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Evaluating conservation threats to reservoirs in the semiarid region of Brazil using the perception of residents

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ABSTRACT

Conservation and management strategies must be holistic, and therefore must guarantee the participation of local communities in the processes of identifying threats. Our study sought to identify the principal threats to reservoir conservation in the semiarid region of Brazil based on the perception of residents, and develop a conceptual model with the main threats to be used as a basis for orienting conservation measures. The study was undertaken with four communities around four reservoirs in two watersheds. A total of 126 people were interviewed to identify threats to reservoir conservation. The Criticality Index (CI) of threats was calculated based on the methodology developed by Open Patterns for Conservation Practices. Among the principal threats to reservoirs identified by local populations were discharging residues (both solid and liquids) and overfishing. In support of local perception, larger Criticality Index values were recorded for: 1- discharging residues (CI = 0.50), 2- deforestation in the riparian zone (CI= 0.20), and 3 - overfishing (CI = 0.17). The recorded threats put at risk the sustainability of local ecosystems and human populations. It will be necessary to develop effective conservation policies that promote environmental awareness and foster the participation of local communities in the sustainable administration of local ecosystems.

Keywords: Water Resources; Environmental Degradation; Lotic Ecosystems; Biocultural Conservation.

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INTRODUCTION

Reservoirs are artificial aquatic ecosystems constructed for water storage, aquaculture, fishing, irrigation, and recreational purposes (Mustapha 2008; Pamplin et al. 2006). Reservoirs have been constructed in the semiarid region of Brazil to mitigate problems related to the long periods of drought common to that area (Gutiérrez-Cánovas et al. 2013). As such, they have high economic, social, cultural (Lima et al. 2012) and ecological importance, although they are subject to numerous threats that can compromise their conservation (Barbosa et al. 2012).

Problems related to the conservation of aquatic ecosystems (including reservoirs) include: silting-up, pollution by chemical products such as fertilizers and industrial wastes, discharges of untreated domestic sewage, and the deforestation of riparian zones (Azevêdo et al. 2017a; Barbosa et al. 2012; Fremier et al. 2015). The long dry periods common to semiarid regions and high levels of evaporation from standing water surfaces will intensify environmental problems because they promote (among other factors) high concentrations of nutrients in reservoir waters leading to eutrophication (Alvares et al. 2013; Barbosa et al. 2012). Those processes tend to culminate in biodiversity losses and water quality degradation (Chellappa et al. 2009), generating negative impacts on biological communities, ecosystems, and human populations. Thus, conservation evaluations are becoming increasingly inclusive, requiring the analysis of both environmental and social factors.

In terms of environmental factors, evaluations of riparian areas are extremely relevant to aquatic ecosystems (Azevêdo et al. 2017a; Kaufmann et al. 2014a; Kaufmann et al. 2014b) as they contribute to the maintenance of water quality, avoid soil erosion, maintain ecosystem services, reduce natural disasters, promote habitat connectivity for species in fragmented landscapes, and favor the development of sociocultural practices (Fremier et al. 2015; Kindu et al. 2013; Mas et al. 2004; Vitousek et al.1997). The Brazilian Forestry Code (Lei nº 12.727/2012) assigns minimum 30 m protected strips (maximum 100 m) around reservoirs (including the riparian zone) as Permanent Protection Areas (APP). Those riparian areas, however, are still highly susceptible to anthropic impacts such as residential construction, the establishment of commercial zones, discarding garbage, road construction, pasture formation, and agricultural activities (Azevêdo et al 2017a; Gennet et al. 2013; Huang et al. 2013; Kaufmann et al. 2014a; Kaufmann et al. 2014b). Thus, there is an urgent need to develop proactive conservation measures to help mitigate those growing problems (Brown et al. 2013; Jackson et al. 2016).

In this context, the environment perception by local residents consists of a promising element to be integrated in conservation actions, since they can indicate real threats to the conservation of ecosystems, which enables the planning of actions and allocation of resources for the mitigation of specific threats (Davis and Wagner 2003). Perception is the apprehension of reality by people, what can be result in the identification of color, sounds, smell and taste; that expresses itself through chemical and neurologic processes, at the level of sense organs and the central nervous system (Silva et al. 2014). However, although the use of the term perception is common, what is accessed from individuals access are representations that they have their experiences through interaction with the environment, it is included the subjectivity of cultural and psychological factors (Nisbett and Miyamoto 2005; Cavalcante and Maciel 2008). Seen in these terms, the way as human beings perceive the environment directs their interaction with it (Artell et al. 2013).

Local residents live in direct contact with reservoir environments and retain specific perception about them – and therefore have the capacity to identify local threats (Cvitanovic et al. 2016) and provide important observations complementary to those of technicians and scientists. Thus, planning conservation measures for aquatic ecosystems must necessarily involve evaluating the principal threats to them and should involve consulting the collective perception of adjacent communities (Artell et al. 2013; Periago et al. 2017; West et al. 2016). The daily experiences of individuals who lives near reservoirs result in diverse experiences and cognitive interpretations that are expressed in the perceptions and collective knowledge of those communities (Ingold 2002; West et al. 2016) – and can result in interactions that promote either the conservation or the degradation of those ecosystems (Artell et al. 2013; Hartter et al. 2012).

Within that context, we sought to identify the direct and indirect threats to the conservation of reservoirs in the semiarid region of Brazil based on the perception of residents that lives in contact with those ecosystems. We also constructed a conceptual model designed to contribute to the development of proactive conservation efforts directed towards those reservoirs. The methodology employed here for threat analysis can be replicated anywhere in the world where human communities interact with local ecosystem.

MATERIAL AND METHODS

Study area

The present study was undertaken at four reservoirs, and included their neighboring communities, within two semiarid watersheds in the Brazilian states of Paraíba and Rio Grande do Norte.

In Paraíba State, we evaluated on perception concerning threats to the conservation of the Poções Reservoir (29,861,562 m³) (7°53'33" S; 37° 0'31" W) in the municipality of Monteiro, and the Sumé Reservoir (44,864,100 m³) (7°40’14” S; 36°54'25" W) in the municipality of Sumé (both in the Rio Paraíba watershed). In Rio Grande do Norte State, we evaluated on perception concerning threats to the Traíras reservoir (49,702,393 m³) (6°30'52" S; 36°55'58" W) in the municipality of Jardim do Seridó, and the Sabugí reservoir (65,334,880 m³) (6°39'10" S; 37°12'20" W) in the municipality of São João do Sabugí (both in the Rio Piranhas-Assú watershed) (Fig. 1).

The mean annual precipitation in Paraíba is 400 mm and in Rio Grande do Norte, 800 mm (Alvares et al. 2013). The reservoirs examined experience intense use, including activities related to providing water resources for human use, fishing, irrigation, animal stocks, and leisure (Azevêdo et al. 2017a, Azevêdo et al. 2017b). Those activities are of great regional social, economic, and cultural importance (Lima et al. 2012).

Documenting threats to reservoirs through the perception of local communities

A total of 126 people were interviewed, including 38 from the communities around the Poções reservoir, 22 in Sumé, 31 in Traíras, and 35 in Sabugí to facilitate the comparison of results, the human communities were named by the reservoirs. In all cases, the interviews were restricted to people that live within about 200 m of a reservoir margin, as those people had greater probabilities of directly interacting with that ecosystem, based on the previous contacts with these communities, it was possible to notice that some people who lived farther from the reservoirs came over

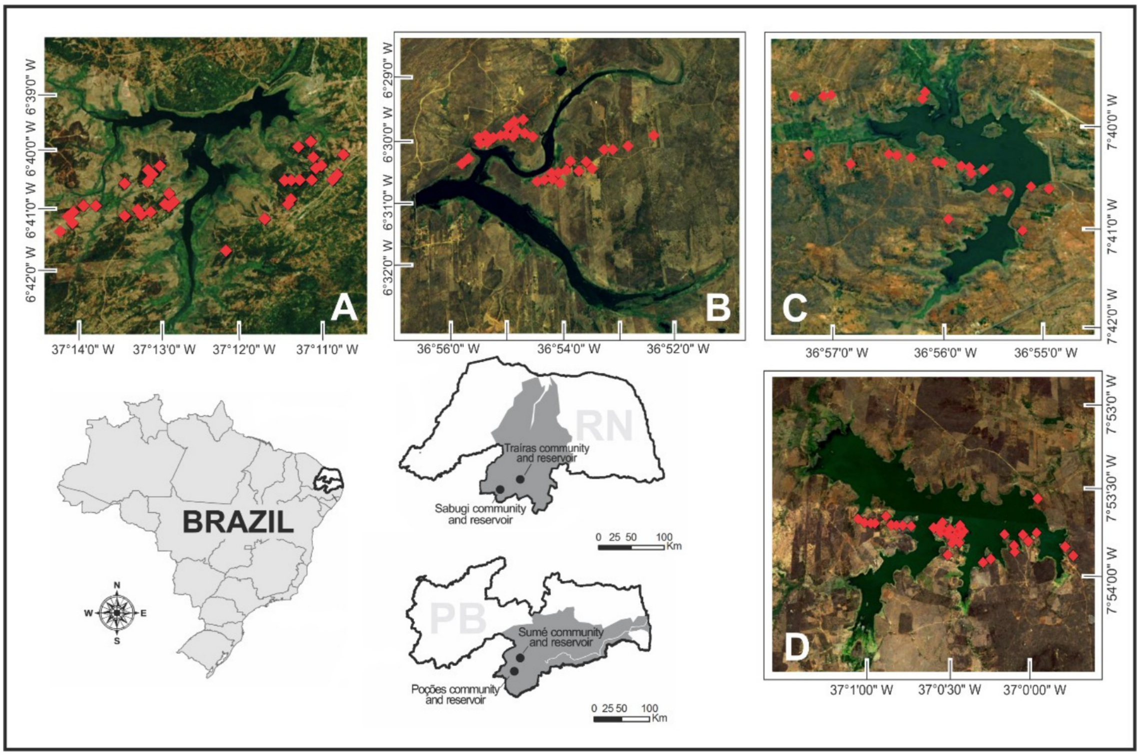

Figure 1. Map of the communities and reservoirs surveyed, in the Piranhas-Assú (A-Sabugí and B-Traíras) and Paraíba (C-Sumé and D-Poções) watersheds, Brazil.

to have less interaction and knowledge with these ones. A previous study developed in this area showed this tendency (Azevêdo et al., 2017a), besides others (eg.: Giles-Cortia and Donovanb 2002). The interviews were held between September and October/2015, using semi-structured questionnaires to collect socio-economic data and information about the perception of the interviewees in relation to conservation threats to the reservoirs. Visits were carried out in all head of households households located within the predefined area, in each one of the households was interviewing one of the heads of family, what was available at the time of the study, head of households were chosen, because they are generally older people and are expected to have more knowledge in relation to the environment they live. Here are some of the questions were performed: 1- Can you see changes in the water quality of the reservoir? 2- If so, what are the changes you can see? 3- What problems do you realize that can reduce the quality of the reservoir?

The objectives of the study were explained to the participants before each interview. Similarly, we obtained their permission to record that information and asked them to sign Free Consent and Understanding Forms, as required by Resolution 466/2012 of the Brazilian National Health Council. Approval for the research was obtained from the Ethics Committee of the State University of Paraíba – UEPB (license Nº 1.030.872).

The target population was principally composed of small farmers (70%, n = 88), fishermen (16%, n = 20), housewives (6%, n = 8), and individuals practicing other professions (8%, n = 10). Eighty-one interviewees (63%) were men and 45 were women (37%). The ages of the interviewees varied from 18 to 82 (mean = 51). Twentyfour percent (n = 31) of the interviewees had no formal education, 3% (n = 4) had completed grammar school, 61% (n = 76) had not completed grammar school, 3% (n = 4) had not completed intermediate school, 7% (n = 9) had completed intermediate school, and only 2% (n = 2) had completed high school. The mean income of the interviewees was R$ 735.71 (approximately US$ 236.56).

Conceptual model

The conceptual model used in the study was constructed following the Open Patterns for Conservation Practices methodology, developed by the Alliance or Conservation Measures, using Miradi software (CMP 2013). The model represents the relationships between the conservation target (in this case reservoirs) and direct and indirect threats. The model was chosen because it is used worldwide for the systematization of threats in conservation units. The Alliance or Conservation Measures, develops a set of Open Standards for project evaluation or adaptive management for the development of effective conservation. The developed Standards, like the model constructed in this study, should not be seen as recipes, as a guide for the development of conservation actions, though.

Direct threats are those that have immediate impacts on the conservation target, while indirect threats are characterized by influencing the occurrence of direct threats (Salafsky et al. 2008). Direct threats were identified through interviews with local residents, as those individuals occupy that environment and therefore had greater chances of detecting them; because these individuals develop daily activities which solely depends on the reservoirs, such as agriculture, breeding of animals, and fishing; thus they present more likely to notice changes in the environment such as threats (Azevêdo et al., 2017a). We also made direct observations of the reservoirs, undertook analyses of satellite images (considering a 200 m perimeter around the reservoirs) (Google Earth), consulted data from regulatory agencies of the drainage basins in each state (Executive Agency of Water Management of Paraíba - AESA, and the Department of the environment and Water Resources of Rio Grande do Norte - Semarh), and had consultations with employees of relevant municipal agencies, to evaluate the levels of threats to the reservoir and subsequently calculate the Criticality Index (CI). Therefore, direct threats were indicated by interviewers and supported through the appointment carried out by researchers, mentioned before. In the other hand the indirect threats were identified by the observations and the authors interpretation. The graphic representation of the model consists of a large rectangular box (green) with an ellipse (blue), inside of which is the name of the conservation target (a box located on the right side of the model). From right to left are smaller boxes (pink) with the direct threats written inside them. Linking the direct threats are indirect threats, represented by other (orange) boxes (substituir por: Direct threats are linked to indirect threats, orange boxes). The direct threats are all linked to the conservation target by arrows, while the indirect threats are generally linked to the direct threats (although they can also be interlinked) (Fig. 5). The layout of the model, as well as the representative colors, follows the methodology established by the Open Patterns for Conservation Practices framework (CMP 2013).

Data analyses

To evaluate the citation frequency ratios of the direct threats identified by the interviewees, the number of times that a given threat was cited in a given community was divided by the total number of interviewees. The threats indicated by interviewing people were grouped according to answers similarity.

The criticality degree of each direct threat was calculated according to the methodology described by the World Wide Fund for Nature (2007). To that end, three factors were considered in the analyses: 1- the extent of damage caused by the activity; 2 - its severity; and, 3- the permanent nature of that damage to the environment, or the degree of irreversibility of the damage to the reservoir and/or to the Permanent Preservation Area (a minimum area 30 m and maximum area of 100 m surrounding the reservoir). A value of from 1 to 4 was attributed to each factor. The multiplication of those values resulted in the criticality level of each direct threat in each of the reservoirs studied. Based then on the criticality value of each direct threat, the Criticality Index (CI) of all of the threats to the reservoir could be calculated – considering the ratio between the criticality of the threat to the reservoir and the maximum criticality that would be obtained if all the factors received a rating of 4 (Nóbrega 2015). We also calculated the Total Criticality Index (CI) for each threat recorded (considering all of the reservoirs) based on the ratio of the total observed criticality for a given threat divided by the maximum criticality value considering all of the threats. The Criticality Index therefore generates values between 0 and 1 (with values near 1 indicating greater criticality).

The frequency of direct threat citation was considered to identify the main threats indicated by interviewed people. With this data (most frequent threats) it was possible to calculate the Criticality Index for each threat in each reservoir. According to this data, was possible to calculate the criticality index to each threat in each reservoir. Subsequently, it was possible to evaluate the total criticality, considering the occurrence relationship of threats in all reservoirs. Assessment of citation frequency and Criticality Index work in a complementary manner, considering that through them we can evaluate the threats perceived by the interviewers (frequency), the most critical threat to reservoir, local threat (Criticality Index) and evaluate the most critical threat among all identified in the communities, regional threat, at hydrographic basin level (Criticality Total Index).

RESULTS

Based on the information supplied by the interviewees, seven direct threats related to the reservoirs were identified: 1 - residue discharges (solid and liquid); 2 - turbidity caused by sediments; 3 - excessive water removal; 4 - dumping animal remains in the reservoir waters or along its margins; 5 - overfishing; 6 - the decomposition of the vegetation (grasses) along the edges of the reservoirs; and 7- deforestation. The most frequent threats mentioned were residue discharges and overfishing (Fig. 2).

A conceptual model was constructed based on the identifications of those direct threats (Fig. 5). Residue discharges appeared as the highest criticality factor for reservoir conservation (CI = 0.5) (Fig. 3). Residues, for purposes of this study, were considered to include any type of material or substance, solid or liquid, which could compromise reservoir water quality, such as organic material, agrochemicals, or sewage.

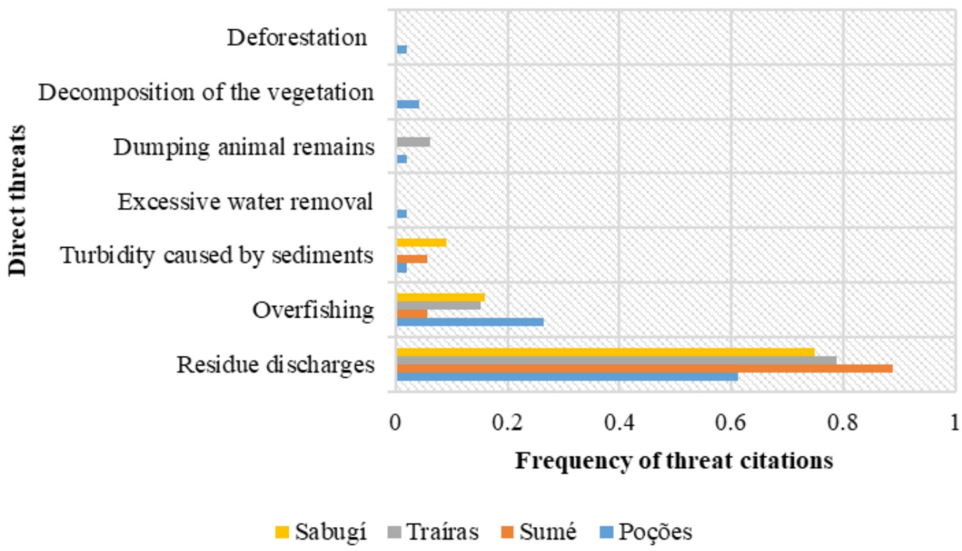

Figure 2. Main threats to the studied reservoirs indicated by the local population. Traíras and Sabugí Reservoirs, Piranhas-Assú river watershed; Sumé and Poções Reservoirs, Paraíba River watershed, Brazil.

Among those substances, untreated sewage from urban areas was indicated by most of the interviewees as the principal source of reservoir pollution (Fig. 2). As can be seen in figure 4, residue discharge represents the threat with the greatest number of links to indirect threats, some of which are of high impact, such as the use of agrochemicals and the lack of (or inefficiency of) garbage collection and sewage treatment.

Deforestation is practiced to prepare pasture for animals (cattle, sheep, and goats), for subsistence and small-scale commercial agriculture (principally vegetables and beans), and to provide firewood. Those threats had Criticality Indices of 0.20 (Fig. 3). Some residents affirmed that the removal of riparian vegetation to maintain the reservoir margins free of plant residues (e.g., branches and leaves) contributed to maintaining clean reservoir waters.

Fishing for subsistence or commercial purposes (artisanal commercial fishing), had a Criticality Index of 0.17 (Fig. 3). Residents complained that fishermen from other areas throw the viscera and scales of the fish they clean into the reservoir waters or discard them along its margins.

In analyzing the Criticality Indices of the threats to each of the reservoirs (Fig. 4), it is possible to note that the threats follow essentially the same criticality patterns as when those threats are analyzed together (considering all of the reservoirs) (Fig. 3). The most critical threats to the Poções, Sumé, and Traíras reservoirs were found to be residue discharges, deforestation, and overfishing. The only reservoir that differed slightly from that pattern was the Sabugí reservoir, as the second most criticality threat there was identified as overfishing instead of deforestation (Fig. 4).

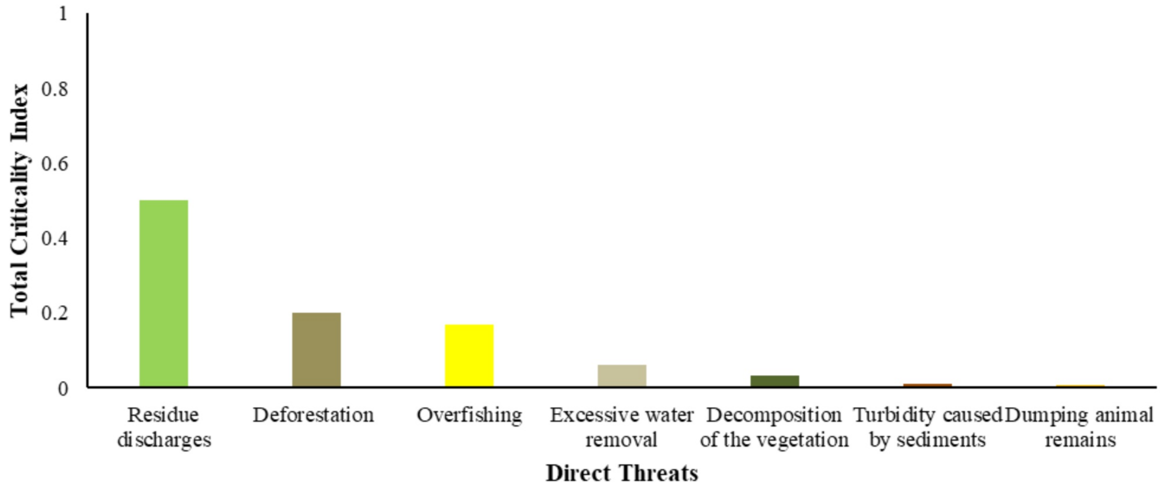

Figure 3. Criticality Index of the threats on the researched reservoirs. Traíras and Sabugi reservoirs, Piranhas-Assu river watershed; Sumé and Poções reservoirs, Paraíba river watershed, Brazil.

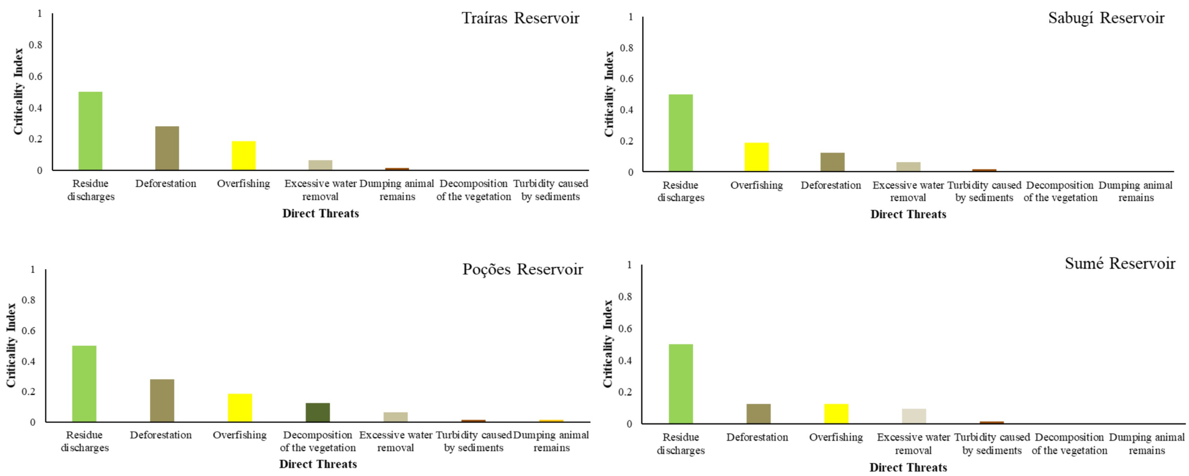

Figure 4. Criticality Index for each of the reservoirs. Poções, Sumé and Traíras reservoirs present as the most critical threats: residue discharges, deforestation and overfishing. Traíras and Sabugí Reservoirs, Piranhas-Assú river watershed; Sumé and Poções Reservoirs, Paraíba river watershed, Brazil.

DISCUSSION

The importance of threats identification by local residents

Living near the reservoirs allowed local community members to identify alterations in those aquatic ecosystems and perceive the main threats to their conservation, this is a pattern that has been observed when relating perception and interaction with enviroments (eg.: Giles-Cortia and Donovanb 2002; Davis and Wagner 2003). Nevertheless, it is necessary to consider the importance of exchange of perception and joint monitoring through interaction between local residents, scientists and technicians. Identifying the seven threats to local ecosystems could have been difficult, if it

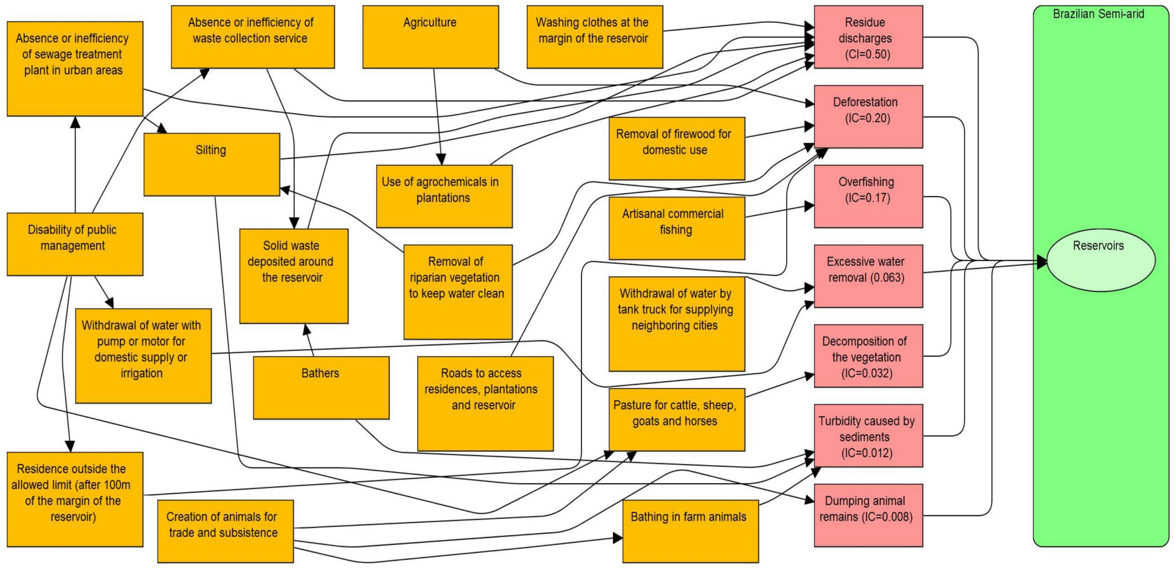

Figure 5. Conceptual model with the identification of direct and indirect threats to the reservoirs in the semiarid region. Reservoirs Traíras and Sabugí, Piranhas-Assú river watershed; reservoirs of Sumé and Poções, Paraíba river watershed. The green box represents the conservation target, the pink boxes indicate the direct threats indicated by the local community, and the yellow boxes indicate the indirect factors that drive the threats. CI = Criticality Index.

were not possible to access the perception of the local community (Artell et al. 2013). These residents may not have, with any exceptions, of scientific information. However, they comprehend the dynamic, and the factors that interfere in the ecosystem, based on their empirical knowledge (Cvitanovic et al. 2016).

Through interaction between human beings and nature, it is possible to develop the ability to recognize the threats to the environment, such as by observing organoleptic properties of water (eg.: West et al. 2016), whereby the individuals can infer about your quality. Azevêdo et al. (2017) performing a study in the same region, identified that the local residents observed the organoleptic properties of water to direct their different uses in the communities. It is necessary to consider the individuals that indicated the local ecosystem threats, they can also be those who cause the same threats. Yet, it should be noted that if conservation actions are implemented, since their planning, with local community participation, these individuals may be integrated in the conservation system, and thus they will be able to build up sensibility to act for the conservation of local ecosystems (Periago et al. 2017).

The precise identifications of threats can indicate priority directions for resource allocations and facilitate effective, proactive conservation efforts (Stephanson and Mascia 2014), by residents, scientists, and technicians' integrations. It is evident that at many times, and depending on the resources available to management institutions, the threats posed cannot be solved in just a single time. For this reason, the development of strategies such as the one applied to this work, enables the identification of most critical threats, with the support of residents' perception and the calculation of the Criticality Index.

In our study, the most critical threat was the residue discharge in the reservoir, so the local managers will be able to allocate resources to solve, primarily, this issue. Collective actions to exclude or mitigate point or diffuse sources of residues may be undertaken with the community. Still, environmental education activities may be carried out combined to these local residents. Silva et al. (2010) analyzing the brazilian students representation in relation to fragments of Atlantic Forest, it can evaluate that in most of the tests developed, it was possible to identify utilitarian aspects of the forest, description of biodiversity, and students' feelings about the need to protect the environment. Sousa et al. (2016), performed environmental education project “Lagoas de Vida” in six schools of central region and Norte de Portugal, by the development of practical environmental education activities, for instance: lectures, techniques of lagoons building, lagoons management and monitoring, training of aquatic animals breeding; after that, the project development could to prove that there was an improvement of students' knowledge and attitudes towards lagoons and associated biodiversity. Works like these show that environmental education actions are essential for information gathering, awareness and project organization in the area.

Implications of perceived threats to the local ecosystem

The raised perceptions converged on residue discharges as the principal factor impacting reservoir conservation. That threat is aggravated by indirect factors such as effluent discharges from urban areas with no sewage treatment stations (Sumé, Sabugí, and Traíras). Effluent discharges directly into rivers constitute constant sources of pollution (Smith et al.1999) in northeastern Brazil, where only 32% of all urban residential sewage is treated (National System of Sanitation Information, SNIS 2015). That data corroborates a more general pattern in the world, as 80% of all residential sewage remains untreated globally, with the highest treatment percentages (70%) being found only in countries with high incomes (70%) (United Nations Conference on Water Resources Development World Report, 2017) – which demonstrates the necessity of developing effective policies for residential water treatment in developing countries.

Other indirect factors related to residue discharges, such as agrotoxins loads from agriculture, and residues from homes along reservoir margins, are characterized as diffuse pollution sources (pollutants from non-specific points, including surface runoff) (Barbosa et al. 2012). Those types of pollution in the study area can also related to extensive deforestation and the presence of grazing animals along the reservoir margins (Azevêdo et al. 2017a; Azevêdo et al. 2017b). A study of threats to ecosystem services undertaken with farmers in the Richmond watershed (in north-eastern New South Wales, Australia) also identified agrotoxins as a local threat (Smith and Sullivan 2014). Both point-source and diffuse pollution can cause serious damage to aquatic ecosystems as they promote, among other problems, eutrophication, habitat alterations, biodiversity reductions, and losses of ecosystem services (Malaj et al. 2014; Perrin et al. 2014; Sibanda et al. 2015).

Effluents from urban areas are carried to reservoirs and are retained there until the next period of reservoir overflow – which may take years to occur in semiarid areas (Cirilo 2008). Another associated factor is the high evapotranspiration rate found in those ecosystems, which heightens nutrient concentrations and significantly reduces water quality (Alvares et al. 2013; Barbosa et al. 2012). The waste disposal in reservoirs, by point or diffuse sources, it is one of the main problems which promote an increase of nutrient concentrations in water, such as P (phosphorus), causes the eutrophication which degrades water quality and reduces the supply of ecosystem services. Mekonnen and Hoekstra (2017) affirm that the charge of P in ecosystem of fresh water in the world was estimated in 1.5 Tg/yr, with around of 68% of P being produced in Asia, followed by Europe (19%), replicated in Europe (19%), Latin America and Caribbean (13%); although 54% of P is from the domestic sector, 38% of agriculture and 8% of industrial segment.

Problems related to residue discharges (such as garbage and sewage) also have impacts on human health, as local residents consume untreated water. Gastroenteritis diseases caused by viruses, protozoans, and/or bacteria represent more than 80% of the waterborne illnesses in Brazil (UNESCO 2015). Cyanobacteria blooms occur more frequently in eutrophic aquatic systems (Hilborn and Beasley 2015), with serious impacts on human health, as those cyanobacteria produce hepatotoxins and neurotoxins, and cytotoxins that can cause death through hemolysis (Drobac et al. 2013).

Deforestation is related to pasture formation, agriculture, cutting for firewood, and “cleaning the reservoir". Among those threats, the most curious is the practice of removing riparian vegetation to maintain "clean" reservoir waters. Awareness seminars should be promoted by watershed committees to diminish that practice, as it causes soil erosion, the silting-up of aquatic ecosystems, the intensification of natural disasters, and reduced water quality (Kindu et al. 2013; Vitousek et al. 1997). If well-maintained, areas of riparian vegetation can increase biodiversity and the overall quality of ecosystem services furnished to the local community, such as food resources, regulation, and cultural support, and the development of recreational and educational activities (Vollmer et al. 2015).

Considering the benefits of biodiversity conservation, the maintenance of those areas are important because they support hydrophilic organisms that depend on the aquatic environment but exchange material and energy with surrounding ecosystems (Fremier et al. 2015). Additionally, numerous species use riparian corridors for access to drinking water, escaping predators, obtaining food resources, as nidification habitats, for dispersal, and for moving between habitat fragments (Fremier et al. 2015).

Although fishing activities in Brazil are regulated (Law 11.959/2009) those regulations are not obeyed in many localities – as was documented by reports of conflicts between fishermen in the different study areas. A factor that could help explain those conflicts was the reduction of fish resources during the study period, which coincided with the longest dry spell in recent years in Brazil (World Meteorological Organization, WMO 2015) – forcing fishermen to seek fishing areas in sites they were unaccustomed to. Additionally, overfishing, the introduction of exotic fish species, and prolonged periods of drought have caused many native fish populations to decline (Attayde et al. 2011; Chellappa et al. 2003; Driver and Hoeinghaus 2016). It will be necessary to develop local strategies and policies that can better coordinate fishing activities as well as provide alternative work opportunities during periods when fishing is prohibited and periods of drought conditions.

The threats identified in the present work will not, of course, be identical to those encountered in other watershed throughout the world, although the same methodology used to detect threats and evaluate their criticality can be implemented with the help of scientists conservation administrators and technicians in any place in the world – as long as there are interactions with local communities that live in and use those ecosystems.

CONCLUSIONS

Pollution due to residue discharges represents a strong threat to reservoir conservation. Those discharges can take different forms, although sewage effluents tend to be the principal sources of pollution. The data accumulated in surveys such as this and consider local perception can aid watershed administrators in directing resources to combat specific identified threats. It is also important that community information policies be developed to stress the importance of conservation – as many of the threats to reservoirs originate in contiguous communities. Local communities must directly participate in administrative and conservation processes involving threat detection and in the elaboration of management and conservation plans for those ecosystems.

The methodology applied in this study can be replicated in other human communities to survey threats and define their criticality. This study also represents a modest theoretical advance on the theme environmental perception and application in metrics for ecosystem assessment against conservation. It was not possible to define conservation actions for the reservoirs during this study; however, future actions can be created from the surveyed data. It is important for threat investigation to take place continuously over time; as such, threats may vary according to climatic, socioeconomic and anthropogenic factors. Future studies can generate models for threat prevention and mitigation, then that local communities, technicians, scientists and managing bodies can act in a coordinated manner in shared management.

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