares for passive restoration. To estimate the cost of restoration, we considered all the operations for active restoration: consultation with forest owners, design, land preparation, including civil construction for soil retention and fire and barriers to protect from insect invasion, seedling acquisition and preparation, planting, and maintenance, including inventories and monitoring. For the passive restoration we calculated the cost based on the following operations: consultation with forest owners, design, inventory of tree species, fencing, construction of wildlife refuges, and maintenance (including patrolling, enrichment planting, and fire and barriers to protect from insect invasion). Thirty-seven hectares were identified for potential agroforestry, the operations considered to estimate the cost of agroforestry were: consultation with stakeholders, design, acquisition of seedlings, establishment and maintenance, including phytosanitary inspections and training of landowners. For environmental education, the cost of six workshops in the first three years was assessed. It is important to highlight that those areas targeted for restoration are not bare lands; consequently, all the operations considered in the cost analysis aimed to enhance the health of the forest in its current condition. Accordingly, the major investment for restoration and agroforestry would happen during the first four years of establishment. The present value for all three projects was of $421 267 dollars[5], 70.6% and 25.3% corresponded to the active and passive restoration respectively; 2.8% to agroforestry, while, environmental education workshops accounted only for 1.3% of the costs.

Discussion

Forest management usually involves a large variety of values related to nature and the human condition; understanding those values is important for policy making (Raymond et al. 2014). Deliberative forums are recognized as mechanisms that can lead to value formation through social learning (Kenter et al. 2016; Reed et al. 2010) and thus serve to elicit peoples' values of ecosystem services (Fish et al. 2011). Deliberation builds political legitimacy based on its efforts to obtain the voluntary and informed consent of citizens, recognizes differences in values, informs and educates citizens encouraging them to formulate solutions to local problems. In rural communities with small numbers of constituents, deliberative forums provide essential information about both ecosystems services and people´s values associated with them (Ramirez-Gomez et al. 2017). The problem tree and participatory mapping techniques used in this research were instrumental to elicit transcendental shared values of the stakeholders of El Quinini forest reserve. During the focus groups, forest owners deliberated, learned from each other, and characterized their territory. These exercises helped forest owners structure their preferences and foster agreement among them (Curato et al. 2017; Kenter et al. 2015), allowing them to design a proposal for a desirable end state that was expressed in their willingness to pay for three projects to increase forest health. The participatory mapping exercise also showed the desire of forest owners to protect their land, as shown in the past-present map (Fig. 5) and that a portion[6] of the territory was abandoned from agriculture and cattle or planted with trees (in the last 20 years); this is consistent with the desired of the forest owners to declare their territory as a forest protected reserve.

Forest owners of El Quinini identified people´s lack of awareness about the relationship between human activities and forest conservation as the main reason related

[5] The average exchange rate for 2015 for Colombia was of $2743.39 Colombian pesos per dollar

[6] Aproximately 683 ha. measured it with GIS

to water scarcity; this reason was also associated with the lack of law enforcement and the use of heavy machinery for agriculture. The consequences reported were water pollution and scarcity, deforestation, economic damage, and dissatisfaction. Although corruption is mentioned as one of the causes, local residents did not feel confident to address this issue, but they rather provided solutions to the causes and consequences where they felt they have more control. The lack of enforcement of environmental legislation has been reported as a driver of illegal harvesting in Colombia (Rodríguez-Piñeros et al. 2018); our findings suggested the need to enhance governance at all levels, in all regions. Although environmental education is considered an ecosystem service *per se* (Hutcheson et al. 2018), there is a need to enhance formal and informal education about ecosystems services and science in rural areas (Silva et al. 2017). While Colombia has a program for environmental education at the primary and secondary education levels, this effort is not enough, there is a need to transform the education system to keep abreast of the current global threats (O'Brien et al. 2013). Informal educational programs for adults can serve as mechanisms to develop awareness and strengthen governance; stakeholders in rural areas need to know basic technical concepts to be well-informed and to be able to deliberate about values and facts (Stern and Fineberg 1996). More scientific knowledge on ecosystem services is a precondition to obtain more accurate non-market economic values in the developing world (Christie et al. 2012). Although forest owners feel that they need more environmental education, their social values reveal a high connection to nature.

The average willingness to pay of $1.84 dollars per month is in the range of the average payments for water bills. Most of the socioeconomic variables were not statistically significant, including age, educational level, occupation, income, locality, major problem of the reserve and preference for project; this is an unexpected finding since several studies have shown that income, age, and occupation variables contribute to people´s WTP. These findings contradict, some of the criticisms made of contingent valuation methodologies that state that total economic value (TEV) does not have any meaning when people do not have money (Christie et al. 2012); despite of their low income, 74% of the participants were willing to pay an extra fee to implement the projects. In this particular case, forest cover is of high value because it guarantees their subsistence, not having forest cover will worsen their already precarious situations.

The variables that explained WTP were: perception about the importance of the reserve, the water bill, and the place from where the individual obtained water. Those individuals who perceived the reserve as an "important" source of water were willing to pay 3.6 times more than the others. This result supports other findings about the WTP for water in rural areas (Martin-Ortega et al. 2009). Similarly, our results corroborate other studies that found that individuals who obtained water from the natural wells were willing to pay more to implement restoration strategies than those individuals who take water from the municipal plant (Silva et al. 2010). However, the negative sign of the coefficient implies an inverse correlation, meaning that for a unit increase in the water bill, the willingness to pay would decrease *ceteris paribus*. Similarly, as more people take water from the municipal plant their willingness to pay for the projects decreases *ceteris paribus*. These results imply that if more water plants are built, constituents will pay for the service in a water bill; however, an extra payment to implement projects to protect the reserve would not be an option. Consequently, there is a need to improve education about ecosystem services and their relationships to human wellbeing and development.

Although the variable AFSM (activity needed for sustainable management) did not predict the willingness to pay, the forest restoration with native species obtained 56% of support, versus the agroforestry that only obtained 2% of support. Similarly, in the regression model income did not predict the WTP, but 74% of the participants stated to be willing to pay $1.84 per month, even though more than 80% of the population has an income lower than the minimum wage. This is an important finding which shows people are willing to pay for a desirable end state that has meaning to them. It is important to mention that those individuals who claimed not to be willing to pay because of the lack of income are eager to contribute with labor, this supports findings from other studies about the perception of values in the labor market as not being a monetized commodity in rural areas (Alam 2013; Casiwan-Launio et al. 2011). In addition, water is considered a normal good; therefore, it is expected that as income increased the WTP for the service will increase. Since the proposed solutions came from deliberative forums and reflected social values, the willingness to pay and to contribute to the establishment of the three projects were high.

The proposed agroforestry and forest restoration solutions indicated the importance of forest cover to local residents, who in turn expressed their willingness to participate in the implementation of such projects on their own lands. The present-past map drawn by forest owners depicted how agricultural monoculture (coffee) displaced native fruit trees resulting in forest degradation; coffee is still the major agricultural product for Colombia that has provided income and jobs for a large portion of the rural population in the country. In the tropics, agroforestry has been shown to be an efficient practice since it contributes to soil retention, increases crop productivity, reduces operational costs, and helps to maintain biodiversity (Udawatta et al. 2019).

The cost analysis showed that informal education has the lowest cost of the three projects proposed. This result, when combined with the WTP, provides insights into how the money can be allocated. Although forest owners are willing to pay for the implementation of the projects, the amount that could be collected for four years would not be enough, implying that state and/or local or NGO monies would be required.

Conclusion

The results of this study indicate that transcendental social-values about water availability are closely related to education and forest restoration. Education, which is conducive to environmental awareness, plays an important role in confronting the current environmental crisis. Our study shows that despite the challenges that stakeholders have to achieve minimal standards of quality of life, they are willing to pay an amount similar to current water bills to implement education and restoration practices; although, that amount of money does not cover all of the forest operations needed to accommodate social values towards water availability. Therefore, regional and local government and NGOs should assist with the restoration strategies and strengthen institutional governance.

Our study shows that both neoclassical economic models and participatory approaches serve to inform local leaders, policy makers, and practitioners about ecosystem services and people´s values. Rural communities are constantly exposed to issues of making tradeoffs between their livelihoods and forest conservation, knowing how people assign monetary and non-monetarily values to their resources as a function of their opportunities is of significant importance for decision making. Forest owners of El Quinini Reserve have shown their strong desire to protect the forest cover of the reserve.

Further research is needed to assess the reasons forest owners themselves do not want to engage in the discussion about corruption and its association to ecosystems degradation.

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Data Availability and Material Data will be available upon request.

Declarations

Conflict of interest The authors declare no conflicts of interest.

Consent to Participate An informed consent was used for participants, participation was voluntary and confidential. Name of participants are not identified and all data will remain secure.

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