

What Did We Learn By Using Participatory Landscape Scenarios In Rio Doce Park, Brazil?

Sónia Carvalho Ribeiro

sonia.carvalhoribeiro@gmail.com

UFMG: Universidade Federal de Minas Gerais <https://orcid.org/0000-0002-3045-8632>

Erika Ferreira

UFMG: Universidade Federal de Minas Gerais

Luiz Gustavo Souza Paula

UFMG: Universidade Federal de Minas Gerais

Ramon Rodrigues

UFMG: Universidade Federal de Minas Gerais

Maria Auxiliadora Drumond

UFMG: Universidade Federal de Minas Gerais

Henrique Purcino

UFMG: Universidade Federal de Minas Gerais

Brayan Oliveira

UFMG: Universidade Federal de Minas Gerais

Vinícios Moreira

IF: Instituto Florestal

Adriana Monteiro

UFMG: Universidade Federal de Minas Gerais

Braulio Fonseca

UFMG: Universidade Federal de Minas Gerais

Natália Almeida

UFMG: Universidade Federal de Minas Gerais

Tim O'Riordan

UEA: University of East Anglia

Úrsula Azevedo

UFMG: Universidade Federal de Minas Gerais

Alfio Conti

UFMG: Universidade Federal de Minas Gerais

Paulina Barbosa

UFMG: Universidade Federal de Minas Gerais

Research Article

Keywords: ecology, Landscape, sustainable, stakeholder

Posted Date: July 22nd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-559792/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at Landscape Ecology on March 2nd, 2024. See the published version at <https://doi.org/10.1007/s10980-024-01860-w>.

Abstract

Context: This study uses landscape ecology tools and methods for developing participatory scenarios through spatially explicit modelling to forge innovative governance frameworks in the buffer areas of Rio Doce State Park in Brazil. We built on experiences from land management to derive contextual knowledge from evidence of landscape management that may be synthesized into theory within the field for supporting progress towards sustainable land use alternatives.

Objective: We examined how evidence from landscape management in Rio Doce Park and its buffer areas can be synthesized to foster landscape governance. For that we used 1) participatory scenarios for envisioning and exploring possible and desirable futures, as seen by the local communities; 2) multicriteria analysis for modeling and mapping areas holding biophysical potential to carry out the activities seen as desirable by local communities; and 3) explored how those desirable futures can be implemented by framing appropriate multiscale governance.

Results: Our results show that landscape ecology tools and methods were able to foster stakeholder engagement and, in an innovative way, brought the views of local community stakeholders into landscape policy making. Although there is institutional capacity for moving towards sustainability there is the need to go beyond sectoral approaches to land management and integrate broader societal demands into the conservation agenda. The institutional setting is confusing and readjusting it to implement desirable futures sought by communities depends on an emerging set of landscape stewards.

Conclusion: The experience emerging from this work and the participation in governance forums for over 6 years (2016-2021), highlights that while landscape ecology helps at envisioning desirable scenarios, and that landscape approaches are helpful for discussing and reconciling different interests, there is not yet a landscape institutional leader pushing by the enforcement of a whole landscape approach reconciling sectoral integration (agriculture, forestry, tourism & conservation) as well as the cross scale governance needed for implementing desirable landscape scenarios in the buffer area of PERD. This adds to the scope for more responsive governance and the changing role of university-based research for working towards sustainable landscape outcomes. This research provides the basis for exciting future innovation in landscape ecology practices and management.

Landscape ecology is a leading field, both in research and practice, for investigating the relationships between social and natural processes mediated by land use changes. Despite a rich variety of empirical case studies, research and practice in landscape ecology has been falling behind in interpreting, modelling, predicting and developing knowledge for helping to influence the behaviour of social agents, including governmental and non governmental institutions, in moving towards more sustainable land uses across tropical landscapes. This study uses landscape ecology tools and methods for developing participatory scenarios through spatially explicit modelling to forge innovative governance frameworks in the buffer areas of Rio Doce State Park in Brazil. We built on experiences from land management to derive contextual knowledge from evidence of landscape management that may be synthesized into theory within the field for supporting progress towards sustainable land use alternatives. Our results

show that landscape ecology tools and methods were able to foster stakeholder engagement and, in an innovative way, brought the views of local community stakeholders into landscape policy making. Although there is institutional capacity for moving towards sustainability there is the need to go beyond sectoral approaches to land management integrating broader societal demands into the conservation agenda by using landscape approaches. This adds to the scope for more responsive governance and the changing role of university-based research for working towards sustainable landscape outcomes. This research provides the basis for exciting future innovation in landscape ecology practices and management.

Introduction

Landscape ecology is a leading field, both in research and practice, for investigating the relationships between social and natural processes mediated by land use changes (Dramstad and Fjellstad, 2011; Hobbs, 1997; Iverson Nassauer and Corry, 2004; Turner et al., 2020; Turner and Gardner, 2015; Zonneveld and Forman, 1990). The purposes and activities through which people interact with land generate many sustainability challenges because of a lack of suitable approaches (Antrop, 2006; Turner et al., 2020; Zonneveld and Forman, 1990). Identifying more sustainable land-use alternatives requires better understanding of the complex and intertwined processes of land-use/cover changes. Although land use changes have been well documented across the world, and particularly in the tropics, there is a lack of contextual generalizations describing and explaining the conditions that trigger, enable, or prevent land use changes. Hence there is no clear path towards creating a reliable generalized knowledge of land use change (Meyfroidt et al., 2018; Turner et al., 2020). This knowledge gathered from evidence of landscape management may be synthesized into theory within the field for supporting progress towards sustainable land use alternatives (Bennett et al., 2021; Meyfroidt et al., 2018; Turner et al., 2020).

Scenario approaches were widely used here as a means of integrating the science of landscape ecology for exploring more sustainable futures (Börjeson et al., 2006; Carvalho-Ribeiro et al., 2010; Hobbs, 1997; Leventon et al., 2019; Sitas et al., 2019; Tress and Tress, 2003; Van Berkel et al., 2011). Scenario refers to the different possible stories, or alternative assumptions, that underlie landscape change (Carvalho-Ribeiro et al., 2010). In landscape scenarios, the alternative futures are spatially explicit, through representations of land cover patterns in maps, digital imaging simulations, or even drawings (Iverson Nassauer and Corry, 2004). Landscape scenarios bring in implications for policy, allowing decision-makers, experts and the broader public to literally “see” the range of possible land use alternatives across landscapes (Carvalho-Ribeiro et al., 2010; Dupont et al., 2015; Van Berkel et al., 2011).

Engaging a group of people through participatory landscape scenarios makes stakeholders more aware of society-nature interactions, helps to discuss stakeholders’ land use preferences and ambitions. This helps to analyse how preferred land uses could be allocated across “their” landscape (Aguiar et al., 2020; Carvalho-Ribeiro et al., 2010; Iverson Nassauer and Corry, 2004; Reed, 2008; Reed et al., 2013; Tress and Tress, 2003; Van Berkel et al., 2011). Trade-offs and synergies can be assessed by evaluating changes in land use and various ecosystem services, and their combined effects towards fulfilling landscape

stakeholder ambitions (Reed et al., 2013). Spatial modelling of alternative future scenarios proved to be a suitable catalyst for building landscape partnerships, and for bringing to the surface stakeholder assumptions, analyses, and negotiations around strategy, production and resource management practices and spatial planning (Carvalho-Ribeiro et al., 2010; Van Berkel et al., 2011). Scenarios based on integrated approaches co-designed by stakeholders from multiple sectors, demonstrate the potential to achieve progress towards landscape sustainability (Chopin et al., 2019; Reed, 2008; Reed et al., 2013).

Despite a rich variety of empirical case studies, research and practice in landscape ecology has been falling behind in interpreting, modelling, predicting and developing knowledge for helping to influence the behaviour of social agents, including governmental and non governmental institutions, in moving towards more sustainable land uses across tropical landscapes. Particularly missing is the use of scenario tools to aid understanding of the spatial heterogeneity of human, policy and environmental factors in order to determine where different types of rural development can be implemented in the context of buffer zones of protected areas in tropical landscapes.

This gap is particularly noticeable in Brazil. While Brazil has placed most of its conservation efforts in protected areas, it has been proven especially difficult to effectively address the consequences of unfavourable land use changes across its buffer zones (Vieira et al., 2019). While scenarios from the 'conservation arena' literature have been focussing on empirically determining what works in conservation, those often do not include detailed descriptions of relevant policies and the broader institutional settings in which particular conservation strategies might succeed (Chopin et al., 2019; Cumming and Epstein, 2020; Kremen and Merenlender, 2018). Relatively few studies in landscape ecology have explicitly considered the constraints that ecosystem heterogeneity might impose on policy making and institutional design (Cumming and Epstein, 2020). This is especially the case in a participatory context where the focus is in the aspirations and achievements of less advantaged stakeholders.

Landscape approaches have been used for balancing and making explicit the trade-offs within conservation objectives and development agendas (Arts et al., 2017; Reed et al., 2020, 2016; Sayer et al., 2013). Such approaches have taken a 'whole-landscape' approach (Dolman et al., 2001) for reconciling conservation and development based on a premise that there will be both winners and losers and that such synergies and trade-offs must be identified, negotiated and accounted for (Sayer et al., 2013). It is time to assess to what extent such approaches have been successful in delivering their objectives or identifying barriers to progress. This learning experience is vital for consolidating social theories within the field of landscape ecology.

Here we use participatory scenarios for exploring how interactions between human and ecological dynamics shape land use change. We focus on the social-ecological systems perspective for learning how features of society and ecosystems create fit and misfit between social and ecological dynamics, and enable or impair collective action to move towards desirable futures, as seen by local communities. Institutions regulating natural resources are diverse and include governments, other public institutions,

traditional regulations, and cultural norms. These institutions span across different levels of governance from local to national and global. Therefore, planning landscapes towards more sustainable futures across Brazilian protected areas requires coordination of policies and stakeholder engagement across different scales of governance (Carvalho-Ribeiro et al., 2010; Cumming and Epstein, 2020; Görg, 2007; Leventon et al., 2019). Given that rural policy decisions implemented at one scale of governance may have consequences on the delivery of goods and services at other scales, there have been calls for the application of multi-scale approaches (Berkes and Folke, 1998; Biggs et al., 2007; Carvalho-Ribeiro et al., 2016; Folhes et al., 2015; Pereira et al., 2020; Rosa et al., 2017; Zurek and Henrichs, 2007, 2007). The relevant literature on this subject is scarce and exposes a number of conceptual and methodological difficulties.

The objective of this work is to summarize contextual knowledge learnt from the experiences of participatory scenario based landscape planning in the buffer zones of the the Rio Doce State park, one of the sites of the International Long-Term Ecological Research Network (ILTER). In the RioDoce ILTER site we explore possible futures for reconciling conservation with livelihood wellbeing, and the scope for institutional cross scale coordination needed for implementing desired nature-people scenarios. We focus on 1) exploring desirable futures as seen by local communities; 2) developing spatial models for mapping biophysical potential for the land use activities considered desirable by local stakeholders; and 3) forging possible governance pathways for implementing desirable scenarios as seen and sought by local communities. After six years of engagement we offer key messages learnt and summarize those for building contextual knowledge deriving from this empirical long term case study.

Study Area

The Rio Doce is one of the largest rivers (850 km long) in Southeast Brazil (Fig. 1). Over 3 million people spread across 229 municipalities live in the region. With a drainage area of 86,725 km², Atlantic forest remnants occupy around 11–16% of the original native vegetation. Many of the municipalities where native vegetation has been lost present high poverty rates and/or low levels of socio economic development. Over 50% of the area of the river basin is human altered (Fig. 1, yellow), comprising agriculture, small-scale farming and pastures. The scarce and declining presence of native vegetation and protected areas (Fig. 1, light green) poses a major challenge for sustainable landscape management in the region.

Rio Doce state park is the largest remnant of Atlantic forests in the state of Minas Gerais. It has the second largest wetland area in South America after the Pantanal. Recent studies however indicate that there is a great opportunity for the Atlantic forest, including Rio Doce river basin, to go beyond biodiversity hotspot status and become a “hope spot” where a history of degradation and loss potentially turned into a sustainable future (Rezende et al., 2018).

In 2015, the region experienced the devastating effects of a large mining-dam break which released a wave of toxic mud into the river basin across the states of Minas Gerais and Espírito Santo. The dam

breach devastated villages, caused the shutdown of water supply services in several cities, and disrupted fishing and other activities directly dependent on the river (Fernandes et al., 2016; Pires et al., 2017). After the dam failure, the federal public prosecutor, together with several government bodies and local stakeholders, reached an agreement with the mining companies to mitigate and compensate for the social and environmental impacts across the basin. A new governance framework and foundation (Renova) were created to implement a public-private agreement called the TTAC (Terms of Transaction of Adjustment of Conduct).

The new governance arrangement agreed that the necessary interventions made over an allocated ten year time frame, should be designed, to restore the prevailing ecological system, and to enhance local livelihoods hence contributing to local adaptation and sustainable development of the watershed. Restoration priority areas were designed to include, agroforestry systems as an option for restoring the whole landscape (Carvalho Ribeiro et al., 2020) restoring the ecology while also bringing in income to small scale farmers. In the last decade Rio Doce park, in line with the overall downgrading of protected areas in Brazil, has been losing resources, both financial and human, undermining implementation of conservation measures.

For more than 20 years the park has been part of the International Long-Term Ecological Research Network (ILTER). It has promoted several research projects targeting ecology, and environmental education programs. While the park has been able to halt land use change within its boundaries, its buffer zone has experienced deleterious land use changes (Fig. 1). To better understand the processes of land use change across these buffer areas a specific project sponsored by the Brazilian research institute initiated in 2016 sought to: 1) explore desirable futures, as foreseen by the communities living in the buffer area of the park; 2) map where there is biophysical potential for delivering the desirable futures as described by these community involvement processes; and 3) to assess which governance arrangements are most likely to deliver the scenarios as desired by local communities.

Methods

This work results from a collaborative research project bringing together research teams with background in landscape ecology, environmental modelling, geography and biological sciences together with park managers, governmental and nongovernmental organizations and private sector. Sponsored by a long term project by Conselho Nacional Desenvolvimento Científico e Tecnológico (CNPq) and part of ILTER the team found the appropriate conditions to use landscape ecology tools and methods for developing participatory scenarios through spatially explicit modelling in order to forge innovative governance frameworks in the buffer areas of Rio Doce State Park in Brazil.

The first stage of the project was to create scenarios of desirable futures (2.2.1), across the Rio Doce Park landscape, then to explore if there was biophysical potential in the area for the land use activities that were desired by stakeholders (2.2.2) and finally exploring the governance arrangements for implementing desirable futures (Sect. 2.2.3). In all the stages of the work the ten principles of landscape approaches as defined by Sayer et al (2013) were followed: Continual learning and adaptive management, common

concern entry point, multiple scale, multifunctionality, multiple stakeholder, negotiated and transparent change logic, clarification of rights and responsibilities, participatory and user friendly monitoring, resilience, strengthened stakeholder capacity. Stakeholder engagement and the development of participatory scenarios were developed in 4 (Revés do Belém, Pindo d'Água, Córrego Novo and Dionísio) out of the 16 municipalities surrounding PERD (see detailed description in SM). These municipalities were selected due to their different land use transition profiles (Oliveira et al., 2020). In some areas the major land use transitions are from forest to silviculture while others are from forest to degraded pasture and agricultural land. The research stages comprised two local workshops (held in each one of the 4 selected municipalities) with a final workshop gathering the participants of the four municipalities. For that workshop, in addition to local stakeholders, private companies (pulp industry CENIBRA, and others), governmental institutions (municipalities bodies, agriculture, education and tourism institutions) participated (SM).

For developing the participatory scenarios in each one of the municipalities, a supervisory team facilitated the process. Although major research phases were predefined (through 2 local workshops and a governance workshop) the participatory processes in different places followed different participatory dynamics according to the participants profile of the different groups (SM). The launching of the project was in March 2017, and the initial research stages in preparation for the workshops comprised a field work and the analyses of the past land use trends (from 1985 to 2015) (Oliveira et al., 2020). The initial workshop held in the four selected municipalities was held in December 2017 and the second in April/May 2017. After the development of the scenario storylines in the workshops we used multicriteria analysis for mapping land use suitability of the region for the land use activities seen as desirable by local stakeholders. With both scenario storylines and mapping of suitable areas for implementing desirable land uses the governance workshop was held in October 2018. After the 3rd workshop the team engaged in multiple governance forums exploring possible ways for implementing land use activities seen as desirable by local stakeholders.

2.2.1 Developing participatory landscape scenarios

Although some members of the research team have worked in the region for more than 20 years, other team members, specifically students with backgrounds in biology, geography and engineering and their supervisory teams, did not know the region. The objective of the first field work was to become familiar with the study area and to have initial contacts with the communities. We used a snowball sampling approach for identifying local stakeholders to participate in the workshops, as well as to identify the places available for the meetings to be held. We found this process was vital to build trust.

In the first workshop, acknowledging that it is difficult to ask participants about their “desired future” we simulated future land use trends based on the land use transitions from the past 20 years for prompting the initial discussion (De Oliveira et al., 2020). This land use modelling showed that if past trends were continued there would be loss of forest and agricultural areas to degraded lands and forms of silviculture that would compromise human well being and future socio economic development of the region. A

brainstorming session was held for opening the workshop. Questions were asked whether or not the land use trend model previously presented was feasible and what were other possible positive and desirable futures for the region. This discussion aimed to foster participants to take ownership and to contribute with their opinions.

In the first workshop participants filled out individual forms containing their desired futures and land uses associated with them. These ideas were gathered and a paired prioritization matrix was discussed in plenary. To preserve the anonymity of the participants, the completed forms were shuffled by the workshop facilitator. With the help of the participants, similar scenarios were clustered. This moment was used to question participants about what factors underlay their views and which institutional arrangements might best assist in the implementation of the desired future. In the same workshop, a participatory mapping process was elaborated with local actors, taking into account the ideas of futures suggested by the participants. In the form of drawings or texts, participants were encouraged to insert them on the printed map of the studied location.

The second workshop was used to further elaborate on the skeleton of the visions from the first workshop and present the first results of the suitability analysis to stakeholders (see Sect. 2.2.3). This workshop bridged knowledge by local communities with local experts in environmental modelling. Major issues discussed related to how best map suitability either using stakeholders opinions or by reviewing scientific literature (SM).

2.2.2. Spatially explicit modelling for allocating visions of desired futures across rio doce landscape;

We used multicriteria analysis, based on the Analytical Hierarchy Process (AHP) using both Quantum Geographic Information System 2.18 (QGIS) and Dinamica EGO. AHP has been widely used for supporting decision making by using repeated comparisons of spatially explicit layers (variables considered important for allocating different land use activities) pair by pair (SAATY, 1987). The first step comprises the selection of geospatial layers that either favour or hamper the suitability of the land for the land use activity that stakeholders considered desirable. In the second step, the relative importance is assigned between the different layers, within a pairwise comparison matrix (eigenvalue, consistency index and the consistency ratio). In the third step, the importance weights for each variable are generated. In each one of the municipalities selected the participation process differed. The detailed description of the stakeholder engagement process and the details of the land use suitability models for four desirable scenarios are described in the supplementary material(SM).

2.2.3. Explore public and private governance mechanisms to implement the visions.

After engaging stakeholders for developing scenarios for the PERD region in the two initial workshops (Sect. 2.2.1) and identifying the suitable areas for allocating land use activities desired by local communities using spatial explicit modelling (Sect. 2.2.2), a third workshop discussed the governance arrangements that would most likely deliver those desired scenarios. In this workshop the participants filled in a plan for action identifying for each desired scenario: What actions need to be implemented, by

whom and whose resources (financial and human) are needed. Following this workshop held in October 2018 until the present the team has been engaging in multiple governance forum for exploring ways for implementing the landscape scenarios seen as desirable by local stakeholders.

Results

Throughout the participatory scenario development stakeholders had chosen four desirable landscape scenarios: Agroforestry, Agri Husbandry, Restoring degraded lands & Conservation and Tourism development (Fig. 3). These scenarios were selected because they were believed to contribute to generating economic returns to the local community and also delivering conservation. Those were placed within two major axes: income generation and conservation. Agroforestry and tourism development were placed into the first quadrant, as likely to deliver both income generation and conservation. Agri husbandry in the second quadrant with lower associations with conservation but with associated higher land use rents. The conservation scenario was ranked high on the conservation axis but associated with lower rents (fourth quadrant). Stakeholders made well explicit that rents from conservation scenarios are to be linked with the tourism development scenario.

Above all, the stakeholder engagement process revealed that the municipalities surrounding PERD lack basic infrastructure, mainly health care, education and transport. Stakeholders do have difficulties in acknowledging the positive benefits that PERD might bring to their livelihoods. They often report the restrictions on access and use of natural resources, and that there is a noted lack of identity between communities involved and park management. In the four municipalities where scenarios developed there were different preferences for the different scenarios. While in some areas agri husbandry was the most preferred scenario other municipalities selected agroforestry, yet others preferred to reconcile conservation and tourism. A description of the preferences coming from the four different municipalities is presented in detail in SM. Putting those scenarios together will deliver a lively 'working landscape' where biodiversity conservation, low intensity agriculture and sustainable tourism are complementary to each other and rural out migration consequently relatively low.

In the discussions of the workshops we understood that the agroforestry scenario was selected because stakeholders associate it with local income generation, as well as to environmental conservation and notably its positive associations with water related ecosystem services. Agroforestry is above all associated with the creation of new sources of employment and income that can add value to local traditional livelihoods. Stakeholders acknowledge that, for centuries, the soil in the Rio Doce basin has been used for economic purposes, promoting several productive chains. However, currently, there are numerous environmental impacts that concern the communities linked to this region. The Vale do Rio Doce is one of the regions with the highest occurrence of degraded areas in Minas Gerais and has long lived with a problem of depletion of water sources. In the region agroforestry can be associated with integrated cultivation of perennial woody species with other agricultural and livestock crops, in shared spaces and in multifunctional land use. These different types of Agroforestry systems can vary in their arrangements (spatial and temporal), physiognomy, floristic composition, functional role of components

and ecological aspects, system management, production objectives and predominant socioeconomic characteristics. With regard to the contribution that agroforestry can make to the conservation of biodiversity, agroforestry systems are believed to likely increase local biodiversity; increase economic resilience; favouring connections between forest fragments. It also reduces economic pressure on native forests and encourages the reforestation of deforested areas. Therefore, assuming that they are implemented in a way to enhance natural regeneration and the succession of species, agroforestry are instruments of recognized interest for the recovery of degraded areas, since they cause improvements in soil conditions and ecological enhancement to stimulate tourism. The agroforestry land use model shows that there are more than five and a half thousand hectares suitable for agroforestry in the region surrounding the Rio Doce State Park. These areas are human-altered rural areas, close to highways, within Permanent Preservation Areas (PPA) and with low vegetation index. It is a significant area of land, when it comes to implementing agroforestry. For this type of information to be useful in the decision making of a possible program for revegetation of degraded areas, other filters will probably still be necessary, using different variables (SM). The model presented here, however, is a promising start to assist in these possible future works.

Other desirable scenario relate to land use such as agri husbandry. This scenario associates agricultural production with livestock grazing in order to promote food production associated with the generation of jobs and income, in addition to favoring gastronomic and ecological tourism in the region. The Rio Doce area is traditionally a milk production basin where small scale farmers are predominant. The problem so far is that there are not yet strategies for adding values to agri husbandry products and therefore income generated by this activity is very low. It was also stated that there needs to be new markets and arrangements for agrifood products. The engagement with stakeholders raises the awareness that for better results, both in terms of income generation and for enhancing environmental conservation, there are trade offs to be made. One of the needs is to restrict the areas for agri husbandry production to the places where there is medium to high biophysical potential (SM). The land use model for agri husbandry shows that 20% of the municipality of Bom Jesus do Galho (where this scenario was the most preferred-see SM) holds biophysical potential from high to very high. Such areas identified with these classes have, in general, plain relief. It is worth mentioning that the National System of Nature Conservation Units (SNUC) provides that the Comprehensive Conservation Units Management Plan should include ways of integrating conservation with the economic and social activities of communities, including services for the installation or improvement of local infrastructure, and therefore native forests cannot be converted into intensive agriculture or urban areas. The results from the agri husbandry model show that from northwest to northeast of the urban sector of the District of Revés do Belém, there are areas destined for silviculture, with agricultural potential ranging from medium to high. Such areas could be destined to consortium use for planting food or strips of land could be assigned for the installation of these crops. If this is negotiated amongst the pulp industry CENIBRA, cooperative work could be encouraged in these locations between business and communities. In addition, areas that have agricultural potential classified as Very High have been urbanizing or allocated to silvicultural activities, mainly with eucalyptus plantations.

The land use intensification deriving from these trends in land use change have been impacting on the lacustrine system. The lacustrine system which includes dozens of natural lagoons has been suffering from anthropogenic land use pressures. Whether public or private areas, it is suggested that the lagoons, as well as their immediate surroundings, receive special attention regarding conservation, and potential areas for ecotourism can be considered. Another alternative, given the respective demand, could be developing product chains of native species. In this way, economic and environmental functions could be promoted in these regions, encompassing the other social and cultural landscape functions by involving both local communities and visitors.

More problematic is to define priority areas for conservation and restoration around the PERD. Two multicriteria models, one with consultation with the local stakeholders, and the other based on the literature review were developed. Results show a low overlap of the priority areas for restoration emerging from the preferences of local stakeholders and from the literature review. This happened because the weights attributed according to the literature were directed towards the conservation of biodiversity, while the weights attributed according to the wishes of the local communities were directed towards the maintenance of ecosystem services (SM). Thus, the overlap was restricted to areas surrounding water features and potential areas for ecological corridors. Within these areas, we identified as priority actions the increase of the Permanent Preservation Areas (PPAs) already existing through the implementation of Legal Reserve areas in their surroundings and the creation of mechanisms for the Payment of Environmental Services. In the latter case, the definition of priority areas on a local scale can act as an important subsidy for the monetary valuation of the area to be conserved, which is not currently the case.

Putting all together and attending to the biophysical potential of each location, the landscape functions can be reconciled in different types of landscapes that work for people and nature (Kremen and Merenlender, 2018). Pasture and agriculture areas with low to moderate levels of degradation can be reforested using agroforestry. Both trade in agricultural products and guided tours encouraging gastronomic tourism can be developed in these places. In the Silviculture areas, intercropping is feasible, as well as activities such as beekeeping, which is already present around the Park.

In view of the meetings held with local actors and research partners, it is believed that this work may influence the application of public policies, project design and improvements for the region. Specifically, the company in the cellulose branch CENIBRA, which showed interest in contributing to the development of the region, either through the provision of areas or a consortium for the cultivation of food. Indeed the scenario development process created cooperation and partnerships across communities, public and private institutions. The same pulp industry company also made itself available to train workers in the production of asphalt pavement with the use of steel aggregate, currently donated to some municipalities in the Vale do Aço region. In this way, it would contribute to the improvement of access routes to these locations. The time involved in mobilizing, establishing and maintaining bonds of trust with the community, and skepticism on the part of some local actors in relation to the research were difficulties that existed throughout this process.

Some gaps could have been filled to improve mobilization and bonds of trust with the community: a longer stay in the study site, including activities suggested by the community to strengthen the bond with our team and the project. For example: meetings, mini-courses, periodic presentations of the progress of the project, among others. Meanwhile the CNPq cut funding for this project. As it is a participatory research, the continuity of the project is essential. The challenges are, therefore, the strengthening of ties with the community; effective contact with the project partners, envisioning the development of the Action Plan; elaboration of more detailed studies on the areas selected for the implementation of projects, etc. In order to move forward with the implementation plan established in the governance workshop held at the park headquarters there is the need to reconcile the activities that have been conducted from the individual sectors separately altogether and make a landscape scenario implementation taskforce. The research team has been still keeping the contacts in the area and participating in the governance forums.

In a complementary way and reporting events in the study area during the execution of the project, for example in the city of Bom Jesus do Galho and extensionist programs (EMATER) developed discussions on family farming, adding issues on the planting of vegetables and tubers, production of greengrocers and the creation of a Fair Free from the Rural Producer of the Municipality. There was a technical visit to the municipality of Piedade de Caratinga, which is a reference in growing vegetables and tubers in the region and the delivery of irrigation kits. Discussions about the program operation with local farmers also include technical assistance activities and rural extension of project adherence, diagnostic steps, participatory management plan elaboration, market prospecting, individual and collective services, until the evaluation of the results. Other actions of the city halls already progress were: corn silage, grass and sugar cane to ensure the feeding of herds in Bom Jesus do Galho; plowing land to assist rural producers, technical guidance from extension programmes governmental body (EMATER) and delivery of poultry at more affordable prices to producers in the region, supporting poultry farming to increase household income through the production of meat and eggs. The Social Assistance Reference Center - CRAS, was carrying out training activities on Modern Russian Stitch Embroidery, including an exhibition of embroidery produced during classes in Revés do Belém. EMATER, in cooperation between the Bank of Brazil foundation and the city hall, was disclosing the monitoring and fencing of springs in the rural area of the Municipality. The city hall's institutional website also linked the project to the Sustainable Development Goals that are part of the United Nations' Agenda with goals for the year 2030. In relation to social interaction, the public sector, together with the Renova Foundation and Instituto Elos carried out in the Revés do Belém District a joint effort that resulted in the construction of a square for the community next to the state school and the renovated court next to the football field.

All of these ongoing actions lead us to believe that this process is under development and its evaluation will have to be continuous over the next few years. All the initiatives that have been carried out so far have been previously discussed within the scope of this project and it can be said that, although in a modest way, this participatory process allowed to change the local reality. We understand that this result of a large number of initiatives occurring after the implementation of this participatory process can be considered a very positive gain given the social context of the area before the realization of this project.

Despite a positive experience, from the governance workshop it was also made clear that in order to implement those scenarios, leading actors had to be the municipality councils. Municipalities in the region, namely in their master Plan, can bring together their land use zones that are seen as more sustainable by local stakeholders. One of the problems is that some of the municipalities do have lack of human resources and lack technical capacities to develop their Master plans and land zones. Furthermore, it was also well acknowledged that in order to have scale for the development of markets for the different activities (tourism, agroforestry products, etc) those had to be implemented at the landscape (regional) scale. However there is not yet an institutional body that reconciles rural development activities across different municipalities with these agro, forestry and tourism drivers of development.

In the governance meetings held so far it was well acknowledged that there is the need for integrating sectors such as conservation (PERD), agriculture (Ministry of agriculture, EMATER), Tourism (secretary estadual Turismo) at the landscape scale. It was also well acknowledged that for landscape scenarios to be feasible and implemented there is the need to reconcile governance mechanisms at different scales of governance. Stakeholders called for cross scale governance in order to implement landscape scenarios such as agroforestry, agri husbandry, tourism and conservation. In all these scenarios relevant policies at the national scale need to be reconciled to regional and local efforts.

The experience emerging from the participation in governance forúns for over 6 years (2016–2021) highlighted that there is not yet a leader pushing by the enforcement of a whole landscape approach. While the goals of environmental governance have been incorporating for example concepts such as ecosystem services and notably payment for ecosystem services (PES) there is not yet a sort of new actors with background for implementing the theory of landscape approaches on the ground moving towards the implementation of landscape scenarios.

The participatory process was helpful for developing landscape scenarios which in turn can be assessed and evaluated by a range of interested parties. This brought in an innovative way the desires of local communities that live in protected areas and its surroundings to be acknowledged by local institutions, governmental and nongovernmental organizations. Participants worked closely and cooperatively through a sequence of workshops to reach more close consensus of land use options. These combined the views of different interests, agricultural, commercial, conservationist and touristic, to establish an agreed process for collective negotiation. Add to this the scope for more responsive governance and the changing role of university-based research for working towards sustainable landscape outcomes, and this research provides the basis for exciting future innovation in landscape ecology practices and management.

Discussion

Although landscape ecology is currently situated among the leading fields for investigating the relationships between social and natural processes mediated by land use practices (Antrop, 2006; Dramstad and Fjellstad, 2011; Tress and Tress, 2003; Turner and Gardner, 2015), there is not yet a

systematic reporting of the relevant contextual generalizations emerging from case studies for further developing social theory geared to describing the conditions that trigger, enable, or prevent more sustainable land use changes for fostering landscape scale governance (Meyfroidt et al., 2018; Turner et al., 2020).

This is of utmost importance in the context of protected areas and their buffer areas in Brazil (Oliveira et al., 2017; Vieira et al., 2019). While Brazil has been placing most of its conservation bets in protected areas, buffer zones of protected areas have been given less attention. This creates conservation “islands” highly vulnerable to unfavourable land use trends in their surroundings. Nevertheless the conservation agenda is still very much focussed on conservation goals while initiatives for fostering community well being across protected areas and its buffer areas are still scarce (Bieling and Plieninger, 2017; Hobbs, 1997; Kremen and Merenlender, 2018).

This work results from a collaborative research project bringing together research teams with backgrounds in landscape ecology, environmental modelling, geography and biological sciences together with park managers and private industry sectors. Our results show that landscape ecology tools and methods were able to foster stakeholder engagement and, in an innovative way, brought the view of local community stakeholders into policy making. Private sector companies, for example the pulp industry CENIBRA, the new governance arrangement lead by RENOVA and others, found that the results of this participatory process helps at envisioning more sustainable land uses for the river basin.

However, our results also show the difficulties within the field from moving from scenario development to effectively implement more sustainable land uses (Carvalho-Ribeiro et al., 2010; Hobbs, 1997; Tress and Tress, 2003; Van Berkel et al., 2011). In linked social-ecological systems (SESSs), groups of people from local communities, industry stakeholders, governmental organizations, etc, collectively regulate their environmental impacts and respond to environmental change via institutions, which are broadly defined as the formal and informal laws, rules, norms, traditions and customs that govern the interactions of human groups with their environment (Cumming and Epstein, 2020). In a context where public funding for environmental management in Brazil is increasingly scarce, attracting funding from non-traditional sources for providing support to communities living in and around protected areas is of utmost importance (Carvalho Ribeiro et al., 2020, 2018).

In the context of one of the worst environmental disasters in Brazil (Carvalho Ribeiro et al., 2020; Fernandes et al., 2016), with new governance arrangements and funding perspectives, this project developed from 2016 to 2021 (ongoing). We organized two local workshops that were held in four different municipalities and a third governance workshop, bringing together all the participants from the local workshops. Following, and from 2018 to the present, the research team has been engaging in a variety of institutional meetings that occurred thereafter. This gave us the opportunity to learn from a six year period of stakeholder engagement experience.

The spatial patterns in ecosystems that result from institutions are widely recognized and well analysed (deforestation patterns under different policies) but the feedbacks from these patterns back to

institutions (and especially, the creation and modification of institutions) are seldom explicitly reviewed in studies of landscape ecology and land cover change and hence are poorly understood. The experience emerging from this work and the participation in governance forums for over 6 years (2016–2021), highlights that while landscape ecology helps at envisioning desirable scenarios, and that landscape approaches are helpful for discussing and reconciling different interests at the landscape scale, there is not yet a landscape leader pushing by the enforcement of whole landscape approaches reconciling sectoral integration (agriculture, forestry, tourism & conservation) as well as the cross scale governance needed for implementing those landscape scenarios in the buffer area of PERD. While the goals of environmental governance have been incorporating for example through concepts such as ecosystem services and notably payment for ecosystem services (PES), there is not yet a sort of new actor with educational background bridging natural and social sciences for implementing the principles of landscape approaches on the ground, moving towards the implementation of desirable landscape scenarios.

As far as implementation is concerned stakeholders call for the leadership of the municipality. Although the Master Plans are a tool for integrating land uses such as agriculture, forestry, conservation & tourism, municipalities in the region do not hold technical nor personal resources to do it. There is in the northern areas of PERD a metropolitan group of municipalities dealing with landscape urbanization. There is institutional capacity for steel and pulp production (e.g. CENIBRA and Usiminas industries). There is not yet, however, in place institutional capacity at the landscape scale for implementing desired landscape scenarios bridging across urban rural areas for fostering the region as a whole. While there is institutions able to represent urban and more intensive production systems there is not yet an institutional leader able to reconcile implementation of a diverse set of land use activities such as agroforestry, agri husbandry also reconciling tourism and conservation in an integrated way at the landscape scale in the Rio Doce buffer area. On the contrary, urbanization and land use intensification trends that have dramatically altered the buffer area of PERD do have well known institutional representatives in the area. While feedback from a management outcome to a subsequent management action are often reported in landscape ecology studies the institutional contexts for such feedback are often un-documented and landscape ecology lacks theoretical frameworks with which to describe and interpret them, despite their interest in other research fields. Our work aims at contributing to raise the need for landscape ecology research and practice in Brazil to be a leading field to educate students for fostering whole landscape approaches (Dolman et al., 2001; Reed et al., 2020, 2016; Reed, 2008; Sayer et al., 2013).

The Brazilian Federal Constitution of 1988, in its Article 204, assures “the participation of the population through representative organizations, in the formulation of policies and in the control of actions at all levels”. The emergence of collaborative or network government practices developed from participatory and consultative processes in many countries, especially in Europe and Latin America, has expanded the area of influence for public managers and social participation.

Universities are being called on to participate and contribute to this process, assuming the mission of being involved with demands from the external public, encompassing civil society, private companies and

governments. An important issue is to increasingly incorporate participatory social responsibility in higher education, both in teaching, research and extension, seeking to contribute more effectively to meeting broadly expressed social goals.

Although the demands for the development of collaborative and participatory research are growing, their results are not always effectively incorporated into decision-making and the formulation of public policies. In this context, universities can contribute by incorporating some practices in the training of professionals for this type of activity, including: (i) creating innovative courses for educating a new generation of landscape stewards that are able to lead integration of sectors such as agriculture, forestry, tourism and conservation at the landscape scale using participatory research in the economic, social and environmental areas; (ii) the involvement of landscape approach practitioners and researchers at all levels (undergraduate and graduate) in research and extension projects acknowledging that for successfully implementing landscape scenarios there is the need to foster multi scale governance; (iii) fostering the creation of junior companies bring in innovation for making sustainable land uses mainstream in remote inland areas; (iv) encouraging the publication of specific activities related to social well-being, environmental conservation and the reduction of inequalities. This is the setting for this research and its contribution to participatory landscape ecology for the betterment of ecosystems and people.

Conclusion

This research focussed on the processes of creating scenarios for future land use options for a buffer areas around a protected park in the remnants of the Atlantic forest in SE Brazil. Its strength lies in the methods for landscape scale scenarios which in turn can be assessed and evaluated by a range of interested parties bringing in the views of local communities to decision makers. Participants worked closely and cooperatively through a sequence of workshops to reach more close consensus of land use options. These combined the views of different interests, agricultural, commercial, conservationist and touristic, to establish an agreed process for collective negotiation. Add to this the scope for more responsive governance and the changing role of university-based research for working towards sustainable landscape outcomes.

References

1. Aguiar, A.P.D., Collste, D., Harmáčková, Z.V., Pereira, L., Selomane, O., Galafassi, D., Van Vuuren, D., Van Der Leeuw, S., 2020. Co-designing global target-seeking scenarios: A cross-scale participatory process for capturing multiple perspectives on pathways to sustainability. *Global Environmental Change* 65, 102198. <https://doi.org/10.1016/j.gloenvcha.2020.102198>
2. Antrop, M., 2006. Sustainable landscapes: contradiction, fiction or utopia? *Landscape and Urban Planning* 75, 187–197. <https://doi.org/10.1016/j.landurbplan.2005.02.014>

3. Arts, B., Buizer, M., Horlings, L., Ingram, V., van Oosten, C., Opdam, P., 2017. Landscape Approaches: A State-of-the-Art Review. *Annu. Rev. Environ. Resour.* 42, 439–463. <https://doi.org/10.1146/annurev-environ-102016-060932>
4. Bennett, E.M., Biggs, R., Peterson, G.D., Gordon, L.J., 2021. Patchwork Earth: navigating pathways to just, thriving, and sustainable futures. *One Earth* 4, 172–176. <https://doi.org/10.1016/j.oneear.2021.01.004>
5. Berkes, Fikret., Folke, Carl., 1998. Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press, New York.
6. Biggs, R., Raudsepp-Hearne, C., Atkinson-Palombo, C., Bohensky, E., Boyd, E., Cundill, G., Fox, H., Ingram, S., Kok, K., Spehar, S., Tengö, M., Timmer, D., Zurek, M., 2007. Linking Futures across Scales: a Dialog on Multiscale Scenarios. *E&S* 12, art17. <https://doi.org/10.5751/ES-02051-120117>
7. Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G., 2006. Scenario types and techniques: Towards a user's guide. *Futures* 38, 723–739. <https://doi.org/10.1016/j.futures.2005.12.002>
8. Carvalho Ribeiro, S.M., Rajão, R., Nunes, F., Assis, D., Neto, J.A., Marcolino, C., Lima, L., Rickard, T., Salomão, C., Filho, B.S., 2020. A spatially explicit index for mapping Forest Restoration Vocation (FRV) at the landscape scale: Application in the Rio Doce basin, Brazil. *Science of The Total Environment* 744, 140647. <https://doi.org/10.1016/j.scitotenv.2020.140647>
9. Carvalho-Ribeiro, S., Pinto Correia, T., Paracchini, M.L., Schüpbach, B., Ode Sang, A., Vanderheyden, V., Southern, A., Jones, P., Contreras, B., O'Riordan, T., 2016. Assessing the ability of rural agrarian areas to provide cultural ecosystem services (CES): A multi scale social indicator framework (MSIF). *Land Use Policy* 53, 8–19. <https://doi.org/10.1016/j.landusepol.2015.04.024>
10. Carvalho-Ribeiro, S.M., Lovett, A., O'Riordan, T., 2010. Multifunctional forest management in Northern Portugal: Moving from scenarios to governance for sustainable development. *Land Use Policy* 27, 1111–1122. <https://doi.org/10.1016/j.landusepol.2010.02.008>
11. Chopin, P., Bergkvist, G., Hossard, L., 2019. Modelling biodiversity change in agricultural landscape scenarios - A review and prospects for future research. *Biological Conservation* 235, 1–17. <https://doi.org/10.1016/j.biocon.2019.03.046>
12. Cumming, G.S., Epstein, G., 2020. Landscape sustainability and the landscape ecology of institutions. *Landscape Ecol* 35, 2613–2628. <https://doi.org/10.1007/s10980-020-00989-8>
13. De Oliveira, B.R., Da Costa, E.L., Carvalho-Ribeiro, S.M., Maia-Barbosa, P.M., 2020. Land use dynamics and future scenarios of the Rio Doce State Park buffer zone, Minas Gerais, Brazil. *Environ Monit Assess* 192, 39. <https://doi.org/10.1007/s10661-019-8016-9>
14. Dolman, P.M., Lovett, A., O'Riordan, T., Cobb, D., 2001. Designing Whole Landscapes. *Landscape Research* 26, 305–335. <https://doi.org/10.1080/01426390120090120>
15. Dramstad, W.E., Fjellstad, W.J., 2011. Landscapes: Bridging the gaps between science, policy and people. *Landscape and Urban Planning* 100, 330–332. <https://doi.org/10.1016/j.landurbplan.2011.02.003>

16. Dupont, L., Antrop, M., Van Eetvelde, V., 2015. Does landscape related expertise influence the visual perception of landscape photographs? Implications for participatory landscape planning and management. *Landscape and Urban Planning* 141, 68–77.
<https://doi.org/10.1016/j.landurbplan.2015.05.003>
17. Fernandes, G.W., Goulart, F.F., Ranieri, B.D., Coelho, M.S., Dales, K., Boesche, N., Bustamante, M., Carvalho, F.A., Carvalho, D.C., Dirzo, R., Fernandes, S., Galetti, P.M., Millan, V.E.G., Mielke, C., Ramirez, J.L., Neves, A., Rogass, C., Ribeiro, S.P., Scariot, A., Soares-Filho, B., 2016. Deep into the mud: ecological and socio-economic impacts of the dam breach in Mariana, Brazil. *Natureza & Conservação* 14, 35–45. <https://doi.org/10.1016/j.ncon.2016.10.003>
18. Folhes, R.T., Aguiar, A.P.D. de, Stoll, E., Dalla-Nora, E.L., Araújo, R., Coelho, A., Canto, O. do, 2015. Multi-scale participatory scenario methods and territorial planning in the Brazilian Amazon. *Futures* 73, 86–99. <https://doi.org/10.1016/j.futures.2015.08.005>
19. Görg, C., 2007. Landscape governance. *Geoforum* 38, 954–966.
<https://doi.org/10.1016/j.geoforum.2007.01.004>
20. Hobbs, R., 1997. Future landscapes and the future of landscape ecology. *Landscape and Urban Planning* 37, 1–9. [https://doi.org/10.1016/S0169-2046\(96\)00364-7](https://doi.org/10.1016/S0169-2046(96)00364-7)
21. Iverson Nassauer, J., Corry, R.C., 2004. Using normative scenarios in landscape ecology. *Landscape Ecology* 19, 343–356. <https://doi.org/10.1023/B:LAND.0000030666.55372.ae>
22. Kremen, C., Merenlender, A.M., 2018. Landscapes that work for biodiversity and people. *Science* 362, eaau6020. <https://doi.org/10.1126/science.aau6020>
23. Leventon, J., Schaal, T., Velten, S., Loos, J., Fischer, J., Newig, J., 2019. Landscape-scale biodiversity governance: Scenarios for reshaping spaces of governance. *Env Pol Gov* 29, 170–184.
<https://doi.org/10.1002/eet.1845>
24. Meyfroidt, P., Roy Chowdhury, R., de Bremond, A., Ellis, E.C., Erb, K.-H., Filatova, T., Garrett, R.D., Grove, J.M., Heinimann, A., Kuemmerle, T., Kull, C.A., Lambin, E.F., Landon, Y., le Polain de Waroux, Y., Messerli, P., Müller, D., Nielsen, J.Ø., Peterson, G.D., Rodriguez García, V., Schlüter, M., Turner, B.L., Verburg, P.H., 2018. Middle-range theories of land system change. *Global Environmental Change* 53, 52–67. <https://doi.org/10.1016/j.gloenvcha.2018.08.006>
25. Oliveira, B.R. de, Carvalho-Ribeiro, S.M., Maia-Barbosa, P.M., 2020. A multiscale analysis of land use dynamics in the buffer zone of Rio Doce State Park, Minas Gerais, Brazil. *Journal of Environmental Planning and Management* 63, 935–957. <https://doi.org/10.1080/09640568.2019.1617681>
26. Pereira, L.M., Davies, K.K., Belder, E., Ferrier, S., Karlsson-Vinkhuyzen, S., Kim, H., Kuiper, J.J., Okayasu, S., Palomo, M.G., Pereira, H.M., Peterson, G., Sathyapalan, J., Schoolenberg, M., Alkemade, R., Carvalho Ribeiro, S., Greenaway, A., Hauck, J., King, N., Lazarova, T., Ravera, F., Chettri, N., Cheung, W.W.L., Hendriks, R.J.J., Kolomytsev, G., Leadley, P., Metzger, J., Ninan, K.N., Pichs, R., Popp, A., Rondinini, C., Rosa, I., Vuuren, D., Lundquist, C.J., 2020. Developing multiscale and integrative nature–people scenarios using the Nature Futures Framework. *People and Nature* 2, 1172–1195.
<https://doi.org/10.1002/pan3.10146>

27. Pires, A.P.F., Rezende, C.L., Assad, E.D., Loyola, R., Scarano, F.R., 2017. Forest restoration can increase the Rio Doce watershed resilience. *Perspectives in Ecology and Conservation* 15, 187–193. <https://doi.org/10.1016/j.pecon.2017.08.003>
28. Reed, J., Ickowitz, A., Chervier, C., Djoudi, H., Moombe, K., Ros-Tonen, M., Yanou, M., Yuliani, L., Sunderland, T., 2020. Integrated landscape approaches in the tropics: A brief stock-take. *Land Use Policy* 99, 104822. <https://doi.org/10.1016/j.landusepol.2020.104822>
29. Reed, J., Van Vianen, J., Deakin, E.L., Barlow, J., Sunderland, T., 2016. Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. *Glob Change Biol* 22, 2540–2554. <https://doi.org/10.1111/gcb.13284>
30. Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. *Biological Conservation* 141, 2417–2431. <https://doi.org/10.1016/j.biocon.2008.07.014>
31. Reed, M.S., Kenter, J., Bonn, a., Broad, K., Burt, T.P., Fazey, I.R., Fraser, E.D.G., Hubacek, K., Nainggolan, D., Quinn, C.H., Stringer, L.C., Ravera, F., 2013. Participatory scenario development for environmental management: A methodological framework illustrated with experience from the UK uplands. *Journal of Environmental Management* 128, 345–362. <http://dx.doi.org/10.1016/j.jenvman.2013.05.016>
32. Rezende, C.L., Scarano, F.R., Assad, E.D., Joly, C.A., Metzger, J.P., Strassburg, B.B.N., Tabarelli, M., Fonseca, G.A., Mittermeier, R.A., 2018. From hotspot to hopespot: An opportunity for the Brazilian Atlantic Forest. *Perspectives in Ecology and Conservation* 16, 208–214. <https://doi.org/10.1016/j.pecon.2018.10.002>
33. Rosa, I.M.D., Pereira, H.M., Ferrier, S., Alkemade, R., Acosta, L.A., Akcakaya, H.R., den Belder, E., Fazel, A.M., Fujimori, S., Harfoot, M., Harhash, K.A., Harrison, P.A., Hauck, J., Hendriks, R.J.J., Hernández, G., Jetz, W., Karlsson-Vinkhuyzen, S.I., Kim, H., King, N., Kok, M.T.J., Kolomytsev, G.O., Lazarova, T., Leadley, P., Lundquist, C.J., García Márquez, J., Meyer, C., Navarro, L.M., Nesshöver, C., Ngo, H.T., Ninan, K.N., Palomo, M.G., Pereira, L.M., Peterson, G.D., Pichs, R., Popp, A., Purvis, A., Ravera, F., Rondinini, C., Sathyapalan, J., Schipper, A.M., Seppelt, R., Settele, J., Sitas, N., van Vuuren, D., 2017. Multiscale scenarios for nature futures. *Nat Ecol Evol* 1, 1416–1419. <https://doi.org/10.1038/s41559-017-0273-9>
34. Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A.K., Day, M., Garcia, C., van Oosten, C., Buck, L.E., 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences* 110, 8349–8356. <https://doi.org/10.1073/pnas.1210595110>
35. Sitas, N., Harmáčková, Z.V., Anticamara, J.A., Arneth, A., Badola, R., Biggs, R., Blanchard, R., Brotons, L., Cantele, M., Coetzer, K., DasGupta, R., den Belder, E., Ghosh, S., Guisan, A., Gundimeda, H., Hamann, M., Harrison, P.A., Hashimoto, S., Hauck, J., Klatt, B.J., Kok, K., Krug, R.M., Niamir, A., O’Farrell, P.J., Okayasu, S., Palomo, I., Pereira, L.M., Riordan, P., Santos-Martín, F., Selomane, O., Shin, Y.-J., Valle, M., 2019. Exploring the usefulness of scenario archetypes in science-policy processes: experience across IPBES assessments. *E&S* 24, art35. <https://doi.org/10.5751/ES-11039-240335>

36. Tress, B., Tress, G., 2003. Scenario visualisation for participatory landscape planning—a study from Denmark. *Landscape and Urban Planning* 64, 161–178. [https://doi.org/10.1016/S0169-2046\(02\)00219-0](https://doi.org/10.1016/S0169-2046(02)00219-0)
37. Turner, B.L., Meyfroidt, P., Kuemmerle, T., Müller, D., Roy Chowdhury, R., 2020. Framing the search for a theory of land use. *Journal of Land Use Science* 15, 489–508. <https://doi.org/10.1080/1747423x.2020.1811792>
38. Turner, M.G., Gardner, R.H., 2015. *Landscape ecology in theory and practice: pattern and process*, Second edition. ed. Springer, New York.
39. Van Berkel, D.B., Carvalho-Ribeiro, S., Verburg, P.H., Lovett, A., 2011. Identifying assets and constraints for rural development with qualitative scenarios: A case study of Castro Laboreiro, Portugal. *Landscape and Urban Planning* 102, 127–141. <https://doi.org/10.1016/j.landurbplan.2011.03.016>
40. Vieira, R.R.S., Pressey, R.L., Loyola, R., 2019. The residual nature of protected areas in Brazil. *Biological Conservation* 233, 152–161. <https://doi.org/10.1016/j.biocon.2019.02.010>
41. Zonneveld, I.S., Forman, R.T.T. (Eds.), 1990. *Changing Landscapes: An Ecological Perspective*. Springer New York, New York, NY. <https://doi.org/10.1007/978-1-4612-3304-6>
42. Zurek, M.B., Henrichs, T., 2007. Linking scenarios across geographical scales in international environmental assessments. *Technological Forecasting and Social Change* 74, 1282–1295. <https://doi.org/10.1016/j.techfore.2006.11.005>

Figures

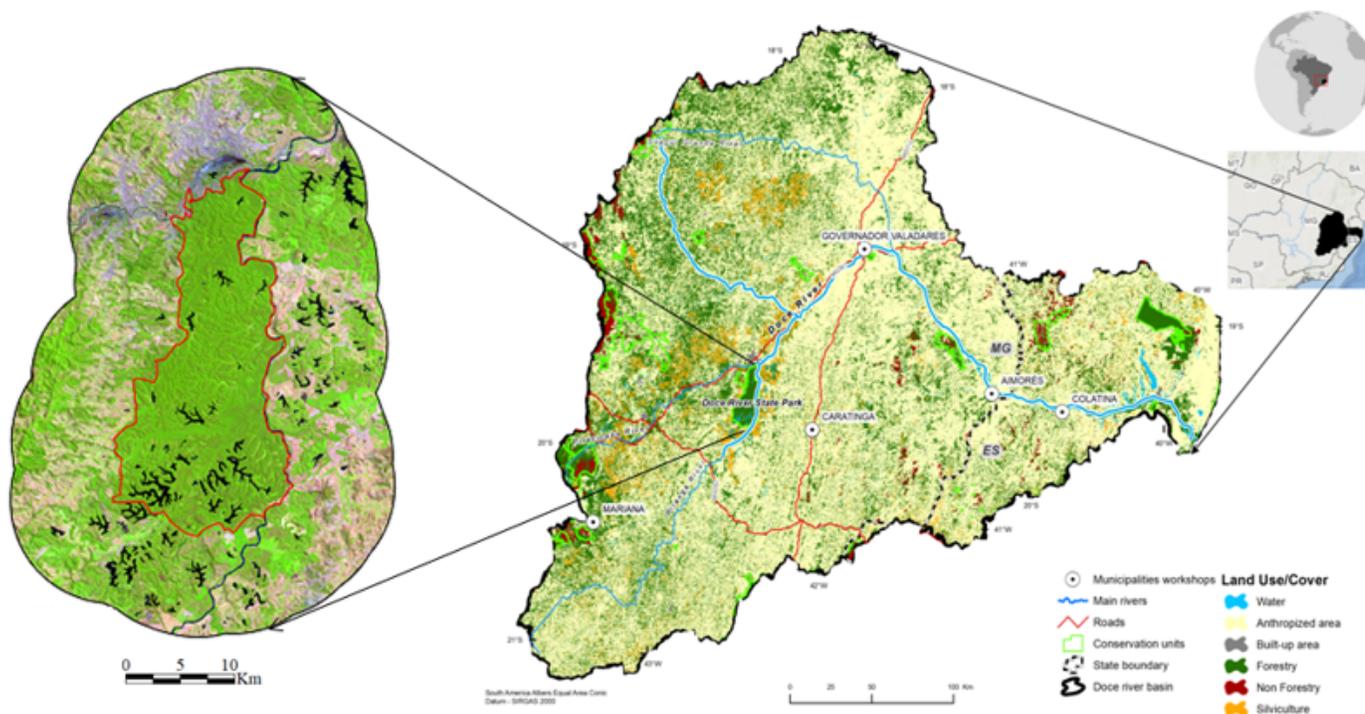


Figure 1

Study area

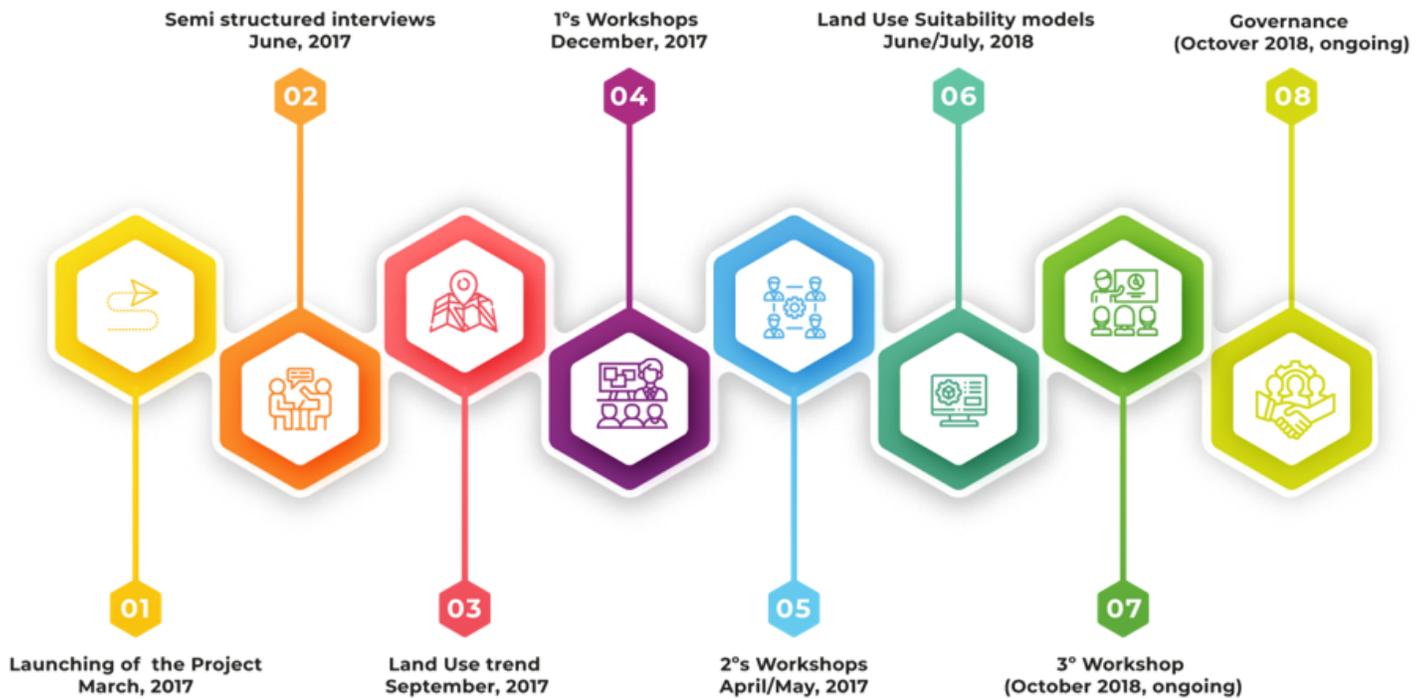


Figure 2

Time line and research stages

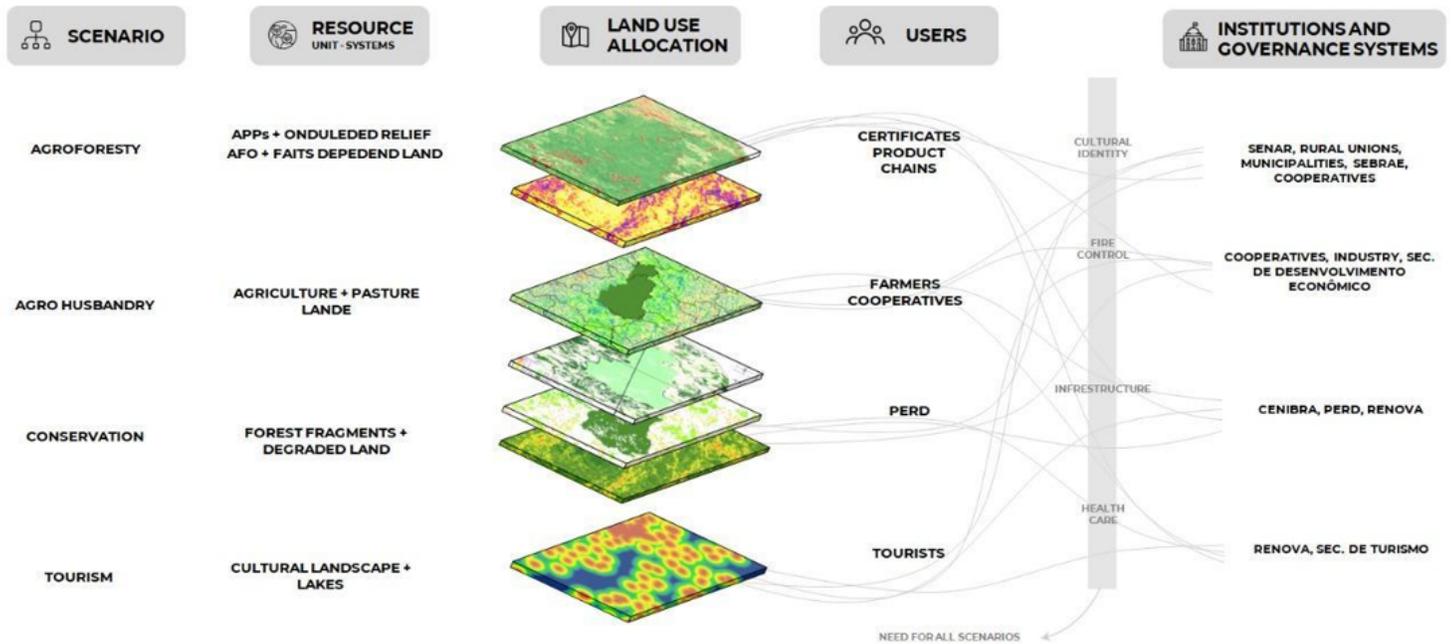


Figure 3

Summary of the desired landscape scenarios, its land uses and institutional governance arrangements

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SUPPLEMENTARYMATERIAL.docx](#)