6 Building consensus through assessment evidence from San Pedro de Atacama, Chile

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Introduction

The work carried out in ProEcoServ-Chile (ProEcoServ-CL) was a collaborative effort led by the Centro de Estudos Avanzados en Zonas Áridas (CEAZA) in partnership with the Chilean Ministry of Environment and the municipality of San Pedro de Atacama (SPA), which is the pilot study area. During the last two decades, the territory of SPA has experienced significant socio-economic changes, mainly associated with the arrival of new social actors, including entrepreneurs, tourism operators and industrial mining. Economic development accompanying this new social diversity has, among other things, led to a marked increase in the local population size (estimated 50% increase from 2002 to 2014). Data from the National Institute for Statistics (Instituto Nacional de Estatistica, or INE) indicates that tourism in SPA has nearly tripled in the last decade, receiving an estimated 240,000 visitors in 2013 (INE 2014). The Los Flamencos National Park, located within the municipal boundaries, registered the second highest number of tourists of all Chile's protected areas in both 2013 and 2014, exceeding Torres del Paine in southern Patagonia. The massive influxes of tourism into the region in recent years has implied significant economic development potential for the municipality of SPA – each tourist budgets about US$1,000 to visit the destination. At the same time, however, these influxes imply a growing threat to the region's fragile high-altitude ecosystems and limited natural resources, particularly water, that sustain the livelihoods of its indigenous communities.

In light of this information, the main objective of ProEcoServ-CL was to develop innovative computer-based tools to guide decision making regarding sustainable management of two key ecosystem services (ESs): water and ecotourism (we apply the term to include both ecotourism and recreation activities). In particular, information on water provisioning and tourism flows was compiled and collated to support future policy and decision making regarding these ESs in the municipality of SPA. Considering relevant policy questions, and potential

future development scenarios based on participatory approaches, ProEcoServ-CL has made this body of knowledge available to decision makers through a decision support system (DSS). The DSS was developed and designed with the participation of local and regional communities, aiming towards substantial capacity-building and the installation of a powerful tool for mainstreaming ESs into decision-making. The conservation and management of fragile Andean ecosystems, and the traditional lifestyles that take place there, require a commitment both from policy and decision makers, as well as the municipality's inhabitants; research embedded in social processes was therefore recognized as key to achieving sustainable development and effective management of ESs in the region (Cowling et al. 2008; Daily et al. 2009).

This chapter aims to synthesize the ProEcoServ-CL team's work in Chile, which included modelling water provision and ecotourism, developing a tool to support decisions and policies, and planning future scenarios considering the legal and economic context.

Objectives of the work

ProEcoServ-CL aimed to demonstrate the profound importance of incorporating ESs in the decision-making process in Chile. The main strategy was improved through the scientific and community-based understanding of social and ecological resources in the Salar de Atacama. Therefore, it combined quantitative and qualitative approaches to develop a baseline understanding of ESs in the region, identify the trends in social-ecological dynamics, and work within the community to develop the capacity to better manage ESs in the present and future. Furthermore, the physical presence of the ProEcoServ-CL team in the SPA community was crucial to the outstanding work of the local team. Members of the team assumed a range of responsibilities and tasks to complete the various project components, which was fundamental to the increased awareness and capacities now installed across a broad swathe of community members in relation to the targeted ESs. In this setting, the ProEcoServ-CL working plan was characterized by four main activities; the first three comprised: (1) modelling water provision and ecotourism (water balance model and ecotourism potential model); (2) developing a decision support tool (Tableau); and (3) building a participatory, inclusive decision-making process (with public and private stakeholders). Finally, ProEcoServ-CL (4) implemented various strategies for mainstreaming ecosystem services that delivered communication and outreach, co-production of knowledge, and policy intake. These strategies supported the integration of water provision services into spatial planning and dialogue, including the production of ES maps, the promotion of public-private cooperation for ecosystem management, and the establishment of a DSS framework that, in turn, has been used in spatial planning.

Modelling water provision and ecotourism

Assembling data

Data collection for the selected ESs, water provision and ecotourism, was accomplished with publicly available information for both, mostly from reports, which was confirmed or complemented through field observations and interviews. The Region of Antofagasta has a weak real-time monitoring system for the variables required for the analyses, which made it challenging to understand ESs dynamics in SPA, and institutions are not well prepared for contingent decision making.

In the case of ecotourism, quantitative data on tourism dynamics was identified as a key requirement for developing effective decision support capabilities. However, there was no system in place to monitor visitor numbers at tourist sites on a project-wide basis, largely due to the fact that there has been no coordination between local and regional institutions in this regard. At the time of writing, data are only available for a limited number of tourist sites in the study area, and, with the exception of those located within formally protected areas, are not efficiently managed or easily accessible in a centralized database. Therefore a key challenge was to explore novel approaches for near-real time monitoring of tourism activity across the project area. To this end, the team tested the use of geo-located tourist photos uploaded to public photo sharing websites such as Flickr. Flickr data have been shown to be positively correlated with actual visitation at more than 800 tourist sites globally (Wood et al. 2013), and were used in this study to derive information on spatial dynamics and relative levels of tourism activity across the project area as an indicator of ES use. The approach revealed several important insights relevant to decision support; for example, proportionally, just 10 sites account for a significant percentage of total tourism flows (30% of total annual visitor days), with 70% of annual visitor days distributed among the remaining ±80 recognized tourist sites. These activities also reinvigorated an initiative for the collection of tourism statistics in the Municipality of San Pedro de Atacama from 2014 to 2016, which was proposed in 2013 by the Fundación de Cultura y Turismo SPA. The initiative is currently being evaluated by INE, with the key objective of capturing tourism data from tour operators and hotels. The pilot proposal includes a 36-month period to identify trends and usage patterns in San Pedro de Atacama. For data collection, the project proposes the use of a monthly online survey that must be systematized by the regional offices (INE Antofagasta).

Improving systems for monitoring visitor numbers at the site level, understanding the social and ecological impacts, and developing appropriate management responses, will be fundamental to sustainable management of ecotourism in the region. In this regard, recommendations regarding sustainable visitor carrying capacities for several areas of ecotourism importance in SPA were sourced from an earlier study EUROCHILE (2006), and proved invaluable in developing decision support capabilities in our capabilities in our work.

In relation to water provisioning, ProEcoServ-CL found minimal reliable data for the Salar de Atacama, as the hydrological and meteorological systems in the Region of Antofagasta are sparse, and measured data commonly has a latency of several years. For example, streamflow data for the San Pedro River at Cuchabrachi (closest and most relevant stream gauge for the town of San Pedro de Atacama) was current through 2013. Precipitation and temperature data needed to estimate evapotranspiration was even more limited, as the meteorological station at El Tatio was current through 2002. Therefore, an explicit groundwater model for the region was not feasible due to the extremely limited data. The project, therefore, focused on the San Pedro Watershed, an important watershed for the region that has sufficient, if limited, data from the Dirección General de Aguas (DGA) website, Dirección General de Aguas (2015), which could be used for the basic statistical analysis of water resources trends and the development of a conceptual water balance model of the storage and fluxes of water in this hydrologically closed basin. The ProEcoServ-CL team's approach to examining water provision throughout the Altiplano/plateau region was suggested by the local Steering Committee, and was based on remote sensing using NASA's Gravity Recovery and Climate Experiment (GRACE) instrument (Tapley et al. 2005). This satellite-based system measures changes in the Earth's mass through time and can reliably detect changes in groundwater. Analysis of GRACE data for the region of the Altiplano where San Pedro de Atacama lies proved a key milestone for ProEcoServ-CL. This data produced the first hydrological balance for the region (Figure 6.1).

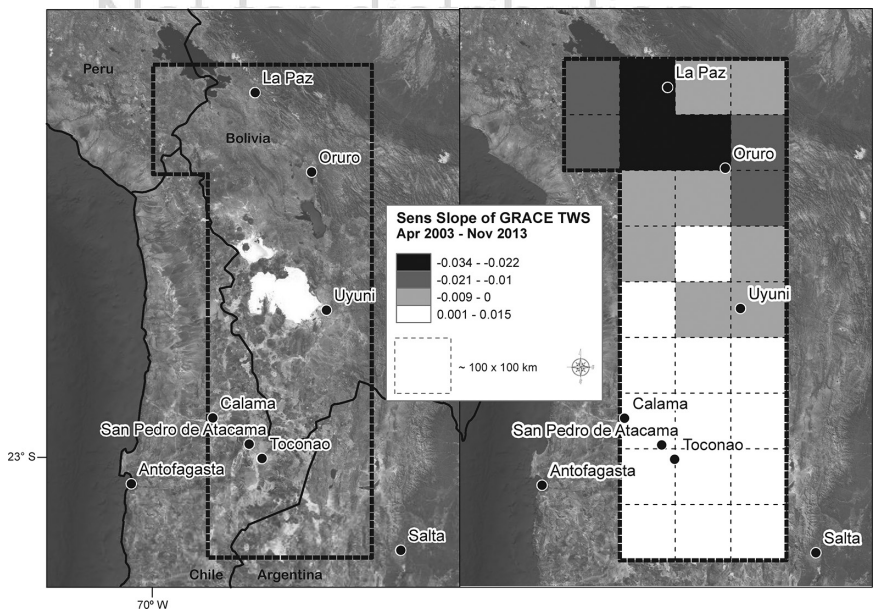


Figure 6.1 Satellite hydrological balance

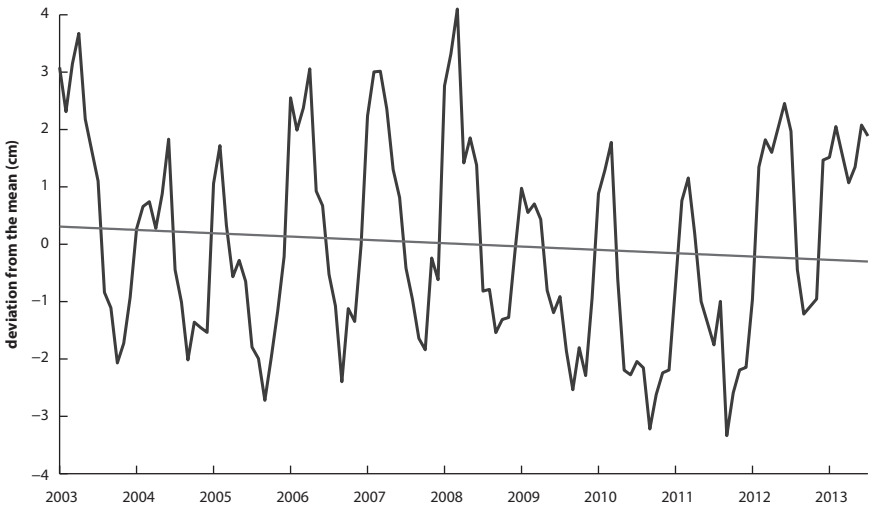


Figure 6.1 (Continued)

Table 6.1 Statistical values for annual Precipitation (P) and streamflow (Q) for 1978 to 2010

	P	*Q*
Coef Var (mm)	0.75	0.32
Median (mm)	123.6	20.0
STD (mm)	104	6.4
P-value	0.59	0.68

Source: Author's computation

The analyses showed that during the mission period examined (2003 to 2013) there was basically no trend in groundwater levels (2% slope over the period). This single result, together with a comparison to literature showing the situation in the Middle East (200% slope) (Longuevergne et al. 2013), emphasized the need to move from discussions governed by perceptions to activities that capture information locally and in a reliable fashion.

Analysis of precipitation (P) and streamflow (Q) data shows variability with regards to precipitation, but minimal variability with regards to streamflow. From 1978 to 2013, annual precipitation represented a high degree of variability, and annual streamflow remained relatively constant across all years (Table 6.1). The coefficient of variation, the standard deviation divided by the mean (i.e. a normalized measure of variation within a data set), for annual P (0.75 mm) was roughly 2.5 times greater than annual Q (0.32 mm). These data demonstrate that even in years of high or low precipitation, streamflow remains fairly consistent across years, strongly suggesting that groundwater is a major contributor to streamflow.

Furthermore, there were no statistical trends associated with these data, indicating that, while variability occurs across years, precipitation and streamflow have not shown any considerable changes during the study period.

Water balance model

The conceptual water balance model was run for 1992 to 2002, based upon the data available from the DGA. The results support the conclusions from straight data analysis – groundwater fluctuations dominate the hydrological cycle even on a monthly basis (Figure 6.2). From 1993 to 1995, nine individual months with more than 12 mm of precipitation occurred. These inputs are not expressed in streamflow (Q), but are likely responsible for considerable increases in groundwater storage (S). The following year, 1996, has markedly less precipitation. However, Q remains consistent, but S decreases. This suggests that the nine precipitation events occurring from 1993 to1995 increased groundwater stores, which then sustained base flows during the subsequent, drier year. The years from 1997 to 2000 each have one month with precipitation over 25 mm, and groundwater recharge fluctuates on an annual cycle.

This same modelling framework was applied to 40-year mean temperature and precipitation data for the region using a distributed data set for the Rio San Pedro

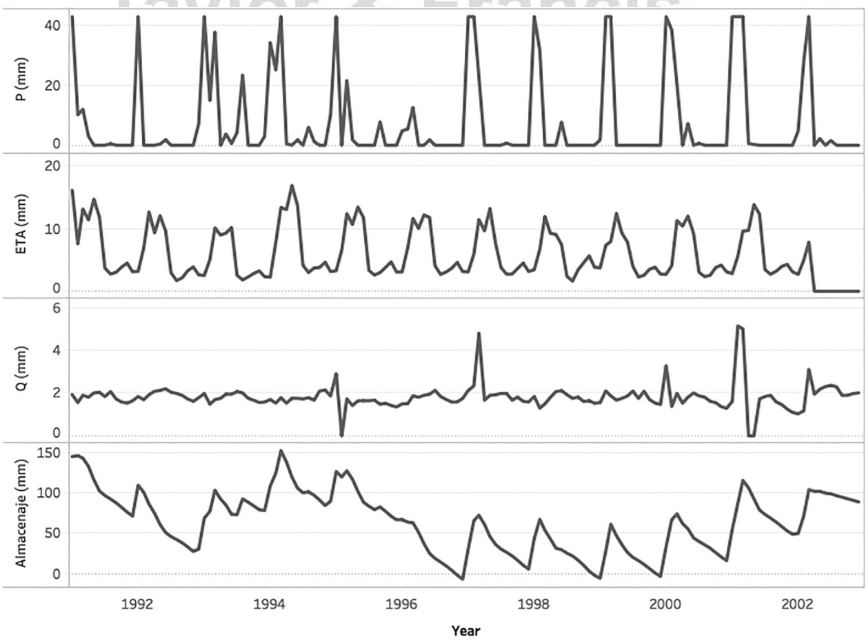


Figure 6.2 Model results for the Rió San Pedro Watershed based on hydrometeorological data from the Dirección de General de Aguas (www.dga.cl/servicioshidro meteorologicos/Paginas/default.aspx)

and adjacent Rio Vilama. This approach provides an overview of groundwater storage and the timing and magnitudes of water fluxes, highlighting December as the month of greatest water scarcity.

We next tested the sensitivity to increases or decreases in precipitation and temperature, perturbing inputs by ±10% in order to simulate climate variability. Each perturbation was run individually for five total model iterations for 12 months. The results show that December is the most climatologically sensitive month with regards to groundwater, and that variability can range by 25%. From a management standpoint this is important, as December corresponds with greatest water scarcity and the onset of the peak tourist season and irrigation. From June to September, the model suggests there is minimal sensitivity to climate variability. The water resources during this time are minimal, but consistent, due in large part to groundwater storage during the wet season (January to March). These results demonstrate that climate variability is not expressed equally across the region. The results provide a conceptual analysis and numerical values should be interpreted with caution. This highlights the lack of capacity for a current interpretation of water resources dynamics in SPA, and its institutions are not well prepared for contingent decision making.

Ecotourism model

Recognizing ecotourism as both a service of ecosystems as well as an important driver of ecosystem change (Millennium Ecosystem Assessment, 2005), developing decision support capabilities for management focused on generating the information required to characterize key variables and feedbacks in linked social-ecological systems in the project area. ProEcoServ-CL integrated an array of qualitative and quantitative approaches to evaluate these interactions, including local knowledge leveraged through participatory processes to inform multi-criteria decision analyses, public data from web-based social media platforms, GIS analyses, and results from a range of earlier studies, providing a basic framework for users to proactively interrogate management interventions according to specific decision-making contexts.

Quantifying ecotourism benefits

Cultural ESs manifest primarily as an expression of subjective individual or societal values attached by humans to nature, and, as such, are only indirectly linked to ecosystems themselves (Hernandez-Morcillo et al. 2013). Efforts to quantify cultural ESs, including ecotourism, have focused on the use of social processes to interpret these values, explicitly linking them to ecosystem structures and processes and other relevant site-level attributes to produce spatially resolved estimates of ES provision across the landscape (Nahuelhual et al. 2013; Casado-Arzuaga et al. 2013; Peña et al. 2015). To map ecotourism benefits in SPA, we convened a specialist focus group comprising local industry professionals to leverage collective knowledge of how tourists interact with the environment, applying formal decision

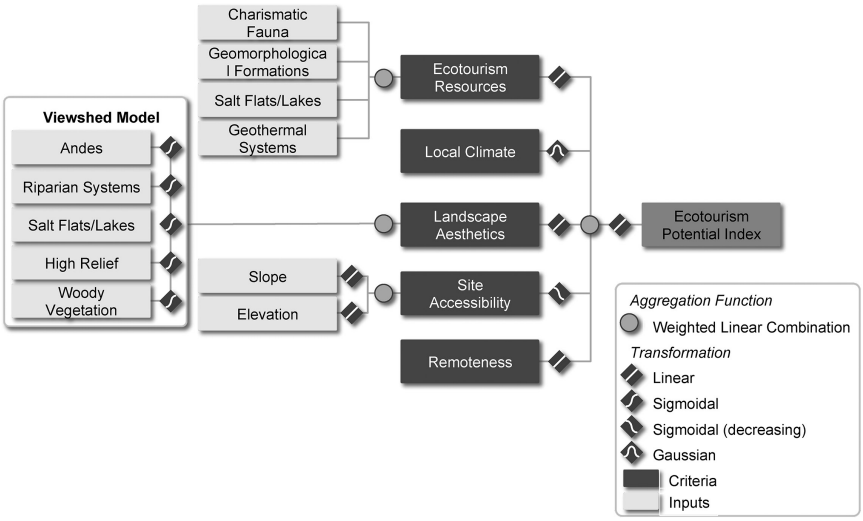


Figure 6.3 Decision hierarchy showing spatial attributes and aggregation and transformation functions applied at each step to derive an index of ecotourism potential (EPI)

rules and procedures based on the Analytic Hierarchy Process (AHP) and pairwise comparison (Saaty 2008) to evaluate a suite of environmental attributes relevant to ecotourism (Figure 6.3). Spatial layers representing each attribute, or criterion, and inputs were created using standard GIS analyses and synthesized according to respective group priority weights to produce a map of ecotourism potential (or Ecotourism Potential Index) reflective of relative levels of service provision across the landscape (Figure 6.4).

To aid visual interpretation and downstream analyses, index values were classified according to natural breaks to produce five ecotourism potential (EP) classes ranging from low (1), medium-low (2), medium (3), medium-high (4) to high (5) EP. By this approach, 2.3 % of the total project area was classified as high EP (5), with nearly half, or 48.9%, qualifying as low EP (1); classes 2, 3 and 4 accounted for 28.6%, 16.1% and 4.1% of the project area respectively (Fig. 6.5). Highest EP values were generally found to occur in association with salt flats and lakes located on the Altiplano east of the cordillera, coinciding with areas of high aesthetic value and animal diversity, with areas of lower potential occurring predominantly in the south and west of the Salar de Atacama.

Mapping visitor trends and defining sustainable use limits

Site-level visitor data offer key insights for researchers and managers, both in terms of understanding how people interact with ecosystems when engaging in

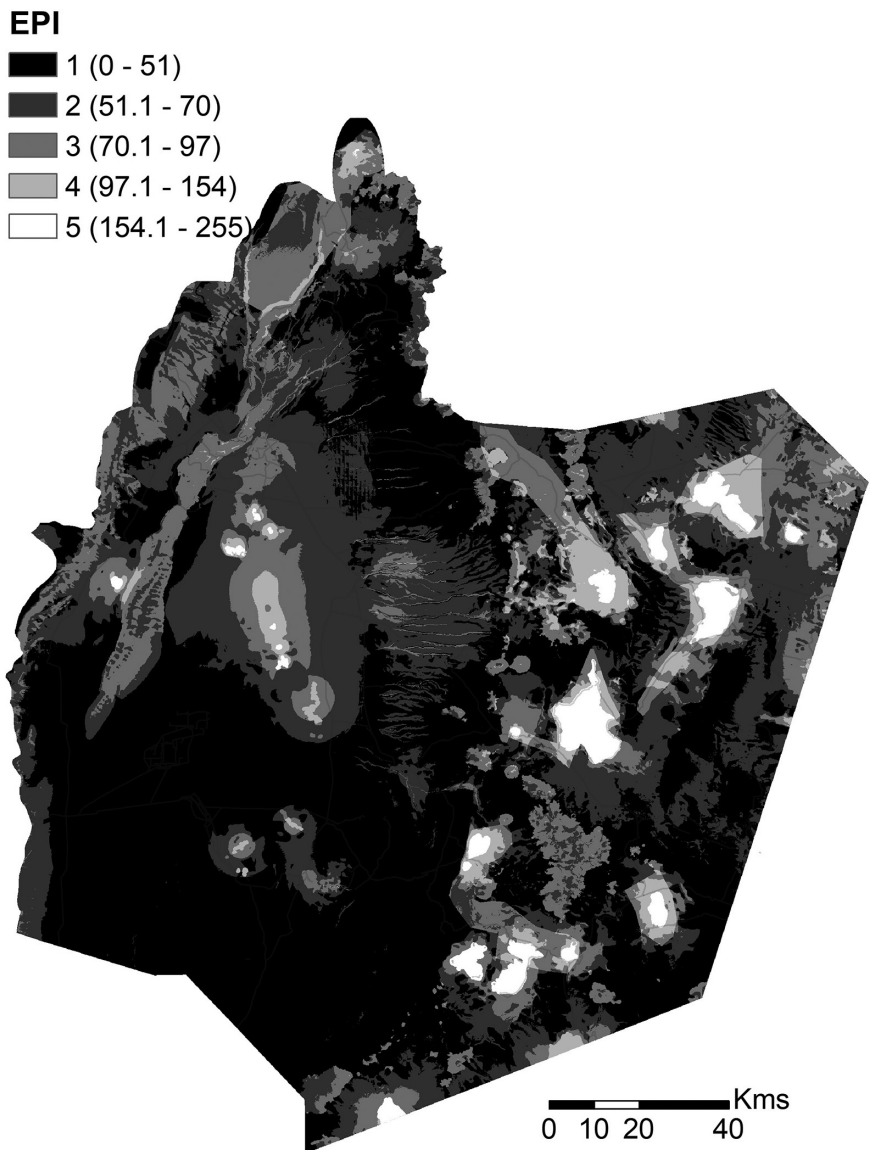


Figure 6.4 Ecotourism Potential Index (EPI) for SPA classified into five classes based on Jenks natural break optimization, from 1 (low) to 5 (high EP)

ecotourism activities, as well as monitoring potential environmental impacts associated with varying levels of tourism use across the landscape. Developing specific science-based recommendations for mitigating tourism impacts on ecosystems is challenging, but, despite valid criticisms, the concept of a tourism carrying

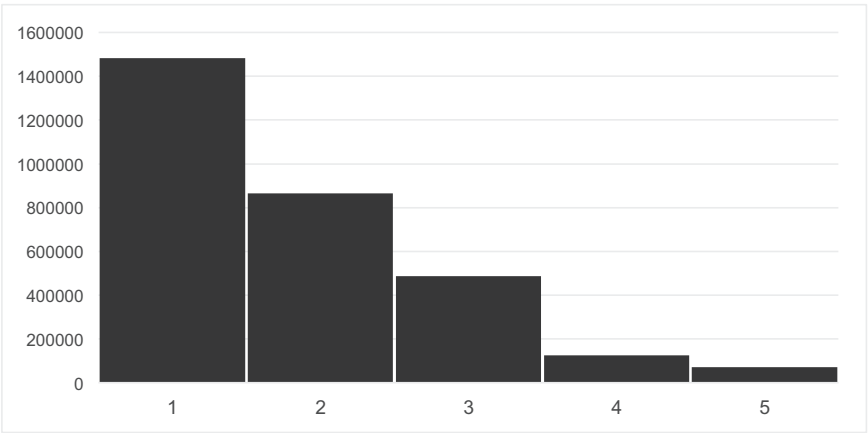


Figure 6.5 Histogram of frequency distributions of the five EP classes in Figure 6.4

capacity (TCC), typically defined on the basis of inferred site-level physical, ecological and sociopsychological thresholds, has frequently been used to establish clear numerical targets for managers (McCool et al. 2007). TCC recommendations were developed for several established ecotourism sites in SPA in an earlier study (EUROCHILE 2006) and were integrated into our approach to improve decision support capabilities in this context (Figure 6.6).

Figure 6.6 shows visitor numbers plotted against TCC at El Tatio geysers (site "a" in Figure 6.7), one of the sites for which both visitation and TCC data overlap in 2012 and 2013, indicating that visitation exceeded recommended TCC on 81% and 65% of days for which data were available in respective years.

The utility of the approach in this case is currently limited by the availability of empirical site-level visitor data, discussed earlier, and is a widely reported problem in the ecotourism literature (Wood et al. 2013). While plans are in place to address this gap in SPA, a proxy method for predicting visitation was tested as a possible alternative, based on geotagged tourist photographs uploaded to the public web-based photo sharing platform Flickr (Millennium Ecosystem Assessment 2005) (Figure 6.7). Although regression analysis revealed a poor fit of photo and empirical data, potentially due in part to the relatively small number of data points available at the spatial scale of this analysis, results could be improved by more careful filtering of inaccurately geotagged photos from the dataset.

With this caveat, the approach was nevertheless assumed to be representative of broad trends in tourism patterns, and revealed several insights relevant to management; for example, just 10 sites were found to account for a significant proportion of total Flickr "photo user days" (33% of total annual Flickr user days), with 67% of user days distributed among the remaining ±80 recognized tourist sites. However, although Flickr-based maps of tourist activity broadly correspond with the EPI developed on the basis of professional judgement (Figure 6.4), results indicate poor spatial agreement between areas of high predicted EP and Flickr use

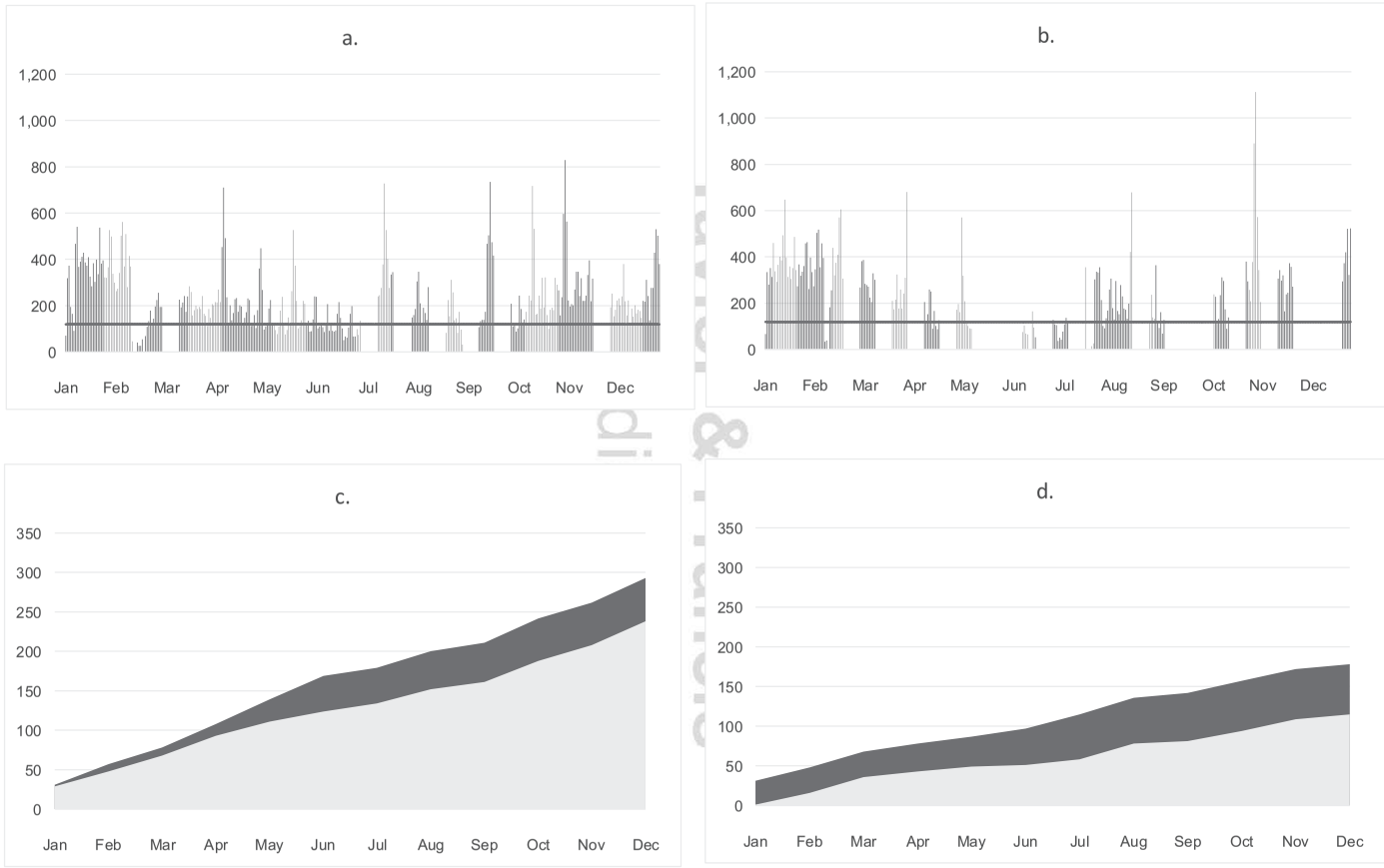


Figure 6.6 a–d: Visitor numbers at El Tatio geysers: a and b show daily visitor numbers plotted against TCC for 2012 and 2013 respectively; c and d show accumulated days where visitor numbers exceeded TCC in respective years for all days for which data were available

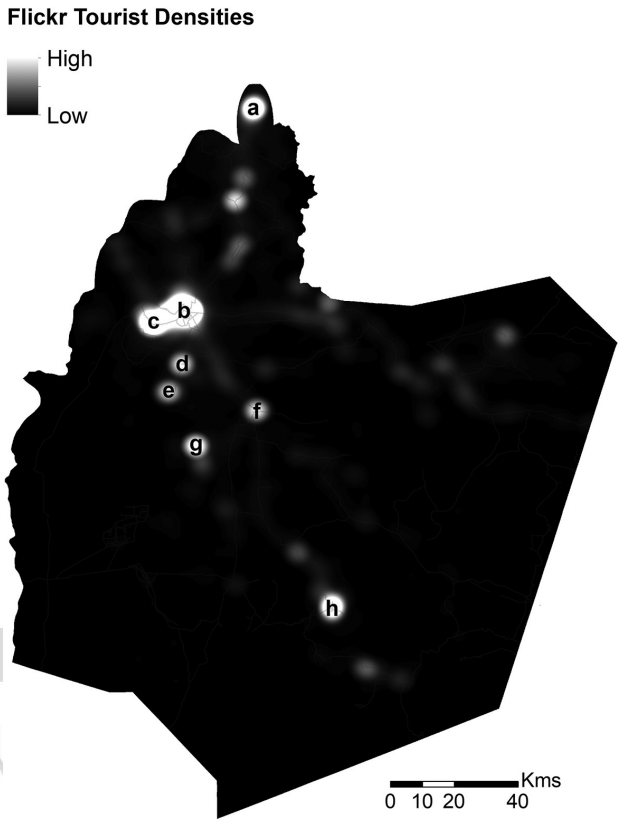


Figure 6.7 Tourism densities modelled according to unique geo-located Flickr user tags recorded at each 90m grid cell in the study area; locations of major tourist sites are labelled a–h, including: El Tatio geysers (a); San Pedro de Atacama town (b); Valle de la Luna (c); Lake Cejar (d); Lake Tebenquiche (e); Jere/Toconao (f); Lake Chaxa (g); and lakes Miscanti and Miniques (h)

particularly in the east of the project area; this may reflect a need to refine the EPI, or alternatively, that current patterns of use are in fact sub-optimal with respect to the supply of ESs across the landscape.

Evaluating impacts of key drivers of change

In addition to ecotourism, mining was identified as among the most important local drivers of change in SPA. Quantifying and characterizing the range of direct and indirect impacts of these processes on ecosystems and ESs is complex (Millennium Ecosystem Assessment 2005), and was not attempted for the purposes of decision support in this study. However, degradation of aesthetic quality of the environment, highly valued in the context of ecotourism both in this study and in

the literature (Casado-Arzuaga et al. 2013), associated with the expansion of built infrastructure is an immediately recognizable direct impact linked to mining and development on ecotourism in SPA. Visual impacts can be relatively easily modelled in a GIS environment based on line-of-sight calculations and freely available digital elevation data. Interrogating the results of visual impact analyses against EPI classes enables decision makers to proactively evaluate development options that objectively imply least impact on areas of high ecotourism potential.

As proof of concept, an analysis of visual impact associated with mining infrastructure located in the south of the project area, intersected with the EPI (Figure 6.4), revealed negligible visual impacts in areas mapped as high and medium-high ecotourism potential (Figures 6.8 a–b); EP classes 5 and 4 (low and medium-low) were determined to experience the most visual impact in terms of area from mining, although impact severity is predominantly low (Figure 6.9).

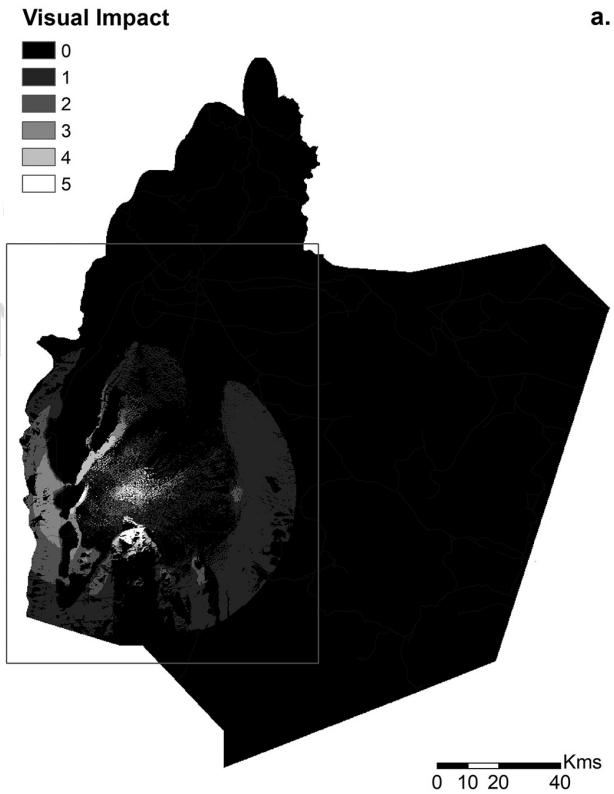
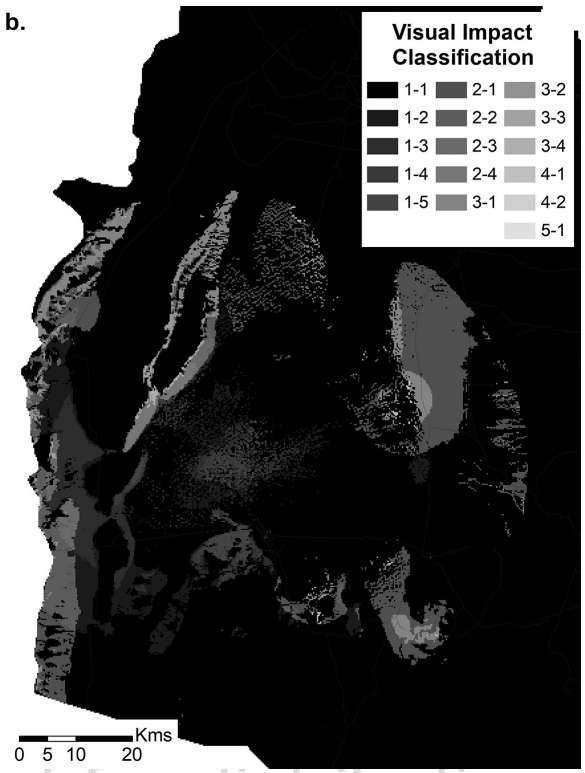


Figure 6.8 (a) Visual impact of mining infrastructure located in the south of the Salar de Atacama: impact is expressed in terms of the proportion of infrastructure visible from each pixel (subject to atmospheric conditions) classified into 5 impact severity classes based on natural breaks in values, where 1 = low impact and 5 = high impact; (b) visual impact intersected with the five EP classes to derive visual impacts per EP class; the legend reports EP class followed by visual impact severity



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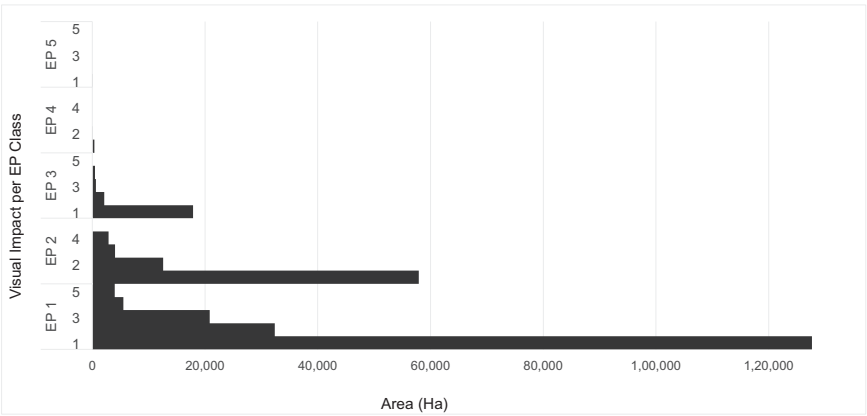


Figure 6.9 Visual impact severity per EP class

Source: Author's own

Economic valuation pilot exercise

Considering the data assembled, as well as the water and ecotourism models, the ProEcoServ-CL team performed an economic valuation exercise. The valuation scenario was discussed with local and regional stakeholders, taking into account the fact that a changing scenario would affect them more directly than it would national actors. This work extended over several workshops. In this framework, 700 survey questionnaires were distributed to local stakeholders and main actors involved in productive and development activities in the region, including mining companies, tourism operators, NGOs, and small and medium-sized enterprises (SMEs). The Unit of Environmental Economics from the Ministry of the Environment was involved in the design of the valuation scenarios. The underlying strategy for economic valuation of the ES of interest, water provision, was to work with several actors involved in the local, regional and national economy to influence economic development planning (see economic value estimates for the tourists, Box 6.1).

Box 6.1 Contingent valuation study in San Pedro de Atacama

ProEcoServ-CL administered an exploratory economic valuation study with the use of questionnaires, which is known in the literature as contingent valuation. In this valuation exercise, tourists are asked to express their preferences with respect to a water management scheme that is characterized by guaranteeing a steady and continuous provision of water in relation to the environmental health, hydrological and living resources of the region of the Salar de Atacama. Estimation results show that tourists' maximum willingness to pay ranges between US$6.90 and $11.32. This corresponds to approximately 1% of the budget reported for visits to the area. Taking into account the visitor numbers for San Pedro de Atacama, about 260,000 according to the latest figures published by the INE, the introduction of a payment scheme that would collect such a monetary amount would create an additional annual revenue to the municipality in the range of US$1.79 to $2.94 million. This corresponds to a revenue of US$20 per inhabitant of the El Loa Province, where the Salar de Atacama is located.

Source: CEAZA – PROECOSERV Report 1143/2014 (UNEP 2015)

These results were discussed in several workshops, and demonstrated how SPA is valued from both internal and external perspectives; in other words, stakeholders were able to understand not only how they value their ecosystems, but also how external actors perceive the destination in economic and productive terms (e.g. attractive landscapes and cultural attributes for tourism). Based on the results, dissemination material and practical guidelines were produced to create widespread impact at the national level.

Developing a decision support tool

Working with Tableau software

One of the key goals guiding ProEcoServ-CL's work was the development and application of a tool that would allow streamlined access to information gathered by the initiative and validated by the local community. By designing and distributing the tool, and then training its users, ProEcoServ-CL's team sought to mainstream ESs, thereby empowering stakeholders to participate with policy and decision makers involved in spatial planning and management of ecosystems and the ESs they supply. The participatory process used to design the tool allowed local and regional actors to be part of the data collection, modelling, assessment, and mapping of ESs. The protracted process was key to strengthening the adaptive governance capacities and social learning skills regarding ecosystem services.

On the other hand, this adaptive participatory process hinged on the identification, discussion and planning of scenarios for San Pedro de Atacama. During the four years of ProEcoServ-CL, several surveys, workshops and meetings were conducted to build future scenarios for the municipality, allowing a broad array of representatives from the national, regional, and local levels to participate in these collective exercises. The results revealed a range of perceptions regarding future scenarios over 10, 30, 50, and 100-year planning horizons. The capacity of the local population to respond to these conditions was synthesized in two main potential scenarios. The first scenario was based upon a "social management of water resources," which envisages that adverse conditions arising from increasing tourism will be compensated for by technological solutions and innovation, and will support better use and planning of ESs, new policies and the opening of new markets. The second scenario was based on "water resources and social mistrust," anticipating that water scarcity will precipitate a major crisis involving biodiversity loss, human migration and diseases. This crisis will generate conflicts of interest, increasing social mistrust. To allow user-friendly access to these results, ProEcoServ-CL's team developed a DSS tool based on Tableau 8.2 software, which is available to all stakeholders from the community and institutions. The same stakeholders are committed to maintain this DSS and provide access to anyone interested in the data. This software is a data analysis platform that is easy to learn and use (Figure 6.10).

Using multiple alternatives for data connection (Excel, servers, etc.), users can visualize trends and dynamics associated with modelling work of ESs. Furthermore, based on the scenario results mentioned previously, users can generate and share scenarios using this data. The software allowed government institutions and organizations, at regional and local levels, to participate in the design and training of the DSS. Government institutions represented at the regional level included the Regional Undersecretariat (SEREMI) of Medio Ambiente (Ministry of the Environment, Antofagasta) and SEREMI de Agricultura (Ministry of Agriculture, Antofagasta). Institutions represented at both the regional and local level included the Corporación Nacional Forestal (National Forest Service, CONAF) and Servicio Nacional de Turismo (National Tourism Service, SERNATUR). Finally, the Consejo de Pueblos Atacameños (Atacameño Peoples' Council), Ilustre Municipalidad de San Pedro de Atacama, Fundación de Cultura y Turismo, Asociación

Figure 6.10 Training workshops in Tableau software, San Pedro de Atacama, January 2015

de Regantes Rio San Pedro, Fundación Tata-Malku, and Asociación de Turismo y Medio Ambiente (ATYMA) were represented at the local level.

Assessment and evaluation

The overall effectiveness of the assessment and evaluation of these ESs analyses and models was monitored throughout the whole process and its design. Additionally, hands-on workshops provided an opportunity for business leaders, decision makers and students from the municipality to apply Tableau software beyond simple "button pushing" of the DSS. The workshops included 10 participants, and placed considerable focus on how to continue development and application of the tool for future decision making. Participants were given the opportunity to ask and answer questions, review the database that was being used, and experiment with different types of data visualization using the software.

Workshop effectiveness was evaluated through surveys. Participants took surveys before and after the workshops to assess their self-efficacy and abilities in applying data and technology in decision making and problem solving (Hiebert 2012). After the training workshops, participants showed an overall 24% increase in self-efficacy. Participants with less experience in natural resources or engineering (primarily business leaders) displayed even greater improvements in self-efficacy (>50%). Additionally, the performance of the workshops was evaluated by asking participants what they liked and did not like about the workshops, and what improvements should be made. These assessments allowed the ProEcoServ-CL team to address students' learning needs and maximize the impact of the DSS.

Public discussion, involvement and participatory process

When designing spatial mapping products for ESs, one of our major goals was to implement them locally to increase participation and trust between stakeholder and policy makers, ensuring the long-term continuity of ProEcoServ-CL results. Using Tableau, the ProEcoServ-CL team developed dashboards, including the model results for both ESs, to be applied in a decision support context. Furthermore, during the closing activity (March 19, 2015), the team presented the DSS tool tutorial, hosted on the ProEcoServ-CL webpage. We highlighted some of the main results and showed some of the activities that ProEcoServ-CL developed with stakeholders during the training workshops in January 2015.

Additionally, the team produced and delivered workshops, activities, meetings, documents and material during this final period to increase awareness and capacity-building regarding ESs at different levels. For example, ProEcoServ-CL coordinated and implemented an educational program at San Pedro and Talabre schools, named "Los caminos de la Patta Hoiri," with the main objective of raising awareness among primary and secondary students about the ecosystems and natural environment around San Pedro de Atacama. Furthermore, in December 2014 we hosted the final dissemination workshops for the Atacameño indigenous communities. Workshops were conducted in seven different communities including Solor, Rio Grande, Yaye, Socaire, Talabre, Toconao and Sequitor.

Social learning, communication and adaptive governance

Overall, the strategy of the ProEcoServ-CL project was to strengthen the awareness and understanding of ESs at the local level, with a particular emphasis on the social learning process behind this strategy. This is widely recognized as one of the fundamental requirements for successfully operationalizing the ES concept (Cowling et al. 2008; Daily et al. 2009; Sitas et al. 2013). This approach promoted better communication with regional and national policy and decision makers. It is critical that national policy makers better understand how policy decisions affect populations whose livelihoods depend directly on different ESs (e.g. you cannot run out of water in the desert). For this reason, ProEcoServ-CL coordinated a series of workshops. One set of workshops was designed to disseminate a strategy for SMEs and entrepreneurs at the local level including NGOs, guilds, organizations, communities and companies linked to ecotourism in the municipality. This activity was aimed at establishing a strategic plan, and underlying policy instruments, to value and develop ecosystem services in the context of SMEs administration. For example, within the indigenous communities and ecotourism operators, there are concerns about minimizing the loss of cultural identity and biodiversity, while managing sustainable economic growth, especially with regards to changes in water availability. From a scientific perspective, interpreting changes in the flow of ESs and the impacts was constrained by a sparse monitoring network and a limited understanding of ESs processes in the region. At a human level, concerns

regarding changes in water resources and tourism impacts are unique across individual communities. This dynamic requires appropriate research initiatives to balance scientific objectives and community needs within the realities of limited data. From a governance perspective, the assessment survey used in the DSS training workshops also provided information about capacity levels among stakeholders and decision makers. This information is useful, as it will allow improved training and dissemination of ProEcoServ-CL project results to other members of the community, thus increasing awareness and capacity-building in relation to the feedback from the surveys. Furthermore, communication and coordination between policy makers was key to promoting better planning and management of ESs in the country. Chile has already taken on the task of implementing ESs in the national policy. Outcomes from ProEcoServ-CL, delivered though activities, workshops, dissemination material, educational programs and a community-based DSS are tangible guidelines for future national level initiatives designed to sustain ESs.

To conclude, scientific and community-based understanding of ESs has been demonstrated as a key ingredient throughout the participatory process, and it underpins the outcomes of ProEcoServ-CL's work. During this process, the presence of a local team was a key factor for consolidating and strengthening the exchange between science and political knowledge. Furthermore, many key actors, including citizen organizations, government institutions and technical experts, collaborated on the objective in many ways. For example, these actors provided information, systematized data, provided physical spaces, disseminated information and participated in the activities that ProEcoServ-CL organized.

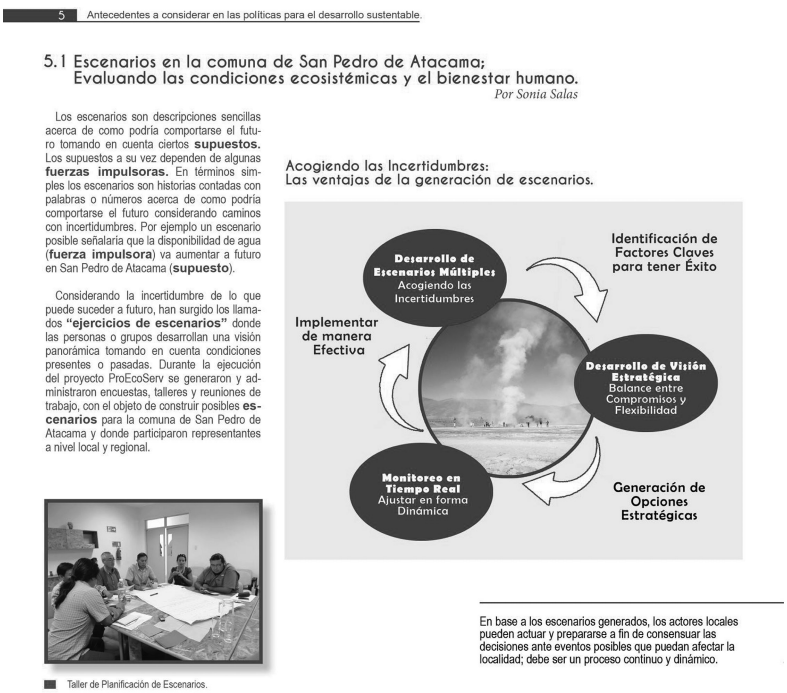
Implementation, outreach and enforcement

The ProEcoServ-CL team aimed to prepare the institutional and organizational conditions required to maintain and monitor the DSS for the ESs package. These conditions implied strong organizational connections between decision makers, policy makers and stakeholders. These connections were crucial to the development of the ESs decision tool. Two workshops at the local and regional level (SPA and Antofagasta) were developed to accomplish this objective. One of the strategies during these meetings (to assure long-term continuity of ProEcoServ-CL's results) was to maintain a copy of the database inside CEAZA's computational infrastructure while decision makers and stakeholders decide which institution will be responsible for updating and maintaining the DSS. The systematization and validated data provision will depend on the collaboration of several institutions related to both ESs: Corporación Nacional Forestal (CONAF), Servicio Nacional de Turismo (SERNATUR), Seremi Medio Ambiente (SEREMI MA) and Dirección General de Aguas (DGA). An interesting outcome of this particular objective was to learn that none of the different government institutions were particularly qualified or willing to take on the responsibility. This emergent finding reinforced one of our strategic recommendations, which was to implement the ESs strategy within locally constituted, intermediate decision-making bodies. This is likely one of the keys to the long-term sustainability of the ProEcoServe-CL results, and is currently being promoted in the national ESs agenda.

Training and capacity building

ProEcoServ-CL, along with decision-makers and stakeholders, decided to use Tableau software as the DSS for both water provision and ecotourism. This platform was ready in December 2014. At the end of January 2015, an intensive two-day workshop was organized in San Pedro de Atacama as the first pilot implementation, dissemination and training of the DSS to decision makers and users. This workshop was intended to empower locals to better understand the local-level processes affecting both ecosystem services and to provide them with the information required to better manage resources.

During the project's closing activity, the ProEcoServ-CL team also provided a book to local and regional communities called Memoria de Gestión ProEcoServ 2011–2015. This book summarizes the major work products of the ProEcoServ-CL project, and also seeks to help decision and policy makers understand and manage selected ESs at different levels of decision and policy making. This particular outreach product also provides some leads for the online training material for stakeholders that was launched along with a webpage (http://proecoserv.ceaza.cl/) that will permanently post all of the key deliverables, training material and databases (Figure 6.11).


5 Antecedentes a considerar en las políticas para el desarrollo sustentable.

5.1 Escenarios en la comuna de San Pedro de Atacama; Evaluando las condiciones ecosistémicas y el bienestar humano.

Por Sonia Salas

Los escenarios son descripciones sencillas acerca de como podría comportarse el futuro tomando en cuenta ciertos **supuestos.** Los supuestos a su vez dependen de algunas **fuerzas impulsoras.** En términos simples los escenarios son historias contadas con palabras o números acerca de como podría comportarse el futuro considerando caminos con incertidumbres. Por ejemplo un escenario posible señalaría que la disponibilidad de agua (**fuerza impulsora**) va aumentar a futuro en San Pedro de Atacama (**supuesto**).

Considerando la incertidumbre de lo que puede suceder a futuro, han surgido los llamados **"ejercicios de escenarios"** donde las personas o grupos desarrollan una visión panorámica tomando en cuenta condiciones presentes o pasadas. Durante la ejecución del proyecto ProEcoServ se generaron y administraron encuestas, talleres y reuniones de trabajo, con el objeto de construir posibles **escenarios** para la comuna de San Pedro de Atacama y donde participaron representantes a nivel local y regional.

Acogiendo las Incertidumbres:
Las ventajas de la generación de escenarios.

En base a los escenarios generados, los actores locales pueden actuar y prepararse a fin de consensuar las decisiones ante eventos posibles que puedan afectar la localidad; debe ser un proceso continuo y dinámico.

Taller de Planificación de Escenarios.

Figure 6.11 Guideline and promotional material: *Memoria de Gestión ProEcoServ 2011–2015*

Source: Centro de Estudios Avanzados en Zonas Áridas; Memoria – ProEcoServ Chile; published by Centro de Estudios Avanzados en Zonas Áridas; La Serena, Chile, 2015; http://proecoserv.ceaza.cl/pdf/memoria.pdf

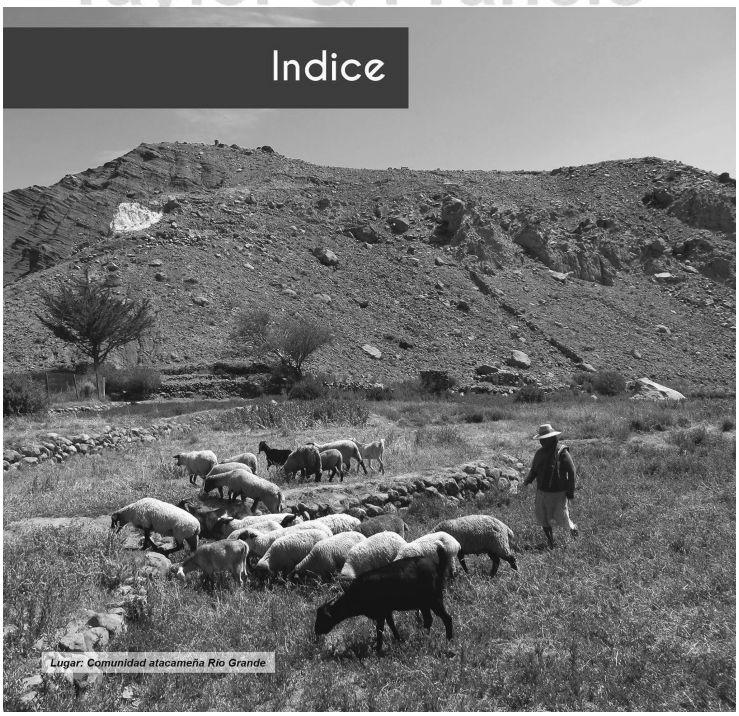


Figure 6.11 (Continued)

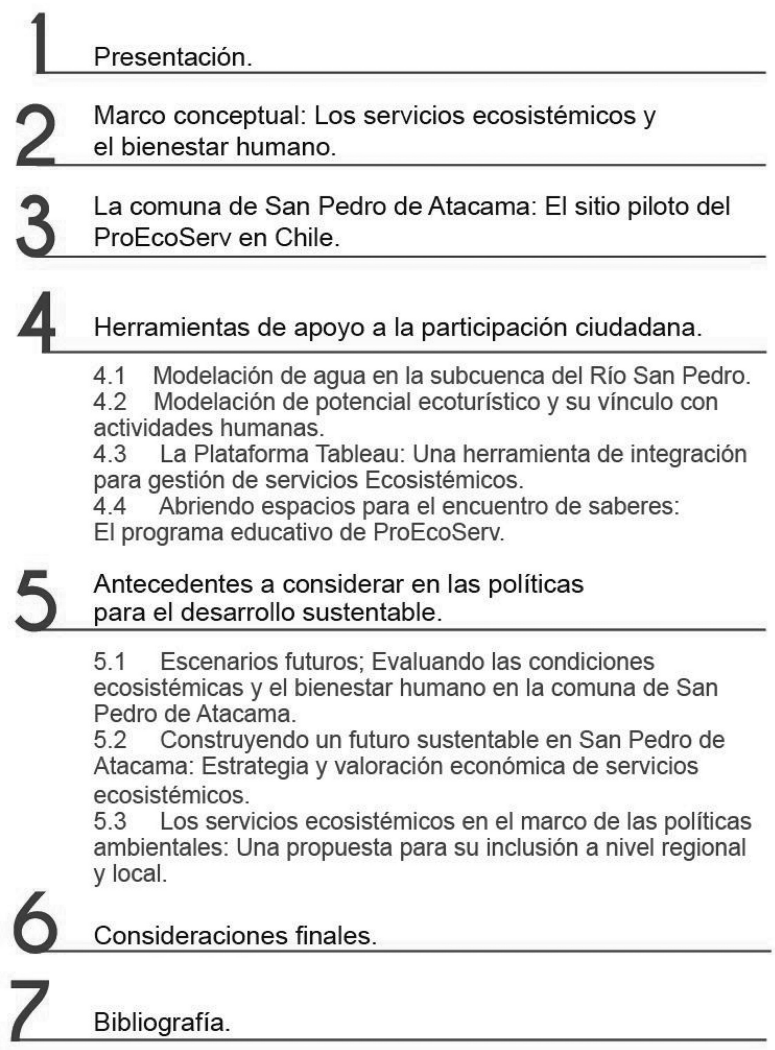


Figure 6.11 (Continued)

Mainstreaming ecosystem services and influencing policy

Participatory decision making at the local level

One of the most important results from ESs mainstreaming during the project implementation was the social learning process attached to each one of the objectives. This approach helps strengthen the exchange of ESs knowledge between

stakeholders at the local, regional and national levels, as well as a community-based understanding of ESs which, linked with a sectoral political framework, can also support planning at the national level. Therefore, one of the main proposals from ProEcoServ-CL, in association with a political strategy to mainstream ESs into sustainable national development planning, is the central role of participatory decision making at the local level. The proposal aimed to link policy support tools at different levels based on local and multi-sectoral interests that promote actions to protect and conserve ecosystems relevant for national development.

Considering this strategy, each outcome can be introduced into the policy support tools selected, especially at the local level, to influence national development planning. The ESs mainstreaming through a participatory process was already validated by many of the project outcomes: (1) identification and weighting, together with stakeholders, of spatial factors that determine areas of ecotourism potential in San Pedro de Atacama; (2) developing and training of models for water provision and ecotourism using Tableau software; (3) training and dissemination of trade-off matrices for both ESs; (4) identification and review of scenarios for San Pedro de Atacama, including the design of final guideline material on this issue and (5) conducting several meetings to identify potential SMEs and engaging with other private-public projects.

The ProEcoServ-CL team worked closely with 12 government institutions and organizations participating in a local steering committee (LSC) that was chaired by the Municipality of San Pedro de Atacama. During the period of project implementation, the group worked closely with the ProEcoServ-CL team to, above all, link activities and outcomes with national, regional and local policy processes, and also to provide important feedback for research. Each government institution chosen for the LSC was related directly, or indirectly, with the ESs targeted by the proposal. Within the government institutions, there was an advisory group that also supports several other participatory processes at the local level. The main institutions and organizations that were part of one or both groups were the Municipality of San Pedro de Atacama (Municipalidad de San Pedro de Atacama), the Council of Atacameños People (Consejo de Pueblos Atacameños, CPA), Rio San Pedro Irrigators and Farmers Association (Asociación de Regantes y Agricultores Río San Pedro), National Service of Tourism (Servicio Nacional de Turismo), National Forestry Corporation – Los Flamencos Reserve (Corporación Nacional Forestal), Water Authority (Dirección General de Aguas), Foundation of Culture and Tourism (Fundación de Cultura y Turismo), Regional Ministry of Agriculture, Secretary of Regional and Administrative Development (Subsecretaría de Desarrollo Regional y Administrativo), National Indigenous Corporation (Corporación Nacional Indígena), Association of Tourism and Environment (Asociación de Turismo y Medio Ambiente) and Tata Malku Foundation (Fundación Tata Malku). Additionally, at the local level, ProEcoServ-CL identified the Communal Development Plan and the Municipal Ordinance for Local Environmental Management as the two major entry points for policy intake. It is worth noting that ESs are not clearly integrated into this political and legal framework, although the ecosystem concept is mentioned in the higher-level policy tools.

Engagement with regional and national development planning

The core of the methodological proposal was a participatory decision-making process at the local level. In this sense, the major concern was to generate a strategy for the sustainable management of ESs from a multi-sectorial perspective, which articulated several actions to protect the ESs in San Pedro de Atacama and ensure the well-being of its people. Innovation and adaptive governance for a sustainable development of ESs in San Pedro de Atacama depended on the strategies used to link national policy tools with regional and local decision tools and decision making. One of the key lessons learned is that participatory processes, together with a scientific and community-based understanding of ESs, have been instrumental in reaching these goals, with the result that the community is now truly empowered to manage their ESs.

At the regional level, ProEcoServ-CL identified two main tools that included ESs in policy and decision making: Regional Development Strategy and the Action Plan for Biodiversity in the Antofagasta Region. The ProEcoServ-CL team also collaborated with the Ministry of Environment, including the regional undersecretary's office. Hence, it was possible to work very closely, enabling the minister to participate in important activities and discuss perspectives regarding ESs, especially in relation to the design and training of the DSS. Furthermore, the ProEcoServ-CL local team was able to link several national and regional initiatives. A concrete achievement in this regard was the submission of a proposal to Antofagasta's Regional Fund for Innovation and Competitiveness that aimed to strengthen the capacity of regional decision and policy makers to analyze decisions on key ESs. ProEcoServ-CL also secured funding for two projects in the 2015 period. The Environmental Protection Fund, sponsored by the Ministry of the Environment, is supporting a renewable energy project called Ckapin isaya Ckonicks: Sol para nuestros Ancianos."= The second project, Valorización de la Quínoa Atacameña a través de la caracterización nutracéutica, elaboración de productos funcionales y cadenas de comercialización, was funded through the Agricultural Innovation Fund and sponsored by the Comisión Nacional de Investigación Científica y Tecnológica. This project will bolster cultural ESs related to traditional crops and techniques.

Policy impact

One of ProEcoServ-CL's strategies to mainstream ESs into policy support was to identify and link existing high-level policy support tools (such as international conventions, laws of the republic, regulations, political strategies and national plans) with other tools operating at the regional and local level. At the regional level, ProEcoServ-CL identified two main tools that included ESs in the policy and decision making: Regional Development Strategy and the Action Plan for Biodiversity in the Antofagasta Region. At the local level, ProEcoServ-CL identified the Communal Development Plan and Municipal Ordinance for Local Environmental

Management. It is worth noting that ESs are not clearly integrated into this political and legal framework, although the ecosystem concept is mentioned in the higher-level policy tools.

In this context, the training and dissemination of Tableau software was critical to enabling policy makers and stakeholders to use the ProEcoServ-CL results to support decisions. During the change in government in March 2014, the Municipality of San Pedro de Atacama experienced shifts in the local policies aimed at protecting and managing ecosystems in a sustainable way. Furthermore, presenting the satellite-based water balance for the Central Altiplano proved that highly sophisticated scientific tools and approaches can be distilled into one simple figure that can still drive home a powerful point. In the SPA case, it allowed the discussion to move from speculation to fact-finding. This has never been achieved in the current national context of broad mistrust of established authorities, which suggests a way forward for dialogue around ESs.

Another concrete policy-making impact is that the Municipality of San Pedro de Atacama is actively working on the first-ever tourism development plan for the Comuna (PLADETUR). They must first determine which area will be assigned a special zoning status designed for tourism development (ZOIT). To achieve this objective, decision makers are using the Tableau software platform to visualize the tourism data that has been collected and systematized by the ProEcoServ-CL team during the project. Furthermore, representatives from the local office of the National Forestry Corporation (CONAF) and of the National Service of Tourism (SERNATUR) have learned from Tableau how to interpret tourism dynamics and how they can affect ecosystems and tourism attractions, and how the water provision between seasons determines the water availability for local communities and tourism activity. Both activities are interesting achievements, as they highlight the potential for engaging with local-level actors in the design of policies that have an enormous potential to cascade into other local initiatives across the country. Given the very limited room for compromise that currently exists between local development and national authorities, particularly where indigenous groups are involved in decision making, these achievements are providing a nationwide benchmark for how to design effective ES policies.

Another important aspect of ProEcoServ-CL refers to the inclusion of ESs in regional policy and national legal tools. This objective was, however, solidly based on local assessment of environmental policies, scenario development for SPA, and application of different strategies for economic valuation of ESs (surveys, workshops and meetings). Each of these actions was carried out during the ProEcoServ-CL project execution in order to influence national policy making. Naturally, this work approach also considered the local relevance of such actions, plans and policies. Without this consideration, the impact that an initiative could have on national policy could not contribute in the same way to the welfare of local communities and their ecosystems. Therefore, a constant exchange of knowledge is necessary between the different levels of decision makers to strengthen the ecosystem approach in the development of the country.

Probably one of the clearest indicators of this ESs integration assessment and political engagement are the projects in which CEAZA has been registered during 2015, ProEcoServ-CL's last working year. Two projects awarded have included the local criteria in the proposals using regional (Regional Ministry of Environment, or FPA) and national (Ministry of Agriculture, or FIA) funding. The implication is that ProEcoServ-CL results have been internalized to support the continuous integration of ESs criteria into the national policy, considering the local relevance as the framework. At this stage, it is also worth mentioning two key results that emerged from the installation of the ProEcoServ-CL team in SPA. Firstly, CEAZA has access to a very good network of professionals that are interested in the sort of applied science activities that CEAZA scientists conduct. Therefore, the ecosystem concept, and the whole concept of evidence-based decision making around ESs, as well as the direct benefits a long-term view may bring about to local communities, is now firmly established in SPA. Secondly, the Council of Atacameñan People (Consejo de Pueblos Atacameños, CPA) was explicitly included in a high-level presidential consulting body that delivered a major policy white paper on the future of lithium mining in Chile, which is now centered in SPA. This policy document explicitly and profusely includes the ecosystem concept, water provisioning, ecotourism and the need for sustainable development to preserve fragile ESs that are key to local livelihoods, representing very concrete proof of the national-level impact of ProEcoServ-CL's work.

To summarize, the policy impact can be assessed in different ways and perspectives. There is a lack of state-level tools to project decision making from the national to local level. Therefore, the ProEcoServ-CL team chose, as a core strategy, to focus on the local work to accomplish this objective. The work was focused on sectoral strategies to achieve a bottom-up influence on higher-level ESs in policy making. Our results show that complex initiatives, such as ProEcoServ-CL, can only be developed at the local (municipal) scale if they are validated with decision makers within the local community (e.g. CPA and Municipality of SPA), and supported by national-level institutions (Ministry of the Environment, Ministry of Agriculture). In this sense, ProEcoServ-CL provides a clear and important precedent for ongoing efforts to operationalize ESs, both in SPA and Chile generally.

Conclusions and recommendations

ProEcoServ-CL's work suggests a series of strategic and practical recommendations to ensure a better understanding of, and capacity building for, sustainable management of ESs in San Pedro de Atacama. To ensure rigorous scientific assessment, modelling and valuation of ESs, it is still necessary to establish real-time monitoring networks to better understand ES dynamics and improve future scenarios for the region and the municipality. Thus, implementing an observation platform with continuous measurements, providing near-real time information of ESs throughout Internet and social media platforms, will enhance decision support capabilities and management of ESs in areas under study. In this respect,

ProEcoServ-CL has made a significant contribution to developing the social capital that must precede the construction of physical infrastructure (hydrological and meteorological stations, groundwater measurements or monitoring visitors in real-time) to nurture sustainability as communities prepare to assimilate these key pieces of information. Furthermore, ProEcoServ-CL established local leaders and participatory processes that can provide interesting technical options. Managing and designing physical ES infrastructure in a participatory way can be replicable in other projects with the tools that every country has available. Using this methodology, specific solutions to ensure human welfare and better management of ESs for each country can emerge. Implementation of the Tableau software platform in the local administration of SPA (Municipality of SPA, Council Atacameños People, CONAF, SERNATUR) is a concrete example in this regard. To our knowledge, ProEcoServ-CL is the first example in this country of a participatory process that has successfully empowered and matched indigenous people with the ESs concept managed by national authorities. Discontent among indigenous people in Chile is increasingly centered on access to ESs, and there is a lack of tools to match the contrasting perception held by authorities and indigenous leaders in this regard. Therefore, the use of this participatory process is under consideration in other contexts, such as Easter Island, where CEAZA scientists have a strong local presence. Similarly, ProEcoServ-CL has submitted a proposal to the regional government of Antofagasta, where the SPA indigenous community will participate in the monitoring effort highlighted at the beginning of this chapter, with the intention of creating a permanent regional study center focused on ESs sustainability in the broader Altiplano region.

Based on the ProEcoServ-CL San Pedro de Atacama experience, our recommendation is to strengthen and monitor the bridge between science and policy throughout participatory processes at different levels. This must be done throughout the entire project, emphasizing the evaluation stage and the design of products (deliverables). As noted previously, implementing agencies (i.e. CEAZA), should be provided with higher-level counterparts within the central administrations that are in more powerful technical positions and not politically appointed. It was a huge burden to reinitiate dialogue with low-level officials who held little political influence in the central administration, and who did not clearly understand the aim of the proposal. Although resources and personnel were dedicated to train them, it was of little practical use, since their requests or motivations were dictated from a political vantage point, with no room for the compromise that ESs mainstreaming required.

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