CHAPTER 22

Interdisciplinary diagnosis and scenario analysis for the implementation of a coastal protected area, Laguna de Rocha Uruguay

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Abstract

Management of protected areas is a complex task due to ecosystems' inherent variability and the conflicting interests of land users. Interdisciplinary approaches are therefore needed to evaluate the feasibility of implementation. We analyzed the environmental and socioeconomic situation of the Laguna de Rocha (Uruguay) protected area and its catchment area to contribute to its induction into the National System of Protected Areas of Uruguay. We mapped the high priority conservation ecosystems, evaluated land use changes, analyzed perceptions, power, and the affinity of social actors toward the protected area implementation, and determined the total economic value of goods and services of the watershed. We analyzed land use tensions and scenarios of economic and climate change. We found that priority conservation ecosystems were well represented within the protected area. The main land use changes were increases in afforestation, oversowing, and artificial pasture. The effective and participatory implementation of Laguna de Rocha protected area will prevent further loss of ecosystem services upon which the community depends.
Keywords: Ecosystem diversity, conservation legislation, Land use changes, environmental analysis, management of protected areas.


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1 The context

Protected areas are defined by the IUCN as terrestrial and marine lands dedicated to the protection of species, natural, and cultural resources, where certain activities may not be permitted. Presently, management efforts in protected areas admit the feasible coexistence of economic activities and the conservation of biodiversity [1, 2]. The concept and management of protected areas has evolved and today recognizes the need (and challenge) to involve local social actors in the planning and the co-management of resources [3]. Moreover, protected areas are now seen as developing nodes (e.g. poverty is relatively lower in their zone of influence than in similar territories without protection [4]). Despite these effects that work as bridges to sustainability [5], social aspects are only considered to meet environmental goals and not to improve human welfare per se.

The management of protected areas is a complex task due to the natural variability of the ecosystems and to the social and economic dynamics involved. Analysis of the feasibility of implementation of protected areas should therefore be considered in an interdisciplinary way. This approach aims to integrate different disciplines and methodologies to achieve new knowledge and understanding of certain issues that would not have been possible following traditional disciplinary perspectives [6]. However, the greatest challenge still remaining is to incorporate social actors and local organizations in the research process.

Laguna de Rocha (LR) is a subtropical choked lagoon located on the Atlantic coast of Uruguay, South America. The lagoon and the catchment area have a surface area of 72 and 1312 km^2, respectively. Among other relevant ecosystem services, it supports the most important inland fisheries of the Atlantic coast of Uruguay [7]. Its northern area is directly influenced by the freshwater discharge from the watershed, while the South area is directly influenced by the Atlantic Ocean through a channel that periodically opens on the sand bar [8] (Fig. 1). The intermittent marine intrusion determines a steep salinity gradient decreasing from south to north (ranging from marine to freshwater conditions). Hydrology is the main driving force for ecosystem function [9, 10], and its effects on the salinity gradient determine the overall ecological dynamics [11–14]. Often, the connection with the ocean is artificially opened by the Rocha state authorities to reduce flooding, but there is no long-term assessment of the impact of this major hydrological modification. This lagoon is a feeding and reproductive area for important regional fish resources [15, 16] and for resident and migratory aquatic birds [17], and is included in the MaB-UNESCO Reserve 'Bañados del Este' and in the National System of Protected Areas. It was also proposed as a new Ramsar site.

The most important land uses in the catchment area of LR are livestock ranching on natural prairies [18], agriculture, afforestation, tourism, fisheries, and biodiversity conservation. However, in the 1990s, land use changes began to occur. Oversowing and artificial pastures have expanded, as more recently, has soy bean agriculture. Afforestation with exotic trees was also established as an expanding activity. In the coastal zone, urbanization for tourism is increasing and small villages are encroaching natural areas [19]. The state capital (Rocha City, 25538

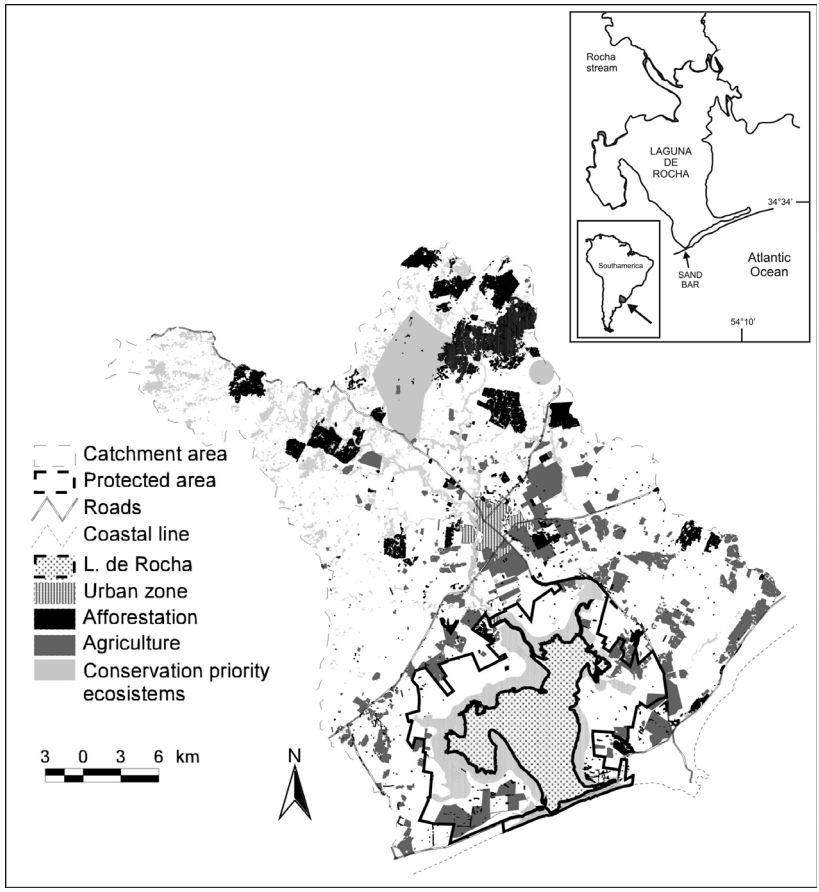

Figure 1: Priority conservation ecosystems (see Table 1 for a specific description of each ecosystem) and land use in the Laguna de Rocha catchment area in 2005. The white color represents natural grasslands under extensive livestock ranching.

inhab.) is located upstream of LR and discharges its sewage into the lagoon's main tributary after primary treatment.

The aim of this chapter is to analyze the present environmental and socioeconomic situation of the LR-protected area to elaborate a strategy to appropriately implement the area within the National System of Protected Areas. A three-step research and analysis strategy was conducted. First, we developed the biodiversity map of the area, analyzed the social actors' relationships, analyzed the relevant environmental legislation, and conducted an economic analysis. Secondly, we GIS layers the most relevant information and overlapped the biodiversity map with current and potential land uses, the spatial distribution of social actors, the map of total economic value, and the different jurisdictional authorities in the area.

Thirdly, we identified current and potential conflicts and developed scenarios of land use and climate change to analyze the contribution of the protected area to the sustainable development of the region, as well as opportunities to promote collaborative work with and between social actors in the frame of the management plan.

2 The diagnosis

2.1 Ecosystem diversity and the protected area boundaries

Ecosystems were classified using a satellite image taken in 2005 (Landsat TM 5, Path/Row 222-084) and verified in the field. All maps and calculations were conducted in a geographical information system. Previous vegetation classification studies were consulted [20, 21] (see Rodríguez-Gallego *et al*. [22]. for a detailed methodological description). Biodiversity specialists were asked to assign priority conservation species and ecosystem services for each ecosystem.

The catchment area of LR has high heterogeneity of ecosystems, many priority conservation species, and diverse ecosystem services (Fig. 1, Table 1). The boundaries of the protected area include 9 of the 15 ecosystems identified, suggesting an effective design. However, the boundaries of the adjacent zone have not yet been established (i.e. the area adjacent to the protected area, which is also the subject of conservation legislation) and should be designed in order to increase the representation of ecosystem types. Temporal ponds with endemic annual fishes and the fluvial forests and wetlands downstream of Rocha City that are important for maintaining water quality should be included. A non-natural but pragmatic boundary of the adjacent zone defined by the main roads and the ocean (South), which closely follows the catchment concept, includes most of the priority ecosystems for conservation (Fig. 1). This boundary would also be easy to communicate and manage. Most of the fluvial and highland forests, highland grasslands, and outstanding landscapes will be left unprotected.

However, there exists other legislation not exclusively related to protected areas that, if effectively applied, may guarantee their protection (see Section 1.4).

2.2 Social actors' dynamics

Population data was obtained from the National Census of Population and Housing [23–25]. The spatial units were larger than the LR catchment area and several villages outside the catchment area (La Paloma, Costa Azul, and La Aguada) were included in the analysis due to their direct influence on the protected area. We conducted a poll in the catchment area to analyze the degree of knowledge of the local population about the LR-protected area. Anthropologic research was done using the ethnographic approach [26], including participant observation and ethnographic interviews. A map of social actors indicating their position regarding the implementation of the protected area was developed based on field work done from 2005 to 2007. Four groups of qualified people were collectively interviewed;

Table 1: Description of the priority conservation ecosystems in the Laguna de Rocha catchment area.

Ecosystem	Area (ha)	Relevance and conservation targets
Laguna de Rocha*	7304	Sustains fisheries; nursery and feeding area for commercial fishes and crustaceans
Laguna de las Nutrias* (on the left side of LR sand bar)	44	Population of capybara; water bird nesting; 30% of bird species of Uruguay; relevance for ecotourism
Lagoon bays *	846	Submerged prairies of aquatic vegetation; feeding area of black necked and coscoroba swans; endangered bird species (e.g. flamingo)
Sandbanks*	129	Connection between the lagoon and the ocean; migratory and endangered birds
Emergent plant wetlands*	2064	Buffer from the catchment area; pollutant filtering; resting and nesting sites for aquatic birds
Coastal prairies*	4907	Sustains 4.7% of the global population of the endangered buff-breasted sandpiper during migration
Coastal forests and shrublands*	6	Endangered ecosystem; endemic species of plants and invertebrates
Fluvial and highland forests	6008	Corridor system for fauna; filtering runoff from agriculture fields
Rocha Stream fluvial forests	284	Recovery of water quality after urban sewage discharge
Temporal ponds	ne	Endemic annual fishes
Sierra del Chafalote (East side of the high watershed)	ne	Nesting site for grassland birds
Sierra de los Rocha (West side of the high watershed)	ne	Outstanding landscapes
Natural grasslands	83,912	Biodiversity values not addressed in this chapter
Marine littoral zone*	399	Erosion protection; sand bar and dune dynamics maintenance; nesting/resting area for migratory and endangered birds; habitat of an endemic toad
Protected marine area*	ne	Exchange of larvae and adults of fish and crustaceans; sea turtles, dolphins and whales of conservation priority frequently observed

*Ecosystems included inside the protected area boundaries; ne: not estimated.

selection was done afterward considering their involvement with the protected area. They were classified as: 1) governmental institutions, 2) social civil organizations, and 3) informal groups, persons, and sectors, and were allocated on the map according to their affinity and power regarding the protected area implementation. 'Power' is understood as the empowerment of social actors and is the agent's ability to mobilize resources and to achieve results [27]. Their relationships were then evaluated.

The total population in the study area was 31,274 people, 81.7% of whom were concentrated in Rocha City (0.7% of catchment surface). The rural population decreased to 21.3% from 1996 to 2004 due to migration to urban zones. The population in coastal urban zones increased to 34% between 1985 and 2005 due to the transformation of seaside resorts into permanent living sites. The two small fishing villages, Puerto de los Botes on the main tributary (Rocha Stream) and La Barra on the sand bar, maintained a stable population of 18 (INE 1963, unpublished data) and 56 people [28], respectively. La Riviera, also on Rocha Stream, was founded in 1980s and had a permanent population of 37 people (in 2004), a number that swells to several hundred in summer.

According to the poll results, inhabitants of the LR catchment area are highly concerned with the conservation of LR. More than half (54.5%) of the people visited at least one coastal lagoon in 2005; LR was the most visited (75.8%). The environmental problems perceived by the respondents were resource overexploitation (32.3%), pollution (22.3%), insufficient protection (31.8%), and species extinction (21.8%). The knowledge that LR is a protected area increased with educational level and people who had previously visited other coastal lagoons were five times better informed, suggesting that the information obtained during field visits is relevant to make people aware of the importance of conservation. Among the people who were aware of the protection status of LR, 65.2% indicated that the management of the protected area should be conducted by a multisectoral consortium, while 94.7% indicated that a management plan was either important or very important. The existence of the National System of Protected Areas was not widely known by the respondents (16.8%).

The social actors' map (Fig. 2) can be analyzed in four quadrants according to the affinity and power of the actors involved. Quadrant 1: actors with high affinity and power, including governmental institutions with jurisdiction in the implementation of the protected area and resources management (e.g.: National System of Protected Areas and other offices at the Ministry of the Environment and Rocha state). Most of these institutions cooperate positively.

Quadrant 2: social actors with high affinity but low power regarding the implementation of the protected area, including social organizations and informal groups with strong and positive interrelationships (also with the previous cluster). The national public university UdelaR belongs to this cluster. Quadrant 3: the high power and lower affinity cluster is comprised by institutions and sectors whose activities or policies may negatively affect the implementation of the protected area. These actors do not interact with the other involved stakeholders. Since there are no conflictive relationships between this cluster and others of higher affinity,

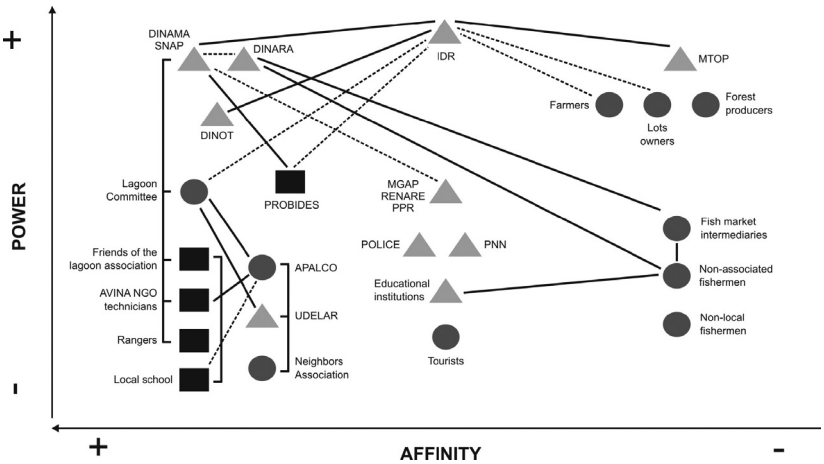

Figure 2: Map of social actors in the Laguna de Rocha catchment area, according to their power and affinity towards the protected area implementation (IDR: Rocha state government; DINAMA, DINARA, DINOT and RENARE: National Bureaus for the Environment, Fisheries, Land Planning and Renewable Resources, respectively; MGAP and MTOP: Ministries of Agriculture and Public Works, respectively; PNN: National Port Authority; SNAP: National System of Protected Areas at DINAMA; PPR: Responsible Production Program at MGAP; PROBIDES: Program for the Conservation of Eastern Wetlands; APALCO: Local fishermen's cooperative; UDELAR: University of the Republic, Uruguay).

they show a great potential to initiate dialog. The Rocha government has territorial influence and jurisdiction and therefore its participation in the implementation of the protected area is relevant. However, it shows an intermediate position between the high- and low-affinity institutions toward the protected area implementation, due to the double influence of conservation and more traditional development sectors. Quadrant 4: the lowest affinity and power cluster is composed of some actors related to fisheries that perceive potential affectations; other important institutional actors show indifferent positions, indicating that the management plan should stimulate their participation.

As a whole, and although the social actors' map is a simplified picture of the real, complex, and dynamic relationships among actors, it reveals a high concentration of stakeholders with positive or neutral relationships and few conflictive situations, indicating a positive scenario for the implementation of the protected area.

2.3 Land use changes

We quantified changes in land use over a 31 year period by comparing satellite images from 1974, 1997, and 2005 (Landsat TM 5, Path/Row 222-084). We also

Table 2: A comparison of land use in the Laguna de Rocha catchment area between 1990 and 2000 according to the National Farming Census (nr: not recorded) [18, 30]. The census units represent a higher surface area than the catchment.

Land use	Surface area (ha) 2000		Surface area (ha) 1990	
	ha	(%)	ha	(%)
TOTAL	172,022	100	128,125	100
Afforestation	8084	4.7	2633	2.1
Horticulture and vineyards	225	0.1	244	0.2
Cereals	381	0.2	627	0.5
Forage	1540	0.9	1051	0.8
Tiled lands and stover	511	0.3	828	0.6
Artificial pastures	10,204	5.9	3986	3.1
Oversowing	16,983	9.9	1431	1.1
Fertilized natural grasslands	976	0.6	nr	—
Natural grasslands	122,068	71.0	109,615	85.6

consulted the National Farming Census [18, 29, 30]. Although the census surface area units were higher than the catchment area, the data was still useful for determining tendencies of land use change.

The main land use in the catchment area of LR is livestock ranching on natural grasslands (Table 2, Fig. 1). Cow and sheep ranching affects 95% of the area [18], while dairy is done on 4% of the area and is mainly located in the surroundings of Rocha City. The main change in land use was afforestation (with *Eucalyptus* spp. and *Pinus* spp., both exotic), which was marginal in 1990 and reached 7.1% of the catchment area in 2005, and is mainly located in highlands.

Horticulture (mainly potato) and cereal crops decreased slightly according to the census, while forage, artificial pastures, and oversowing increased (Table 2). Unfortunately, the boom of soybean agriculture in LR occurred after 2005 and therefore was not captured by this study. Agriculture is located on middle lands, between the lagoon floodplains and highlands. The satellite image analysis showed a 10% decrease in the surface area of natural grasslands from 1974 to 2005 due to afforestation and agriculture expansion. The 1990s were the inflection point in the land use changes.

2.4 Institutions and legislation

All social actors were mapped according to their territorial interests and jurisdictions. Maps were overlapped and the number of social actors in a grid of 1 km^2 was estimated. A revision of laws, decrees, and treaties related to the LR catchment and protected area was conducted. Jurisprudence and doctrinal positions were revised and the evolution of the conservation legislation analyzed.

The number of social actors with interest or jurisdiction in the LR catchment area was as high as 34. National institutions that regulate waters, environment, and land planning totaled 19, while the other 15 social actors mainly included NGOs and other less formal groups. The concentration of social actors was higher inside the protected area (17–23) and also in highlands (15 to 16), where conflicts with afforestation had surfaced recently. The high concentration of nongovernmental actors inside the protected area, while considered to be a strength, should be properly managed through a participatory and transparent process to avoid conflicts. Co-ordination seems an important requisite for the implementation of the management plan due to the high number of governmental institutions with a large range of overlapping responsibilities. The social actors' map (Fig. 2) shows the need to establish clear regulations for fisheries to achieve collaborative management. On a catchment scale, a major zone of conflict is the highlands, where afforestation and social opposition to it drove the creation of the Basin Committee in 2009. Relationships between the protected area and ranchers will depend on the participatory process during the management plan elaboration and implementation.

The declaration of LR as a protected area evolved from the first decree in 1977 to the actual incorporation into the National System of Protected Areas, progressively incorporating the new concepts of conservation science and becoming more effective at reaching biodiversity targets. The first legal recognition only considered public lands (basically the lagoon surface). The area has progressively incorporated private lands and the current boundaries combine terrestrial and marine habitats.

Although environmental legislation in Uruguay has evolved rapidly in the last two decades (Table 3), there still exists a large degree of overlap, especially at the level of institutional jurisdiction. Besides protected area legislation, there are other specific norms for the protection of biodiversity, water, soils, and fluvial margins that regulate the use of natural resources in the territory. These norms are dispersed and overlapping, and sometimes are ineffective because of lack of field control.

Rocha is the only state that has a modern coastal legislation, the Coastal Ordinance of Rocha [31], which incorporates the concept of integrated coastal management. The OCR segments the coast for operational planning and encourages the active participation of local people. Strategic zoning is done for the purpose of diversifying tourism and preventing a uniform, linear, and continuous urban development along the coast. Nevertheless, the government of Rocha later modified the status of certain land registries (decrees 17/05 and 2/06), transforming rural lands into urban and making the legislation more permissive for traditional tourism development.

2.5 Total economic value

Direct, indirect, and option values were estimated and added to obtain the total economic value (TEV) for goods and services of the LR catchment area. Direct value (marketable goods) were estimated with classical economic methodologies considering the productive functions, using data from the agriculture census [18], 2005

Table 3: Main environmental legislation in Uruguay relevant for 'Laguna de Rocha's' case study.

Legal document	Details and scope
Impact Environment Act (1994; Law 16466 – 2005; Decree 349)	Activities in protected areas and in a protected strip of 250 m from estuary or ocean coasts require environmental assessment
National Constitution (1996; Art. 47)	Declares environment protection of 'public interest', collective interests have preeminence over private or individual ones
General Environmental Protection Act (2000; Law 17283)	Waters, soils, landscape quality, and biodiversity are of 'public interest'; seeks 'sustainable development'
National System of Protected Areas – SNAP (2000; Law 17234)	SNAP is of 'public interest', imposing obligations on governments and potentially enabling limitations to private rights
Rocha Coastal Ordinance – OCR (2003; Decree 12)	Based on the principle of Integrated Coastal Management; discourages continuous linear urban development and roads parallel to the coast; promotes fusion of small coastal lots
Constitutional Reform on Water Rights (2004; Law 18610/2009)	All waters enter into the Public Domain, by popular initiative
Land planning and Sustainable Development – LOTDS (2008; Law 18308)	Main national regulatory framework for land planning

prices, and other information [32–36]. Indirect values of ecosystem services are not taken from the market. We analyzed only two ecosystem services, water quality maintenance and water yield. Both were estimated by the substitution method (cost of implementation of a sewage treatment plant and water quality maintenance service, respectively). Other ecosystem services (e.g. grassland productivity, soil maintenance, fish production, carbon fixation, erosion protection, and so on) were not valued because of a lack of specific information; we therefore expect this TEV component to be underestimated. Option and existence values were valued with the contingent method to determine the willingness to pay [37], based on a poll conducted in the catchment area in 2006; a total of 230 people (excluding tourists) were asked their willingness to pay a hypothetical task to maintain LR as a protected area (same poll described in Section 1.2). A cost-benefit analysis was then conducted (benefit values were taken from the TEV estimation and costs were evaluated as the protected area basic implementation).

Direct use values represented 84.4% of TEV while the indirect use values represented 4.1% (Table 4). Livestock ranching was the main economic activity, followed by tourism and afforestation. Option and existence value showed that the

Table 4: Total economic value of goods and services in 'Laguna de Rocha's' catchment area in 2005.

Activity	USD y^{-1}	%
TOTAL ECONOMIC VALUE	25,240,122	100
USS y^{-1} ha^{-1}	207,9	–
DIRECT USE VALUE	21,299,156	84.4
Livestock ranching (caw)	8,496,300	33.7
Dairy	1,007,767	4.0
Livestock ranching (sheep)	678,905	2.7
Wool	1,313,693	5.2
Afforestation	1,854,012	7.3
Potatoes	752,640	3.0
Rice	200,363	0.8
Corn	29,654	0.1
Inshore fisheries	195,472	0.8
Tourism	6,770,349	26.8
INDIRECT USE VALUE	1,024,000	4.1
Water quality	270,000	1.1
Potable water supply	754,000	3.0
OPTION AND EXISTENCE VALUE	2,916,966	11.6

population in the catchment area would pay around 9 USD per capita per month to manage the LR protected area, representing 11.6% of TEV. This value could increase if tourists are included in the analysis. The spatial distribution of TEV (Fig. 3) shows how livestock ranching is conducted in the entire catchment area and also inside the protected area, while tourism, the second most important activity, is located in the coastal zone adjacent to the protected area. Some agriculture is also located inside the protected area but afforestation is entirely outside. The two ecosystem services valued in this chapter are not included within the protected area boundaries; therefore, other protection mechanisms are required.

The option and existence values, as well as also the indirect use values, were higher than the costs of the basic implementation of the protected area (~324,000 USD). Therefore, the implementation of the protected area is highly feasible economically and significant on a local scale. The net present value of benefits and costs of the LR catchment area per hectare ranges between 693 and 896 USD, depending on the rate of opportunity cost used (5–15%). If a hypothetical tax of 10 USD is implemented to visit the LR area, a potential direct annual income of 50,000–265,000 USD could be obtained, based on a figure of 5000–26,500 tourists that annually visit LR and the adjacent La Paloma, respectively. Therefore, tourism could support an important proportion of the annual budget of the protected area.

The impact of afforestation on water yield is currently a social concern in Uruguay. Farley [38] demonstrated that reductions in annual runoff from

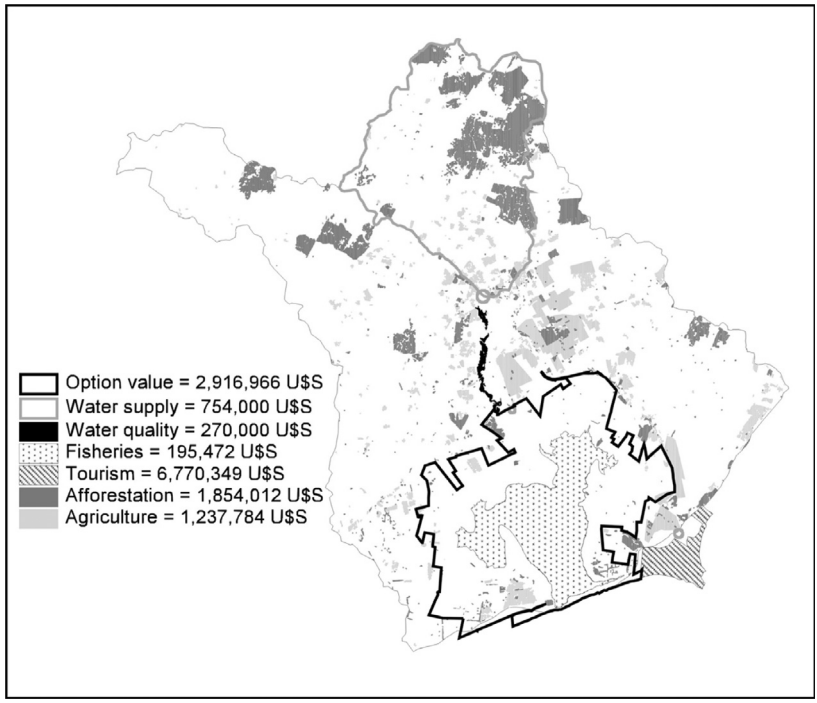

Figure 3: Spatial distribution of the total economic value in the catchment area of Laguna de Rocha.

afforested lands can cause and intensify water shortages. Potable water supply for Rocha City is taken from Rocha Stream, whose catchment area is being afforested rapidly (68% is suitable for afforestation); thus, local social actors and government are concerned about water shortages. We analyzed the potential economic income produced in the Rocha Stream catchment area if all the suitable soils were afforested (14,090 ha; 255 USD per hectare; total value ~1,854,000 USD in 2005) and compared it with the cost of the water supply for Rocha City (based on water consumption; total value ~755,000 USD). The monetary value of the potable water use represented 40.7% of the potential economic value of afforestation in this subcatchment area. Therefore, if afforestation is to affect Rocha City potable water supply, it should compensate for the costs of supplementary water sources. Discussions and research on the maximum proportion of accepted afforested area in the watershed is needed to establish an appropriate regulation.

3 The key arising conflict: tension between land uses and biodiversity conservation

Land use intensification may drive several tensions with biodiversity conservation due to the modification of natural ecosystems [39]. Agriculture replaces natural

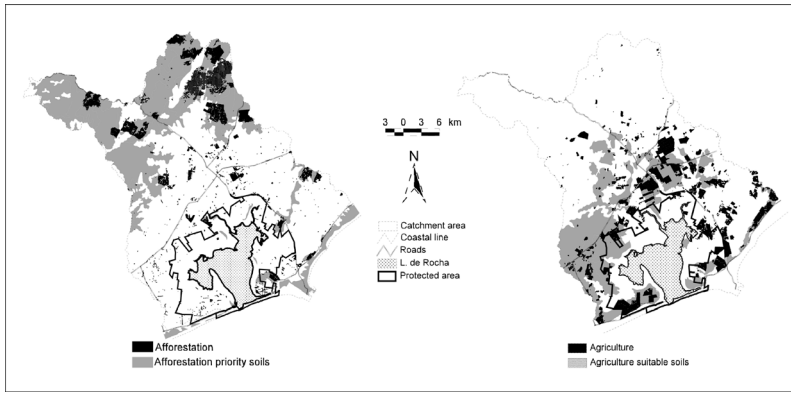

Figure 4: Tensions between current or potential agricultural (left figure) and afforestation lands (right figure) and Laguna de Rocha protected area.

grasslands and forests, and employs fertilizers and pesticides that are later exported to aquatic ecosystems. Nutrient exportation from agriculture and sewage effluents may drive eutrophication processes. In LR, because emergent macrophyte wetlands are quite narrow, the buffering capacity is relatively low. Therefore, artificial pastures near the lagoon (NE zone, Fig. 4b) may be a critical source of phosphorus [40], and also of glyphosate. Aubriot [41] reported initial phases of a cultural eutrophication process in LR and cyanobacterial blooms were already recorded (Conde *et al*. 2003, unpublished). Nevertheless, other ecosystem services would mitigate this impact, such as the freshwater discharge during the sand bar opening [19]. Agriculture within the protected area boundary is small and it is represented mainly by oversowing and artificial pastures. Most suitable soils for agriculture are located in the northwest zone of the protected area and well within the recommended adjacent zone boundary, indicating potential conflicts in a short term (Fig. 4). Therefore, protection of the fluvial forests and riparian wetlands may be crucial for maintaining stream water quality and mitigating eutrophication in LR.

Livestock ranching is mainly conducted on natural grasslands with low fertilizer consumption and is therefore an activity relatively compatible with biodiversity conservation. Nevertheless, improvements to management practices should still be incorporated to mitigate other impacts. Animal stock should be adjusted to reduce overgrazing and to enhance grassland richness and growth of the most valuable native forage species. This management can not only improve grassland quality but also increase productivity, making agriculture less attractive to landowners. Temporal grazing exclusions should be designed to permit regeneration of natural forests and protect certain wetlands during the nesting period of aquatic birds. The forage contribution of wetlands vegetation should be quantified since it is an important food resource for cattle. Because of meat production on natural grasslands that can be as high as that on artificial pastures, livestock ranching may intensify in a short term due to the increase of international meat prices, so an increase in the use of fertilizers and gliphosate can also be expected. The LR management

plan should therefore protect the fluvial forests as well as encourage traditional grazing on natural grasslands.

Afforestation was the main land use change in the study area in the last 10 years. Suitable lands for afforestation are distributed mainly on highlands (31.5% of LR catchment area). Although direct interference between afforestation and the protected area implementation is marginal (Fig. 4a), the impact on natural grasslands in the catchment area is high as these ecosystems are being replaced by tree plantation. Moreover, highland natural forests can be cleared and fragmented for tree plantation. However, the comparison of the surface area of natural forests in 1974 and 2005 indicated no major replacements of natural forests although fragmentation was not evaluated.

The most intense tension with biodiversity conservation is likely traditional tourism urbanization on coastal sand dunes. The eastern coastal zone of Uruguay was fragmented in small resorts after 1940, and following the increase of land prices the pressure to urbanize these resorts increased. Even the sand bar of LR is fragmented into hundred of lots. Although urbanization in the coastal zone has several legal drawbacks, this issue remains a conflict of complex resolution. The Coastal Ordinance of Rocha [31] lists several alternatives to solve this conflict (e.g. Rocha state can offer other lots to owners and confiscate lands due to tax debts) that have seldom been applied. Managers of the protected area will need to be creative enough to find a solution to avoid linear urbanization on one of the last wild areas of the coastal zone of Uruguay.

4 The scenario analysis and final recommendations

Based on the information of this chapter, we adapted plausible scenarios of land use and climate change elaborated by Paulino *et al*. [42] for Uruguay to the local situation of LR and its catchment area. The scenarios helped us to underpin the planning recommendations emerging from the previous integrated analysis. Three scenarios for five sectors (four land uses and climate change) were developed (Table 5): i) current situation, ii) intensification of the current land change tendency (maximum surface area representing the suitable soils for different land uses), and iii) full implementation of the protected area through a management plan.

Among several negative impacts of the two less conservationist scenarios, the most worrying are lagoon eutrophication, dune erosion, habitat loss, water shortage, and flooding. On the other hand, comprehensive agreements pursued by the Basin Committee, technical support and protocols for environmental and tourism best practices, and a local trademark are notable benefits of the more advanced scenario. Comparing the numerous drawbacks of the current/intensification situations with the many benefits of the protected area setting, it becomes clear that present threats to biodiversity and ecosystem services can worsen if current land use intensification tendencies continue. To confront this possibility, the effective implementation of the protected area (i.e. urgent development and application of a management plan) becomes the only sustainable alternative.

Table 5: Scenario analysis of the main land use sectors and climate change in Laguna de Rocha protected area and its catchment area (see abbreviations in legend of Fig. 2 and in Table 3; MINTURD: Ministry of Tourism).

Sector	Scenario	Basic description	Main agents	Impacts (negative and positive)	Management plan facilities
Agriculture	Current situation	Potato, sorghum and transgenic soy bean in the adjacent zone (less than 6% of the catchment area)	Landowners, tenants and corporations, MGAP	Fertilizer and agrochemical use; soil erosion; natural grassland loss	None
	Intensification	Continuous soybean agriculture intensification within the protected area and adjacent zone (more than 22% of the catchment)	Mainly corporations; MGAP	Intensification of the current situation; cultural eutrophication; displacement of the rural population	None
	Protected area	Not permitted in the protected area; permitted in adjacent zone under best practices	Landowners; tenants; corporations; MGAP; SNAP	Natural grassland and water quality maintenance; soil protection; maintenance of the rural population	Contract with landowners to regulate land use; technical support for best practices; SNAP trademark
Livestock ranching	Current situation	Livestock ranching over natural grasslands; increase of oversowing and artificial pastures (<6% of basin)	Landowners; tenants; MGAP	Loss of grasslands and resilience to droughts and floods; increase of fertilizer and glyphosate use	None
	Intensification	Grassland conversion to oversowing and artificial pastures in the protected area and adjacent zone; increase of the number of animals and feed lots	Landowners; tenants and corporations; MGAP	Intensification of the current situation; cultural eutrophication; soil erosion	None

Continued

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Table 5. *Continued.*

Sector	Scenario	Basic description	Main agents	Impacts (negative and positive)	Management plan facilities
	Protected area	Livestock ranching over natural grasslands in the protected area and most of the adjacent zone; feed lots not permitted in the protected area	Landowners; tenants; corporations; MGAP; SNAP	Natural grasslands and resilience to droughts and floods maintained; habitat and water quality maintained	Contract with landowners to regulate land use; technical support to ranching on grasslands; SNAP trademark
Afforestation	Current situation	Afforestation increase in the highlands to less than 7–10% of the catchment area	Corporations; MGAP	Grassland and forest substitution; water shortage; competition with agriculture and ranching; rural population displaced	None
	Intensification	Afforestation increase (30% of catchment area)	Corporations; MGAP	Intensification of the current situation	None
	Protected area	Afforestation does not occupy more than 10 to 20% of the main subcatchment areas	Corporations; Basin Committee; MVOTMA; SNAP	Grasslands and traditional land uses maintained; water shortage risks reduced, rural population maintained	Coordination with the Basin Committee
	Current situation	Coastal zone highly urbanized in nearby seaside resorts; urbanization advance on natural coasts and to the protected area	Corporations; landowners; IDR; MVOTMA	Landscapes and habitat loss; coastal erosion increase; loss of habitat; risk of climatic change impacts increase	None

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Coastal urbanization	Intensification	Densification of nearby seaside resorts; creation of new resorts with lower densification inside the protected area; landscape modification; urbanization of the sand bar and lagoon shores	Corporations; landowners; IDR; MVOTMA	Intensification of the current situation; displacement of fishermen due to land occupation pressure; cultural eutrophication; invasion of alien species due to gardening	None
	Protected area	Densification of nearby seaside resorts; prevention of the urbanization of the sand bar; regulation of the densification of new resorts and prevention of the urbanization of the lagoon shores and landscape deterioration	Corporations; landowners; IDR; MVOTMA; SNAP; MINTURD	Landscape, endangered species habitat and water quality preserved; fishermen keep jobs and houses; coastal erosion prevented; sand bar and coast preserved; introduction of alien species prevented	OCR and LODTS effectively applied; climate change adaptation measures applied; contract with lot owners to regulate gardening; ecological sewage
Tourism	Current situation	Spontaneous aquatic sports, fishermen and camping; 4 × 4 circulation; ecotourism on sand bar; boat circulation; no services for tourism; income from tourism lost	Local tourists operators; rangers; tourists; IDR	Sand dune erosion; trash; habitat affected; conflicts between sport and inshore fishermen; conflicts with rangers; pouching; loss of income	None
	Intensification	Intensification of activities; tourism expands to other areas of the lagoon; lack of regulations; conflict with rangers	Tourism operators; IDR; MINTURD	Intensification of the current situation	None

Continued

Table 5. *Continued.*

Sector	Scenario	Basic description	Main agents	Impacts (negative and positive)	Management plan facilities
	Protected area	Regulation of ecotourism activities; load capacity controlled; tourist operators and nature guides trained; tourists informed; better facilities to receive tourists; entrance fee; diversification of the tourism offers and operators	IDR; SNAP; MINTURD; Local tourists operators; rangers	Reduction of conflicts with rangers; interference with biodiversity reduced; increase in the number of local jobs; contribution to protected area financing; improvement of visitor experience	Visitor load regulated; tourism zoning; visitation protocols for tourism promoters; training for nature guides and tourist promoters; more protected area personnel; self-financing
Climate change adaptation	Current situation	Increase of extreme events of coastal winds; precipitation and sea rise during storms; floods increase	IDR; MVOTMA	Erosion by inappropriate urbanization; floods more intense due to urbanization in floodplains	None
	Intensification	Coastal erosion and floods intensify due to frequent and intense extreme events; increase of urbanization in coastal zones and flood plain of lagoon and streams	IDR; MVOTMA	Intensification of the current situation; artificial openings of the lagoon more frequent to avoid floods; natural functioning severely affected	None
	Protected area	Urbanization in the sand bar and flood plain avoided; environmental impact of artificial opening determined; protocol to artificially open the lagoon	IDR; MVOTMA; SNAP	Coastal erosion is prevented; floods avoided and artificial opening of the lagoon regulated	OCR/LODTS applied; urbanization avoided in areas of flooding risk; opening of sand bar permitted only under extreme events

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Currently, national and municipal agencies act as promoters of traditional urbanization and tourism, for which environmental issues are seldom considered, a situation that increases the probability of conflict. However, conditions for a favorable implementation of the LR protected area also exist. Firstly, the outstanding landscape, biodiversity values, and ecosystem services offered by LR and its catchment area are beyond question, being one of the priority areas for biodiversity conservation in Uruguay [43]. There exists a consensus about the need to effectively implement the LR-protected area into the National System of Protected Areas. The empowered citizenry is also promoting the protected area implementation, and is a significant and permanent local force. The local citizenry promoted the dialog among all actors, contributing to discussions of complex issues (e.g. fisheries regulation) and assuaging distrust about the implications of a protected area.

Despite the affinity of the social actors toward the protected area, the high number and diversity of interests may become problematic if certain requirements are not met. Communication and participation conditions should be carefully undertaken, otherwise conflicts of interest may arise. Social actors include landowners and fishermen who will face restrictions to their productive activities. Therefore, a participative space for dialogue is a basic requisite.

One of the most critical issues for the implementation of a protected area is its management plan, a conceptual and dynamic legal document that establishes the developing guidelines for the area and promotes the participation of social actors. However, in LR the management plan will not regulate most activities in the adjacent zone or in the catchment area where other national legislation can be applied (e.g. poaching, forest clear cutting, vehicle traffic in sand dunes). The dispersion of this legislation in a diversity of governmental institutions makes its control ineffective, suggesting the need for additional coordination mechanisms.

Protected areas meet diverse objectives, including environmental education. LR is an important tourist and recreational zone at a regional level. We found that almost half of the population in the catchment area has never visited the lagoon. Since mass media are an important source of information for local people, it seems evident that a communication strategy should be carefully designed in the management plan.

The management of protected areas where most land is private indicates that responsibilities should be shared. Actions toward co-management should therefore be taken [44]. Co-management is not a common present practice in Uruguay and a long process will likely be necessary before it can be established in LR. According to Natera [46], governmental institutions should adapt their functioning, but private owners and citizenry will also need to develop new skills to reach a better governance scenario. Co-management will have to face the challenge of the local intensification of land use, which promotes the generation of high income in a short term, then prevailing over social interests.

This chapter showed the various challenges of the management of a protected area in a country with a historical delay in this matter. Our team faced the internal challenge of conducting an interdisciplinary analysis with diverse disciplines and

people working together. The different rationale, methodologies, and theories not only enriched the analysis but also introduced complexity which was derived in occasional divergence. The GIS was a key issue for crossing the information from the different disciplines. When the diverse information was digitally recorded in space, the discussion became more fluid because variables could be interrelated and better visualized. Moreover, several results only emerged after the information was overlapped. The map of social actors was also a powerful tool to summarize information, communicate findings, and facilitate recommendations. Working in interdisciplinary teams is an opportunity to change the levels of reflection although several issues remain to be addressed. An issue that generated disagreement within the interdisciplinary team was the economic analysis, because an open epistemological discussion exists on the implications of the concept of economic price. Consistent valuation methods of indirect uses are still imperfect, resulting in underestimations of the ecosystem services.

As a whole, this environmental analysis gave insight into information and methodological gaps needed to analyze tensions among land uses in a relevant coastal protected area facing a scenario of economic development. The lesson learned was that personal attitudes are relevant for group work and when researchers are concerned with a central task, paradigms or methodological gaps need not limit the discussion, so a consistent academic product can be achieved and new question opened.

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