Research

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Participatory scenario-planning in place-based social-ecological research: insights and experiences from 23 case studies

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1.

ABSTRACT

2. Participatory Scenario Planning (PSP) is an increasingly popular tool in place-based environmental
3. research for evaluating alternative futures of social-ecological systems. Although a range of
4. guidelines on PSP methods are available in the scientific and grey literature, there is a need to
5. reflect on existing practices and their appropriate application for different objectives and
6. contexts at the local scale, as well as on their potential perceived outcomes. We contribute to
7. scenarios theoretical and empirical frameworks by analysing how and why researchers assess
8. social-ecological systems using place-based PSP, hence facilitating the appropriate uptake of such
9. scenario tools in the future. We analysed 23 PSP case studies conducted by the authors in a wide
10. range of social-ecological settings by exploring seven aspects: 1) the context; 2) the original
11. motivations and objectives; 3) the methodological approach; 4) the process; 5) the content of the
12. scenarios; 6) the outputs of the research; and 7) the monitoring and evaluation of the PSP process.
13. This was complemented by a reflection on strengths and weaknesses of using PSP for the place-based
14. social-ecological research. We conclude that the application of PSP, particularly when tailored to
15. shared objectives between local people and researchers, has enriched environmental management and
16. scientific research through building common understanding and fostering learning about future
17. planning of social-ecological systems. However, PSP still requires greater systematic monitoring and
18. evaluation to assess its impact on the promotion of collective action for transitions to

sustainability and the adaption to global environmental change and its challenges.

Key words: Futures research; methodological insights; participation; place-based research; scenarios; social-ecological systems

INTRODUCTION

A scenario is a coherent, internally consistent, and plausible description of a potential future trajectory of a system (e.g. Heugens and van Oosterhout 2001). Scenario planning exercises aim at articulating multiple alternative futures in a way that spans a key set of critical uncertainties (Peterson et al. 2003*a*, Kok and Van Delden 2009), using qualitative and quantitative methods and data (Carpenter et al., 2015; Swart et al. 2004). Scenario planning has its roots in operations research developed in the Second World War and was substantially elaborated upon in corporate strategic planning in the 1970s. It has been increasingly applied in diverse environmental research contexts during the past 25 years, including biodiversity assessments, the management of protected areas, ecosystem services and their relationship to human wellbeing, climate change and land-use change in general, and more specifically, desertification and land degradation (e.g. Brown et al. 2001, Kok et al. 2004, Sala et al. 2000, Bradfield et al. 2005, Jessel and Jacobs 2005, Pereira et al. 2005, Carpenter et al. 2006, Gude et al. 2007).

The steady increase of scenario planning in environmental research can be attributed to a number of perceived benefits. These include fostering long-term and complex thinking that allows for an exploration of the dynamics and sustainability of social-ecological systems. The adaptability and accessibility of scenario planning compared to other modeling approaches might also explain this increasing trend. While lack of rigor is a potential weakness in scenario planning exercises, this is often compensated by its utility to clarify distinct and explore social-ecological feedbacks and potential surprises that cannot be easily represented in more formalized modeling approaches (Bennett et al. 2003). Addressing feedbacks and surprises, however, is fundamental when managing sustainability in complex social-ecological systems (Kok et al. 2007, Walz et al. 2007).

Scenario planning processes are often oriented towards influencing decisions (Wollenberg et al. 2000), which means they can potentially have a wide range of implications for a diverse set of stakeholders. Accordingly, scenario planning in environmental research and management of natural resources has become more participatory. Involving diverse stakeholders with influence and interest in the social-ecological system, including those potentially most affected (Bohnet and Smith 2007, Kok et al. 2007), might foster social learning and collective action to achieve desired goals (Butler et al. 2014*a*, Butler et al. in press). Hence participatory scenario planning (PSP) is a

process in which stakeholders, frequently guided by researchers, are engaged in a highly collaborative process and develop a leadership role within some or all stages of a scenario development process to investigate alternative futures.

The rationale for stakeholder engagement in scenario planning follows normative and pragmatic arguments, many of which relate to process-oriented results that are emerging from broader participation discourses (Stringer et al. 2006, Butler et al. in press2013); empower stakeholders (Reed et al. 2013*a*); stimulate innovation (Butler et al. in press); mitigate conflicts (e.g.), such as to encourage social learning (e.g. Volkery and Ribeiro 2009) and to integrate different types of knowledge (e.g. scientific, local), perceptions, expectations and aspirations (e.g. Bohnet 2010, Von Wirth et al. 2013). In particular, PSP processes can facilitate discussions regarding the future effects of drivers of change on human wellbeing, ecosystem services and their trade-offs, biodiversity, or other social-ecological components across multiple spatial, temporal or institutional scales. Further, PSP can be viewed as a solutions-oriented technique because it can: increase adaptive capacity (Carlsen et al. Kahane 2012); and identify policy recommendations for sustainable development (e.g. Cork et al. 2005, Bohensky et al. 2011*a, b,* Palomo et al. 2011) and adaptation pathways (Butler et al. 2014*a*). PSP can elicit how stakeholders might respond to future challenges, hence contributing to the management and understanding of complexity in social-ecological systems.

Despite the increased application of PSP, as far as we know, there has been no comparison or review that assesses the multiple claims of PSP studies (e.g., social learning, innovation, empowerment) and synthesizes the knowledge gathered. This limits the understanding of the applicability of different methods, and the strengths and weaknesses of different processes relative to different goals and contexts within PSP (Vliet et al., 2012). Such an understanding is needed to improve the rigor, inclusiveness, and effectiveness of PSP, and to inform future practice as PSP becomes more common through its adoption by global initiatives such as the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES).

This paper studies the application of PSP in social-ecological systems via an in-depth review across 23 case studies. First, we explore seven components of each PSP case study: 1) the case context; 2) the original motivation and objectives; 3) the methodological approach; 4) the process; 5) the content of the scenarios; 6) the outputs of the research; and 7) the monitoring and evaluation of the PSP process. Second, we compare PSP practice across these cases. Finally, we synthesize strengths and weaknesses, reflect on lessons learned and highlight areas of potential improvement in PSP practice.

METHODS

Case selection

This paper is based on a structured ex-post multiple case enquiry (Yin 2009) and reflection by researchers who have been involved in place-based PSP in social-ecological systems as part of an action research project or as a participatory component of a larger research project. As a starting point, a core group of researchers from multiple disciplines and with relevant experience in qualitative scenario exercises initiated this synthesis activity at the "Resilience 2014: Resilience and Development: Mobilizing for Transformation" conference. A subsequent snowball search procedure, among colleagues in the resilience and social-ecological systems research communities resulted in identifying 23 scenario cases that were included in our analysis (Table 1). Criteria for inclusion were discussed by the first co-authors to be involved in the process and were: 1) first-hand experiences would be contributed by the principal investigators of the scenario cases; 2) cases would feature place-based PSP addressing and linking social and ecological dimensions; and 3) major gradients in terms of geography, ecosystems, socio-economics and natural resource management would be covered. Our cases were thus selected through information-oriented sampling focused on maximizing variation, and are not necessarily representative of all PSP exercises recently conducted (Flyvbjerg 2006). Our systematic comparative analysis aimed at understanding the commonalities and differences in PSP exercises that have been conducted within diverse social-ecological systems.

[INSERT TABLE 1 ABOUT HERE]

Data collection and analysis

We developed an analytical framework for the analysis of the 23 PSP exercises. The cases included in this study were conducted between 2003 and 2014 (Table 1). This framework was tested on sample cases and reviewed by 18 authors who refined and translated it into a survey of 75 open and closed questions (Appendix 1) that were grouped into nine categories: 1) case details (e.g. basic information such as study title, name and role of contributor, references); 2) context and case identity (e.g. location, scale, ecological, socio-economic and governance context, type of stakeholders in the case study, and thematic focus); 3) the original motivation of the study and its objectives (e.g. main general aim and specific objectives); 4) methodological approach (e.g. background information and guidelines used, the process to identify drivers of change, the scenario design); 5) methodological process (e.g. stakeholders engagement, process stages, tools used, storyline types etc.); 6) content of scenarios (e.g. storyline characteristics, consideration of ecosystem services (ES), biodiversity, human well-being, trade-offs); 7) outputs (e.g. type of outputs, such as reports, drawings, collages, videos, etc.); 8) monitoring and evaluation (e.g. impacts of the exercise and if monitoring and evaluation phases were developed); and 9) lessons

learned (e.g. main strengths and weaknesses of the process, key insights and reflections). Two rounds of data collection took place in order to clarify responses and to incorporate additional questions arising from the first round.

The information from each of the aforementioned categories was analysed by a subgroup of co-authors following a four-step process: 1) where applicable, responses were coded into pre-existing or emergent typologies; 2) the diversity of the responses to each question was summarized, including notable outliers; 3) particularly strong trends, dominant approaches or common findings or lessons were noted; and 4) descriptive and multivariate analyses. Multiple Correspondence Analysis (MCA, the counterpart of Principal Component Analysis for large sets of categorical data) and Hierarchical Cluster Analysis (HCA) were applied to explore the linkages and associations between different variables and similarities between cases, respectively. To define the number of axes retained for the HCA, we employed two criteria: scree test (Cattel 1996) and eigenvalue, which determines the inclusion of MCA axes with inertia above 0.15 (Hair et al. 1998). We used Euclidean distance as the dissimilarity matrix coefficient and Ward's method as clustering technique in order to minimise the error in sum of squares (Ward 1963). Clusters of case studies were then associated with original motivation for performing the study and lessons learned. Data were analysed with Excel (Microsoft Office) and Xlstat 2012 (Addinsoft) software.

RESULTS

Case context and identity

Geographical and temporal distribution

The case studies were located in 17 different countries and six continents (Fig.1). Most cases were from Latin America (seven cases), closely followed by Europe (six cases), then North America (three cases) and Australia (three cases). Africa and Asia were represented by two case studies each. Case studies were most frequently located in the tropical and sub-tropical forest biomes (Fig. 1; Olson et al. 2001). Some of them were conducted in agroecosystems and others, such as the German, Kenyan and South African cases, included urban and peri-urban areas. While terrestrial settings prevail, three case studies also dealt with estuaries or coastal wetlands (#6, #13 and #22), tropical islands (#18, 19 and 20) and a tropical coral reef (#17).

[INSERT FIGURE 1 ABOUT HERE]

The end year of the PSP research projects ranged from 2003 to 2014 with most processes finishing between 2012 and 2014.

Scale and system boundaries

Half of the cases (13) were defined by political boundaries (e.g. municipality, district, province or officially recognized community boundaries) while the other half defined their boundaries according to natural features such as watersheds, coastal regions or landscapes (Appendix 2). In sixteen of the cases, protected areas were included within the research area. Twenty one cases were developed at a local scale (e.g. communities, municipalities or sub-districts) and only six explicitly used a multi-level approach (i.e. included analysis at local, regional, national and/or national and global scales).

Governance and institutional contexts

The vast majority of cases involved complex governance and institutional arrangements. The most prominent institutions participating were municipalities (22 cases), regional and national (20 cases) governmental institutions; community councils, indigenous organizations and tribal forms of organization (16 cases); and conservation groups, NGOs, co-management groups and natural resources regulatory agencies including park authorities (22 cases) (Appendix 2). In eight cases, supranational governmental organizations, such as the European Union (Water Framework Directive and Common Agricultural Policy) and international trade agreements, like the North-America Free Trade Agreement, were also mentioned as influential. In 14 cases, large natural resource industries like fishing, mining and palm oil industries were noted as key actors, even if not formally considered part of the environmental governance system. In the two Colombian cases (#5 and #13), criminal and guerrilla groups were also considered part of the governance system.

Economic contexts and livelihoods

In most cases (20) agriculture was the primary sector supporting local livelihoods (Appendix 2). The services sectors, including trade and tourism, were also important (18 cases), whilst extractive industries - such as fishing, mining, palm oil and timber plantations - were important in 11 cases. Nine cases dealt with subsistence economies or economies with a strong dependence on subsidies or remittances. In four cases, illegal economic activities (such as coca plantations or illegal timber extraction and mining) were an important part of the local economy.

Subject and objectives of the PSP exercise

The main issues subject of PSP included conservation (e.g. biodiversity, wildlife and natural habitat protection), sustainable development pathways and natural resource management (Appendix 3).

Following van Notten et al. (2003), cases were classified according to (Fig. 2A):

1) their goals - classified as a) exploratory (i.e. creating scenarios to examine plausible drivers of change), b) pre-policy or decision-support (i.e. building scenarios to examine futures according to their desirability), or c) both exploratory and pre-policy;

2) their treatment of norms - classified as d) descriptive (i.e. developing scenarios without considering researchers' preferences), e) normative (i.e. including researchers' preferences or interests in scenario development), f) both descriptive and normative; and

3) the function of the scenario exercise - classified as g) process-oriented to stimulate reflexivity, creative thinking and raising awareness about the future of the social-ecological system), h) product-oriented (i.e. leading scenarios to create an outcome, e.g. a set of narratives of plausible scenarios), or i) both process- and product-oriented.

Four main reasons were given for the use of place-based PSP (Appendix 3): 1) to guide and support local stakeholders' decision-making by promoting reflection on likely impacts of future drivers of change in socio-ecological systems (nine cases); 2) to generate social learning and knowledge integration among multiple stakeholders in order to find ways to respond to potential changes (six cases); 3) to complement research projects by incorporating stakeholders' views in the research process (five cases); and 4) to raise local stakeholders' awareness of future changes and to confront skepticism e.g. about climate change (three cases).

Methodological approach

Background information

All case studies collected background information (Appendix 4), often through desk research (13 cases) or in a participatory process (e.g., with workshops or focus groups, 12 cases) for a range of purposes (Fig. 2B).

[INSERT FIGURE 2 ABOUT HERE]

Type of scenario design

In 14 cases the scenarios were designed through stakeholder-driven approaches. In the remaining cases stakeholders participated in other stages of the PSP as explained below. Twenty one cases used a projected year, ranging from 2025 to 2090; although 2030 was the most commonly projected year (nine cases). The time span between the creation of the scenario and the projected year was, in most cases between 10 and 20 years (14 cases).

About half of the cases (15) created four scenarios. A common motivation to the number of scenarios created was that it should be a manageable and feasible number for further discussion and

deliberative purposes (nine cases).

Drivers of change

All but two cases identified drivers of change through participatory methods (21 cases), particularly through workshops (17 cases), but also by way of interviews and surveys (nine cases). Formal scientific knowledge from outside of the participatory process (e.g., previous research, predefined drivers by researchers) was also used to identify drivers in all cases. The majority of cases used alternative states of key drivers as the basis for the storylines. Among all the available reasons for using drivers of change in PSP, inspiring the creation of qualitative storylines was the most common (15 cases). A 2x2 matrix approach (e.g. Carpenter et al. 2006) was also quite common (10 cases), while only four cases used drivers to derive formal models.

The number of drivers of change varied widely across the cases (from 2 to 392), but most commonly, 10 or fewer drivers of change were identified (10 cases). The process to prioritize drivers, once they had been identified, was usually by ranking (10 cases), based on their impact, probability of influence, importance and relevance for a given SES. The majority of drivers identified were related to social issues (e.g. demographics, governance, economics, market conditions).

Process

Duration of the scenario planning process

The duration of the complete process varied from two to 60 months (median 12, average 16 months), with between one and 18 workshops (median three, average five workshops) lasting between half a day and four days (median of one day, average of one and a half days).

Engagement of participants and facilitators

In 19 cases a research team identified stakeholders jointly with (or with significant input from) local stakeholders. In some cases specific stakeholder identification methods were used, including stakeholder analysis and mapping techniques (12 cases), such as the two-axis importance/relevance and interest/concern tool (e.g. Reed et al. 2009), social network analysis (two cases) and/or snowball sampling (four cases).

The total number of participants involved in the cases ranged from 14 to 167, with an average of 52 (median 50), although the average number of participants per workshop was 26 (median 22) (Fig.2C). The diversity of stakeholder groups considered in the PSP exercises ranged from only one group to seven different groups (Fig. 3). Almost all cases involved the local community, local policy-makers, natural resources management agencies and non-governmental organizations (NGOs). Other commonly

involved groups included supra-local policy-makers, academics, and representatives from the business and recreation sector (Fig. 2D).

[INSERT FIGURE 3 ABOUT HERE]

Workshops were typically facilitated by four or five facilitators, entailing an average 1:2 facilitator - participant ratio. In 21 of the studies, facilitators came from their own research team, sometimes after facilitation training (14 cases) and often with previous experience in future scenarios workshops (10 cases). Only four cases used independently contracted facilitators.

In most cases, the researchers had prior knowledge of the participants, either through research team members who were local to the study region or because of previous engagement with stakeholders. Conflicts sometimes emerged during the participatory process (seven cases), mostly between participants with different views but also between participants and researchers (one case) and between funders and researchers (one case).

In almost all cases (19) participants collaborated in the envisioning process (i.e. imagining drivers interacting to form future events), and the identification or selection of guidelines or drivers (18 cases, Appendix 5). Participatory methods/process design (i.e. the design of the methods/process itself) took place in 11 cases. Eleven cases also received feedback and comments from participants. In roughly one third of cases (seven) participants were involved in the back-casting (i.e. analyzing how desirable future outcomes can be reached for long-term complex issues, Dreborg 1996, Carlsson-Kanyama et al. 2008) and a similar number did participatory modeling (six cases).

Methodological tools applied

A wide range of tools and techniques were used to support PSP. Group discussions were implemented in all cases, often in small groups (17 cases). Other common tools included individual reflections (11 cases), drawings (11), capturing ideas on post-its and index cards (10), mental models (nine), quantitative models or data about climate change or land-use change (nine), rankings of different issues (eight), interviews (eight) and maps (six). Less common tools (five cases) included collages, stock-flow diagrams, wall-mounted time-lines and fictional newspaper headlines.

Storylines were elaborated in almost all case studies through a combination of methods. Storylines were developed by participants (10 cases) or the research team (eight cases) and the storylines were spatially explicit, at least partly, in 10 of the cases.

Type of data analysis

In all cases, the research team analyzed data using qualitative analysis, through descriptive analysis and narrative development, while just under half the cases also carried out quantitative analysis. Quantitative analysis focused on assessing (and sometimes modeling) ES trends (e.g. #22), human wellbeing trends (e.g. #12), tendency of drivers of change (e.g. #8), as well as the analysis of policy responses (e.g. #10).

Presentation of results

Some case studies (11) presented the results of the PSP in a separate workshop with this specific aim while others presented results within the same workshop (four cases). For the different types of outputs to communicate results, see section 3.6.1. Most cases performed some kind of validation or plausibility check of the scenarios, either by workshops (nine cases) or within larger meetings that other stakeholders attended (four cases). In seven cases a draft of scenarios was sent to particular stakeholders to receive comments for validation.

Uncertainty and vulnerability

Uncertainty is inherent to scenario planning but only 16 cases mentioned it explicitly during the PSP, usually in the analysis of drivers of change. Vulnerability was explicitly analyzed in 14 cases, through the analysis of ES trends (10 cases), stakeholders' vulnerability (five cases), and in some cases specifically through vulnerability with regards to food security (seven cases).

Content of scenarios

Guidelines and scenario names

To aid in developing the scenarios, most cases (18) provided participants with guidelines and 12 cases used focal issues and drivers. The MA (2005) and MedAction (Kok et al. 2007) were sources of inspiration in four cases (Appendix 6).

Titles of the scenarios were chosen by researchers or by participants. Fifteen cases had four scenario names, ranging from the commonly used best future to business as usual (BAU), and one or two somewhere in between. Examples of names given by participants were: 'Doom and Gloom', 'A Confused State', 'Slow Boil' and 'New Mombasa'. Some examples of scenario names given by researchers were: 'Privatization and Urban Solutions: Don't stop me now', 'Rising Fences: Another one bites the dust', 'Market forces: reallocation of resources', 'Less is more', 'Caos', 'Grand transitions: a new paradigm of sustainability', 'Rural-urban migration', 'A double-edge', 'Back-to-the-future: Transhumance moves', 'Our land, their wealth, 'Balance brings beauty', 'Enjoyment Brings Misery', 'Smiling West', 'Shaky future', 'What's Ours is Yours', 'Adaptive Doñana - Wet and Creative',

Variation in the scenarios' content

The content of scenarios in eight of the cases varied according to mixes of two main factors (related to the drivers) in each scenario. For example, case study #7 presented 10 scenarios that mixed various extents of intensive land use vs. management for a range of other ES, with landscape planning and management being the key issues addressed. Case study #8 presented four scenarios that mixed various extents of traditional land use vs. population growth and development, with forest conservation being the key issue addressed. While the case studies that presented scenarios based on mixtures of two main factors were highly diverse, they were all essentially variants of conservation or sustainable management vs. unfettered growth or industrialization/mining, with a range of issues being addressed throughout the variations (Appendix 6 [8 i]). Seven cases included scenarios that varied their content according to mixes of three main factors in each scenario. For example, case study #11 presented two scenarios with a mixture of varying extents of real estate development vs. agricultural intensification vs. habitat conservation, with biodiversity being the key issue addressed (Appendix 6 [8 ii]). Half of the cases using mixes of three main factors introduced a contrast between locally-driven vs. globally/externally-driven (e.g. # 15, #21 and #23). Seven cases varied according to mixes of four or more main factors in each scenario (Appendix 6 [8 iii]) of which four introduced an explicit governance dimension (cases # 4, #10, #17 and #19).

Topics discussed in the PSP

Thirteen case studies discussed ES provision in the different scenarios (Fig. 2E; Appendix 6). When ES were explicitly addressed, the Millennium Assessment list of ES was sometimes provided to participants and certain ES were used in discussions and subsequent models. In the cases in which ES were not made explicit, certain ES appeared in the storylines. In other cases the scenarios were created around values (e.g. intrinsic value of nature) rather than ES.

Almost all cases (21) discussed biodiversity topics (Fig. 2E; Appendix 6), either explicitly e.g. through a model output for biodiversity (or involvement of stakeholders that explicitly represent biodiversity), or only implicitly, e.g. through biodiversity related drivers that were discussed in the context of the SES.

All except two cases discussed human wellbeing via one or more variables (Fig. 2E; Appendix 6). When human wellbeing was made explicit, it commonly focused on livelihoods. Otherwise, poverty alleviation, social development goals or employment were mentioned.

All cases dealt with trade-offs among different social-ecological components, though in different ways (Fig. 2E; Appendix 6). The explicit trade-offs tended to be between winners and losers in relation to the use of ES, between development and wellbeing, between scenarios, or between ES and

human well-being. When trade-offs were not addressed explicitly, they featured strongly in the narratives and emerged during discussions.

Outputs

Types of outputs

The majority of cases (20) produced creative or artistic outputs (Fig. 2F; Appendix 7) such as collages, drawings, or illustrations to visualize the scenarios and facilitate the PSP process (Fig. 4). Illustrations, for example, included timeline illustrations, colorful drawings depicting scenarios, cartoons and oil on canvas paintings. In one case, the process of creating collages (#22) activated the groups and allowed other people that were less willing to speak, to participate in another "language".

[INSERT FIGURE 4 ABOUT HERE]

Beside artistic outputs, a wide variety of outreach material was produced in the case studies including posters (15 cases, Fig.4C,D), reports (23), scientific journal articles and books (21), leaflets (5, Fig.4A), postcards (5, Fig.4B) and videos (10) (Fig. 2F). Other outputs mentioned were cartoons, animations, game boards, newspaper articles, radio interviews, a TV show and a children's book.

Process and target audience for outputs

All of the PSP study cases produced outputs to communicate the results of the scenario project to different audiences, especially local communities (19 cases), academic audiences (16 cases), participants (15 cases) and policy and decision-makers (15 cases) (Appendix 7). In addition to developing outputs for communication purposes, the creative process itself offered alternative ways to engage with stakeholders. One case (#17) used the scenario outputs to inform later interviews with a different set of stakeholders and at another scale.

Monitoring and evaluation

Monitoring of PSP impacts

Monitoring of PSP impacts (i.e. systematic collection of data to track the extent of progress and achievement of outcomes and impacts using indicators, Appendix 8) was performed in 11 cases (Appendix 9), either solely within the project timeframe (8 cases) or also extending beyond the project timeframe in three cases (which were led by the same research team). An equal number of cases identified their reasons for monitoring as a contractual obligation, to assess learning, or to assess outcomes.

In about half of cases monitoring was impossible due to constraints of time, personnel or finances (11 cases, Appendix 9). In two cases (#3 and #21) monitoring was not necessary or important to the goals of the PSP. Two cases (#14 and #23) found it impractical to monitor because it was too early or because detecting impacts seemed intractable.

Evaluation

Evaluation (i.e. assessment of the scenario design, implementation and results through a formal methodological approach) was conducted in 15 cases by a range of different methods including interviews (nine cases), surveys (eight cases) and observation (four cases) (Appendix 9). As with monitoring, resource constraints were the main reason for the lack of evaluation of the scenario planning exercise in nine cases. In five case studies it was too soon to evaluate the effects of scenario planning.

Assessing participants' learning was the top reason for conducting evaluations (six cases) followed by assessing the usefulness of the process, and providing feedback to the research team. Note that these two objectives were inter-related (i.e. assessment of process can also include an assessment of social learning), but we were not able to infer whether any case studies intentionally addressed both.

Outcomes and impacts

The majority of cases (20) did not formally evaluate, and correspondingly did not detect evidence of outcomes or impacts (Appendix 9). However, in all these cases informal evaluations were undertaken. Strong and moderate evidence of short-term impacts was found in some cases that did not undertake a formal evaluation (six cases), but strong evidence of long-term impacts was found exclusively in two cases (#18 and #19) undertaking a formal evaluation. There is strong evidence of either short- or long-term impacts in seven cases, of which five are the formally evaluated case studies, suggesting that with structured evaluation processes the other case studies may have discovered that they had in fact generated more profound effects.

Strengths and weaknesses

The most commonly identified (21 cases) strengths of PSP processes were related to the added value of engaging stakeholders actively in the research process and to the technical and methodological advantages of developing participatory workshops to explore feasible futures (19 cases) (Appendix 10). Among the weaknesses, the most frequently reported dealt with the technical development of the PSP processes (20 cases) and the quality of results (15 cases).

Stakeholders' engagement

PSP's strengths were generally attributed to their potential as a research tool to engage a wide diversity of stakeholders (i.e. women, men, young, old, local people, researchers, etc.) in a knowledge sharing process that ultimately led to a shared understanding of the social-ecological system, its dynamics, and future management challenges. Such a process was referred to as social learning or mutual learning in 13 cases (Appendix 10). The creation of partnerships among different stakeholders (including researchers) was also identified as a strength in 11 cases. In addition, involving participants in the process raised awareness of local management challenges-overcoming initial skepticisms-and of the relevance of taking action in local planning (five cases). In four cases participants' engagement also led to an increase in social cohesion at the community level and involved community members who usually had been excluded from decision-making (e.g., women, young people).

Nevertheless, some weaknesses in terms of stakeholder engagement were highlighted. The lack of diversity of stakeholders and the continuity of their involvement were recognized as constraints for the success of the participatory process (8 cases). Power relations between stakeholders are inherent in every SES so when the process fails to incorporate someone's voice, these relations and inequities might be hidden. Eight cases in fact reported limitations due to the low representativeness or absence of powerful stakeholders (e.g. industry, big landowners) and decision-makers that undermined the credibility of the process. Five cases reported biases due to the researchers' authority and voice undermining ownership of the process by stakeholders as a weakness. In three cases (#2, #3 and #4) the absence of powerless actors and especially gender discrimination in participation were reported as weaknesses because of the potential underrepresentation of power asymmetries. In two cases (#8 and #16), cultural barriers relating to indigenous people were pointed out as explanatory factors of limited engagement.

Technical development

The methodological and technical design of the PSP was key in engaging stakeholders in the process. Facilitating discussions among stakeholders on the drivers of change in each scenario and how to respond to them was the strength most frequently perceived (nine cases). Other strengths mentioned in this sense were: 1) the adaptability and dynamism of the design and the use of multiple approaches during the workshops; 2) the adoption of a systematic and/or interdisciplinary approach; 3) the exploration of comprehensive drivers, trade-offs (winners and losers) and values; and 4) the previous training of facilitators in scenario exercises.

However, some of the constraints for the success of PSP were related to the methods and tools used. In 11 cases PSP was recognized as expensive, not only in economic terms, but also in terms of time and energy consumption. Nine cases cited the lack of quantitative information, statistical and

data-based testing or modeling to support trends analysis as weaknesses. Five cases reported as a relevant weakness the unavoidable trade-off between the accuracy requested by the science base (which includes high complexity of scientific information) versus the social relevance of the process. In fact, some authors recognized that the methodological choices sometimes reflected the research purposes rather than the social learning objectives. In a few cases, linguistic and cultural barriers (three cases) as well as logistic and facilitation problems (six cases) hampered the process.

Outcomes

Nine cases highlighted the strong policy relevance of the findings and outcomes, since scenarios were used to discuss and guide implementation of potential adaptation strategies. In seven cases the inclusion of a diversity of worldviews in the results was mentioned as a strong direct added value of PSP. By contrast, in five cases, authors reported that the preferences, cultural attitudes or background of some participants or researchers might have biased the understanding of drivers (e.g. farmers' belief in fate's role shaping their daily life) and the way of thinking about the future (e.g. indigenous understanding of time and the future). The substantive results of the scenario analysis was perceived as too polarized in three cases and/or repetitive and limiting creativity and novelty in four cases due to the excess of guidance by researchers. A poor incorporation of drivers of change or indicators (e.g. for wellbeing analysis) were recognized as key weaknesses in five cases.

Similarities among case studies and associations between objectives, methods and lessons learned

Variables associated with methodological procedures were selected for the MCA (for the definition of the variables see Appendix 1). The first three axes presented an inertia above 0.15 and together explained 69.0% of the total variance (F1: 50.2%; F2: 12.2%, F3: 6.6%) (Appendix 10). The HCA of these three axes identified four groups of PSP studies, characterized by the particular techniques and methods used (Fig. 5). Cluster 1 corresponded to those case studies that performed desirability and vulnerability analysis, variables that are basically associated with negative scores of F1and positive scores of F3, respectively. Cluster 2 is characterized by those PSP exercises that identified stakeholders and drivers of change before workshops, and developed back-casting during the participatory process. Cluster 2 is associated with positive scores of F1. Cluster 3 is comprised by those case studies that identified direct drivers of change prior to PSP and explicitly included uncertainty, being associated with positive scores of F2. Finally cluster 4 is characterized by case studies that used modeling as a quantitative technique after the workshop and monitoring processes, being associated with negative scores of F3. The abovementioned characteristics of each cluster are however not exclusive of the cases that are grouped under that

cluster.

[INSERT FIGURE 5 ABOUT HERE]

These results seem to indicate a connection between motivations for performing PSP, specific methods used and lessons learned in terms of learning process, stakeholder relationships fostered and management outcomes (Fig. 5 and Fig. 6). For example, cases of cluster 1 explicitly analyzed vulnerability in order to broaden the thinking of social actors about social-ecological systems and they also identified the stimulation of creative and complex thinking as a strength. Cases of cluster 2, through performing back-casting, aimed to understand the social and institutional mechanisms behind management decisions and they recognized insights for landscape management as a positive outcome . Cases of cluster 3 that explicitly incorporated uncertainty aimed to promote community-based solutions and recognized as a positive outcome to have engaged social actors that are unrepresented in decision-making. Finally, cases of cluster 4 aimed to facilitate sharing experiences among stakeholders in a creative and collaborative way. In this cluster, a complex understanding of the current situation and the co-learning process between scientists and non-academic stakeholders were highlighted by researchers as positive outcomes.

[INSERT FIGURE 6 ABOUT HERE]

DISCUSSION: LESSONS LEARNED

Across the diversity of PSP cases reviewed in this paper and the experiences of the involved researchers, three main questions were addressed: How was PSP useful to participants and researchers? How did PSP contribute to decision-making? And what are common methodological challenges for PSP? We discuss each of these questions below, before concluding with some recommendations for the future research of PSP.

How was PSP useful to participants and researchers?

This review demonstrates that PSP almost always has a process function that promotes stakeholders' active engagement in place-based social-ecological research that is or can be linked to environmental decisions. Stakeholders' engagement in this type of research is a benefit because it contributes towards improving the equity, legitimacy, and quality of environmental decision making. Involving stakeholders in the research process through place-based PSP provides voice to multiple perspectives on social-ecological futures (Ravera et al. 2011*a*, Reed et al. 2013*a*, Mistry et al. 2014), which can potentially reduce power asymmetries and provide more equitable decision making. By including stakeholder responses in scenarios and across scenarios, PSP can also potentially increase

the legitimacy and acceptance of policy options across stakeholders involved in a process (e.g. Peterson et al. 2003*b*, Bohensky et al. 2011*a*, *b*, Ravera et al. 2011*a*). Further, by including knowledge and information from a diversity of sources the quality of scenarios and identified policy options can be increased (e.g. Hill et al. 2010, Palomo et al. 2011, Ravera et al. 2011*a*, Vilardy et al. 2011, Martin-Ortega et al. 2014), and innovative strategies and opportunities for collaboration among multiple stakeholders can be identified (Peterson 2006, Butler et al. in press).

Many of the examined cases demonstrate how PSP processes succeeded in increasing dialogue, resolving conflicts, producing outputs that otherwise were not possible and enhancing multiple learning outcomes between stakeholders, researchers and policy makers in natural resource management planning (e.g. Ravera et al. 2011*a*, Hamann et al. 2012, Oteros-Rozas et al. 2013, Plieninger et al. 2013, Martin-Ortega et al. 2014; Fig. 6).

The scenario processes increased stakeholders' awareness of the existence of local and global drivers of change and threats, and the need for long-term planning to deal with such changes (Waylen et al. 2014). The scenario processes enabled collective reflections and discussions of potential policy options to deal with current and future environmental and socio-economic changes in SES. By enabling discussions and creating shared understanding, PSP can further facilitate mobilization of stakeholders to respond to newly identified threats or opportunities. New partnerships among actors might also be created or reinforced and new leaders emerge to address new issues of interest (Plieninger et al. 2013).

Finally, PSP can encourage complexity thinking (i.e. clusters 1 and 4) (e.g. Ravera et al. 2011*a*, Waylen et al. 2014), which is a key aspect of resilience (Biggs et al. 2015). By requiring participants to reflect upon and characterize their SES's internal dynamics, as well has how the SES interacts with external processes, the PSP enhances participants' social-ecological understanding, and integrates their qualitative, context-specific local knowledge of the system. Scenarios also engage participants in embracing uncertainty, surprises and contradictions (e.g. Oteros-Rozas et al. 2013, Butler et al. 2014*a*, Martin-Ortega et al. 2014). However, nearly half of the cases did not explicitly address uncertainty during the PSP. Greater attention to this aspect could enhance participants' learning.

PSP content and outcomes contributing to decision-making

By bridging multiple knowledge systems PSP can bring together and produce new knowledge for environmental decision making. PSP can enhance the ability of environmental decision making to engage with complexity. In our review the two dominant ways this occurred was first by exploring complex social- ecological trade-offs, and secondly by creating novel solutions. We outline each of

these benefits below.

PSP has proved to be an arena where multiple knowledge systems interact (e.g. Palomo et al. 2011, Ravera et al. 2011*b*, Oteros-Rozas et al. 2013, Reed et al. 2013*a*) to co-create a new understanding of the present situation and shared visions of possible future developments. PSP can provide a platform that supports stakeholders from different knowledge-systems by enabling communication and interaction in order to co-produce synthetic social-ecological knowledge as well as co-design new environmental management strategies (Martín-López and Montes, in press). The new Intergovernmental Platform of Biodiversity and Ecosystem Services (IPBES) plans to bring together different knowledge systems in its global and regional assessments to co-produce knowledge and design management strategies to face the challenge of biodiversity and ecosystem services conservation (Tëngo et al. 2014, Díaz et al. 2015). A participatory and interdisciplinary research process such as PSP can be seen as a parallel research process, helpful to complement and strengthen existing research based on non-participatory methods (Peterson et al. 2003*a*). Although, it is noticeable that PSP is a useful tool to explicitly combine local or traditional knowledge with technical knowledge (i.e. cluster 2; Fig. 6), greater attention to non-formal and indigenous governance may assist in effectively utilizing opportunities to engage multiple knowledge systems (Hill et al. 2012). This might be particularly important in regions of the world that are underrepresented within the group of cases assessed here, such as Africa and Asia.

PSP studies typically go beyond simplistic win-win assumptions (Daw et al. 2015). Rather, they acknowledge the multiplicity of ES, for instance, by explicitly considering the trade-offs around them. Trade-offs occur when the provision of one ES is reduced as a consequence of increased use of another service (Rodriguez et al. 2006), or due to certain practices or management techniques that enhance one ES while another one is decreased. They occur along various dimensions (Mouchet et al. 2014): 1) supply-supply (conflicts between simultaneously provided ES), 2) supply-demand (spatial or temporal lags between ES supply and social benefits), and 3) demand-demand (arbitration between different and divergent stakeholders' interests). In most of the cases reviewed here, a particular focus was set on different stakeholder groups that would benefit or lose from trends in ES supply in the respective scenarios, i.e. on demand-demand trade-offs. By this, PSP may foster the awareness for visible and invisible social conflicts and power relations around ES, which is an underdeveloped field in ES research (Sikor 2013). The inclusion of an explicit governance dimension in about half of our cases supports the usefulness of PSP to address key aspects of governance such as the influence of local vs. global-drivers of change; centralized government vs. collaborative governance; fragmented weak governance with and without innovators; and community vs. neoliberal orientations.

Another strength of PSP is that the participatory processes bring the research closer to a complex reality in order to support adaptive governance (Waylen et al. 2014.), as well as creativity, which is fundamental to promote resilience (Berkes et al. 2003) (see clusters 1 and 4, Fig. 6). On one hand, PSP leads to a focus on plausible futures to discuss concrete actions, strategies and policy options according to both scientific information, local knowledge and stakeholders' perceptions of SES and its dynamics (Daw et al. 2015). On the other hand, PSP outputs, for example in the form of images, video and storylines, are also attractive and useful tools to engage wider sections of society, as well as to invite reflections about the future from the public (Sheppard et al. 2011). Both pragmatism and creativity are fundamental to support adaptive governance and to promote resilience (Garmestani and Benson 2013). PSP's capability to bring governance discussion and learning to the fore is useful given the recognition that governance is both a key determinant of humanity's ability to respond to environmental change, and very challenging for a wide range of stakeholders to understand and incorporate in their analyses (Simon and Schiemer 2014). Furthermore, PSP provides data on locally perceived changes and impacts of possible futures that are useful in achieving a better and holistic understanding of the current, and future system's conditions and dynamics at local and regional spatial and political scales (Butler et al. 2014*a*).

Challenges and opportunities

Our review identified four widely shared challenges in conducting PSP. The first is the tension between explorative and normative analysis. The second is navigating conflict among diverse unequal stakeholders. Third is the challenge of communicating with a diverse group, and fourth the challenge of assessing impact.

PSP processes usually contain an inherent tension between explorative and normative analysis of SES dynamics. In our review, while we found that the most reported approach to PSP was strictly explorative (Fig. 2A), many of the scenario names suggest that normative judgments were important. Carpenter et al. (2006) follow much scenario practice (Wack 1985, van der Heijden 2000) in arguing that scenario planning is most powerful when a small set of scenarios explore clear and striking differences. Normative scenarios are distinctive in their portrayal of futures that "should be" (e.g. Opdam et al. 2002) and they can inspire policy by providing images of landscapes that could meet societal goals (Nassuer and Corry 2004). Value judgments clearly have a role in generating the vivid and distinct choices that Carpenter et al. (2006) advocate, and our analysis suggests that it would be helpful to more explicitly discuss and present these value-choices in the scenario generation. This is particularly important because most scenarios conducted here were funded and conducted as sustainability science projects that are explicitly not value neutral but pro-sustainability, and consequently have specific normative frameworks which are assumed rather

than articulated (Abson et al. 2014). Articulating values is important because it enables them to be discussed, and used in deliberation or comparison of alternatives. However, value-laden discussions are often emotionally charged and require substantial efforts to manage in an effective participatory process.

The diversity of stakeholders and their inherent power dynamics within a PSP process can also present challenges and requires substantial investment in facilitation (Butler et al. in press). In these case studies PSP has usually been built upon previous research within the study region that has identified multiple actors shaping and impacted by the region's dynamics, which may explain the high diversity of stakeholders considered (Fig. 2D)(Kok et al. 2007). However, even if stakeholders identified as relevant in the SES usually match the actors involved in the PSP, some frequently remain absent, particularly industry representatives and indigenous people, hence possibly misrepresenting power relations that can be important within the SES dynamics. Therefore, if the aim is to co-construct future scenarios and share the pros and cons of each of them among the stakeholders involved, to conduct a systematic identification of stakeholders relevant to the SES and matching those with actors invited to the PSP is highly recommended. In addition, the high diversity of stakeholders necessary for inclusive participatory processes can trigger the appearance of social conflicts.

Communicating PSP results is another challenge shared across scenarios. Due to the requirement of engaging with a diverse set of stakeholders, communication requires careful thought and substantial effort. We recommend different types of outputs, from the common scientific outputs (i.e., papers and technical reports which pursue the academic audience and environmental and development technicians, respectively) to those outputs that combine the arts and science, such as posters, drawings, illustrations or videos (Fig. 2F). For example, in 'The role of visual arts as a communication tool in scenario planning' session performed at the Resilience 2014 conference in Montpellier (for more details, see http://ideas4sustainability.wordpress.com/2014/05/08/the-role-of-visual-arts-as-a-communication-tool-in-scenario-planning/), it was highlighted that artwork not only served as a tool for communicating PSP results, but also as a tool for facilitating communication among different stakeholders groups during the PSP process and afterwards. However, the role of art in PSP could be further explored and the results assessed.

While a goal of PSP is to promote action, it is challenging to produce evidence that PSPs have actually lead to management actions, new partnerships and collaborations between stakeholders, or social learning processes. This gap exists both because identifying the impact of interventions is difficult and our sampling strategy within the 23 case studies might not have been sufficient to record all outcomes, but also because monitoring and evaluation stages were largely missing in the

cases we assessed. The extent to which scenarios achieve outcomes is highly variable and often unknown due to a lack of formal mechanisms to evaluate outcomes (Fazey et al. 2014) and to the potential time lag between the end of the exercise and the delivery of certain outcomes. Thus broad claims of attribution between PSP and impacts cannot be clearly substantiated. Adopting an explicit adaptive management approach (Peterson et al. 2003*a*) or articulating a theory of change (Butler et al. in review) might assist with embedding PSP within larger and longer term projects that may help researchers to plan their projects and then formally evaluate their outcomes and impacts (Table 2). This would also facilitate the comparison and contrast between experiences, and would therefore enhance the opportunity to learn from and refine PSP methods. Some tools and potential questions to ask for evaluation and monitoring of PSP are provided in Table 2. Particularly, systematic long term monitoring and evaluation of PSP in other studies has shown that this approach can generate social innovation, collective action and encourage transitions to sustainability (Butler et al. in press). Comparative studies that allow for an assessment of impacts as well as the pros and cons of different methods within PSP to develop scenario quality criteria are therefore needed (Vliet et al. 2012). Project timescales and budgets need to allow for evaluation and monitoring.

Future of Participatory Scenario Planning

Participatory social-ecological scenario planning is increasingly used to explore ecosystem services in alternative futures. Furthermore, given the expectation that IPBES will produce a variety of global, regional and local biodiversity and ecosystem service assessments, its practice can be expected to increase further. While such scenarios enable diverse and qualitative knowledge about ecosystem services to be combined with quantitative models, it is currently difficult to compare and build upon specific scenario processes as they are wedded to particular people, times, and places. Based on this review we believe that there are a number of practical guidelines which could promote good practice for PSP and its practitioners.

As discussed, conducting participatory social-ecological scenarios is challenging, time consuming, and requires integrating diverse types of knowledge. The success of PSP processes can be increased by recognizing the challenges associated with them and planning accordingly. Consequently, PSP processes should be designed for multiple iterations that maintain focus, but use multiple methods and approaches to elect and reflect people's definitions of system and theories of change. One of the ways of increasing the efficiency and policy relevance of this process is to build upon existing work, both in terms of future visions contained in official documents, other scenario processes, existing social-ecological networks, as well as existing ways that diverse stakeholders are connected to one another, through policy networks, NGOs, governments, education, or other social institutions. While all PSP processes should learn from previous work when starting a new project,

processes need to be planned for the particular social-ecological context in which it is occurring and be based on reflections about the potential consequences of every phase of the process for the participants and SES (Martín-López and Montes, in press).

We believe that the practice of PSP would be improved by building a community of practice that uses a portfolio of common methods, addresses shared issues, and shares results, methods, and challenges in a comparative way to improve the ability of PSP to bridge across scales and cases. The field of PSP is emergent, and connects many diverse actors across, within and outside of academia. Building such a community of practice should enable access to tools, ideas, and people. As such, PSP researchers should work on making their methods and results accessible, open access, and non-technical, but also be aware of other efforts that take a PSP approach. This paper is a step towards building such a community of practice, and we hope that both scientists and the larger IPBES community can act to promote the knowledge sharing, training, and translation that are needed to develop such a community.

CONCLUSION

PSP is an increasingly used approach in place-based social-ecological research, and has been applied with a wide diversity of methodological approaches, processes, outcomes and outputs. Across the 23 case studies assessed here, PSP enhanced stakeholder engagement and supported the diversity, equity, and legitimacy of environmental decision making. PSP also improved the quality of dialogue among stakeholders with complementary types of knowledge and has the potential to support creativity and social innovation. PSP also created new local understanding of the impacts of global and local environmental change that has the potential to lead to new partnerships among stakeholders. Finally, PSP also enhanced complexity thinking among participants, especially the ability to embrace uncertainty, surprise and contradictions. In addition, the scenarios produced by PSP can be disseminated to trigger engagement and reflection among the wider public.

However, despite these benefits PSP is time consuming and subject to particular challenges. First, balancing the normative and explorative aspects of PSP requires careful reflection of what values are being promoted or suppressed. Second, systematic short term process combined with evaluation and long term monitoring of impacts is often difficult since people and resources are rarely available for long term commitment. Third, the design of a PSP process needs to fit scientific goals as well as the local social-ecological context, the different types of knowledge and the way they are integrated.

Participatory social-ecological scenarios are increasingly used to explore ecosystem services in

alternative futures. Based on this review of cases, we believe that this method has enriched environmental management and improved scientific understanding. To improve the future success of PSP, including those evolving within IPBES, we suggest that scientists and practitioners engaged in PSP should be more self-aware and build a community of practice to improve the quality of individual PSP processes, as well as provide a platform for diverse, new groups of people to conduct PSP processes that build on and improve current methods, tools, and processes. We hope that this comparative assessment is a first step towards building such a community.

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Table 1. List of case studies analysed

Number #	Location	End year of PSP	Contributed by	Reference(s)
1	Canada, southwest Yukon Territory	2011	Dylan Beach	Beach and Clark 2015
2	Germany, Swbaian Alb, Römerstein and Owen municipalities	2012	Tobias Plieninger	Plieninger et al. 2013
3	South Africa, Eastern Cape Province	2012	Maike Hamann	Hamann et al. 2012
4	Mexico, State of Oaxaca, Community of Santiago de Comaltepec	2014	Kerry Waylen & Julia Martin-Ortega	Waylen et al. 2014, Waylen et al., under review
5	Colombia, Valle de Cauca, Buenaventura, Communities of Alto y Medio Dagua, and Calima.	2014	Kerry Waylen & Julia Martin-Ortega	Waylen et al. 2014,
6	Argentina, Monte Hermoso-Bahia Blanca Estuary region, Bahia Blanca, Punta Alta and Monte Hermoso.	2014	Kerry Waylen & Julia Martin-Ortega	Waylen et al. 2014,
7	England, Peak District National Park and Nidderdale Area of Outstanding Beauty; and Scotland, Galloway	2010	Klaus Hubacek	Reed et al. 2013*a*, Reed et al. 2013*b*
8	Bolivia, Beni, Pilon Lajas Biosphere Reserve and Indigenous Territory, Tsimane' communities of Alto Corolado and San Luis Chico	2014	Isabel Ruiz-Mallén	Ruiz-Mallén et al. under review.
9	Guyana, North Rupununi (District 9)	2012	Jay Mistry	Mistry et al. 2014.
10	Nicaragua, Miraflor- Moropotente protected area, Department of Estelí, northern mountain region	2008	Ravera Federica	Ravera et al. 2011*a* Ravera et al. 2011*b*
11	Australia, Queensland, Mission Beach	2008	Rosemary Hill	Pert et al. 2010, Hill et al. 2010
12	Spain, transhumance in the Conquense Drove Road (CDR), Teruel, Cuenca, and Guadalajara provinces	2010	Elisa Oteros-Rozas, Berta Martín-López & Ignacio Palomo	Oteros-Rozas et al. 2013
13	Colombia, Coastal zone of Magdalena Department, Ciénaga Grande de Santa Marta	2010	Sandra Vilardy, Berta Martín-López & Elisa Oteros-Rozas	Vilardy et al. 2011

(con'd)

14	Australia, Great Barrier Reef region, Mackay Whitsunday Isaac NRM region	2008	Iris Bohnet	---
15	Romania, Southern Transylvania	2013	Jan Hanspach	Hanspach et al. 2014
16	USA, Wisconsin, Northern Highland Lakes	2003	Garry Peterson	Peterson et al. 2003*b*
17	Kenya, Coast and nearshore waters of Mombasa, Nyali landing site	2012	Tim Daw	Daw et al. 2015
18	Indonesia, Nusa Tenggara Barat	2012	Erin Bohensky & James Butler	Butler et al. 2011, Butler et al. 2012*a*,
19	Papua New Guinea, West New Britain	2013	Erin Bohensky & James Butler	Butler et al. 2012*b,c, d*
20	Australia, Torres Strait Islands	2014	Erin Bohensky & James Butler	Butler et al. 2012*e*, Butler et al. 2013, Bohensky et al. 2014*a,b*
21	Canada, eastern Ontario, Bonnechere River watershed	2012	Allyson Quinlan	Quinlan et al. in prep.
22	Spain, Andalusia, Social-ecological system of Doñana Protected Area	2009	Ignacio Palomo & Berta Martín-López	Palomo et al. 2011.
23	France, French Alps	2012	Sandra Lavorel	Lamarque et al. 2013; Lamarque et al. 2014

Fig. 1. World map of biomes (Olson, 2001) indicating the location of the 23 case studies explored

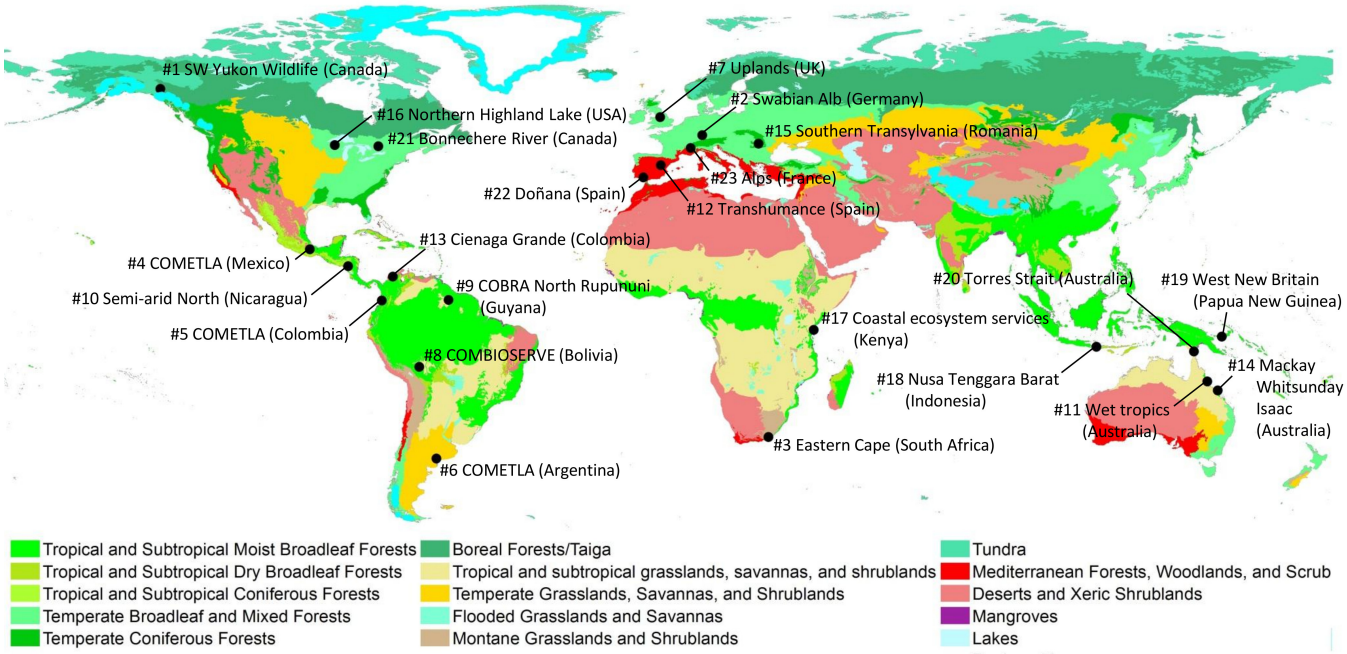


Fig. 2. Histograms of the number of cases in each category of A) objectives, B) background information, C) number of participants, D) stakeholders' diversity, E) topics' discussed, and F) outputs.

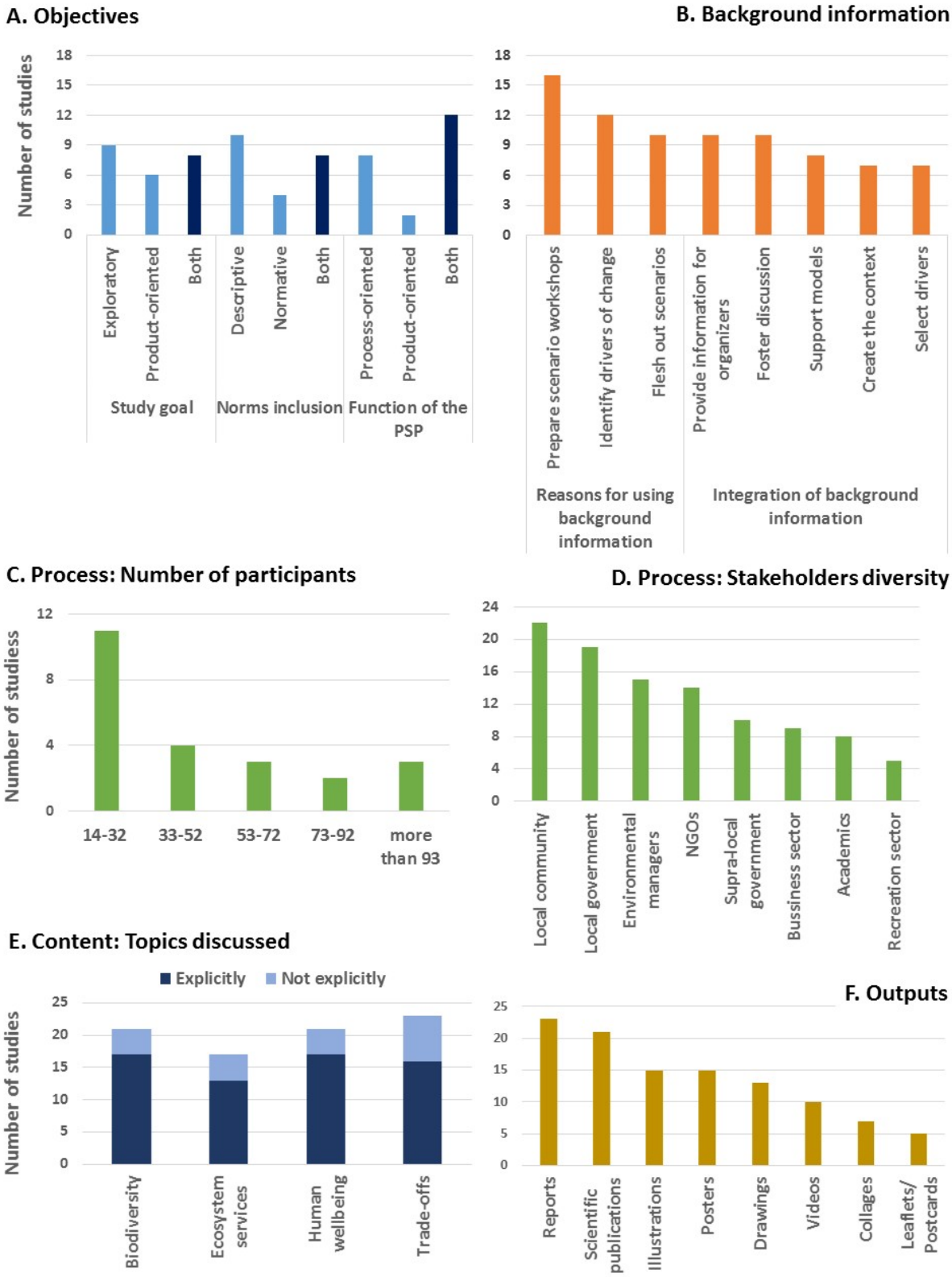


Fig. 3. Photographs from PSP processes in four case studies (#10, #13, #17, #22).

Fig. 4. Examples of outreach material used for communicating scenarios results: (A) leaflet of the Ciénaga Grande of Santa Marta case in Colombia (#13); (B) postcard of the Southern Transylvania case in Romania (#15), (C) poster of the drawing of the fours scenarios of the Papua New Guinea case (#18) and (D) poster of the social-ecological system of Doñana Protected Area case in Spain (#22).

Fig. 5. Clusters resulting from the HCA with the corresponding names of the case studies.

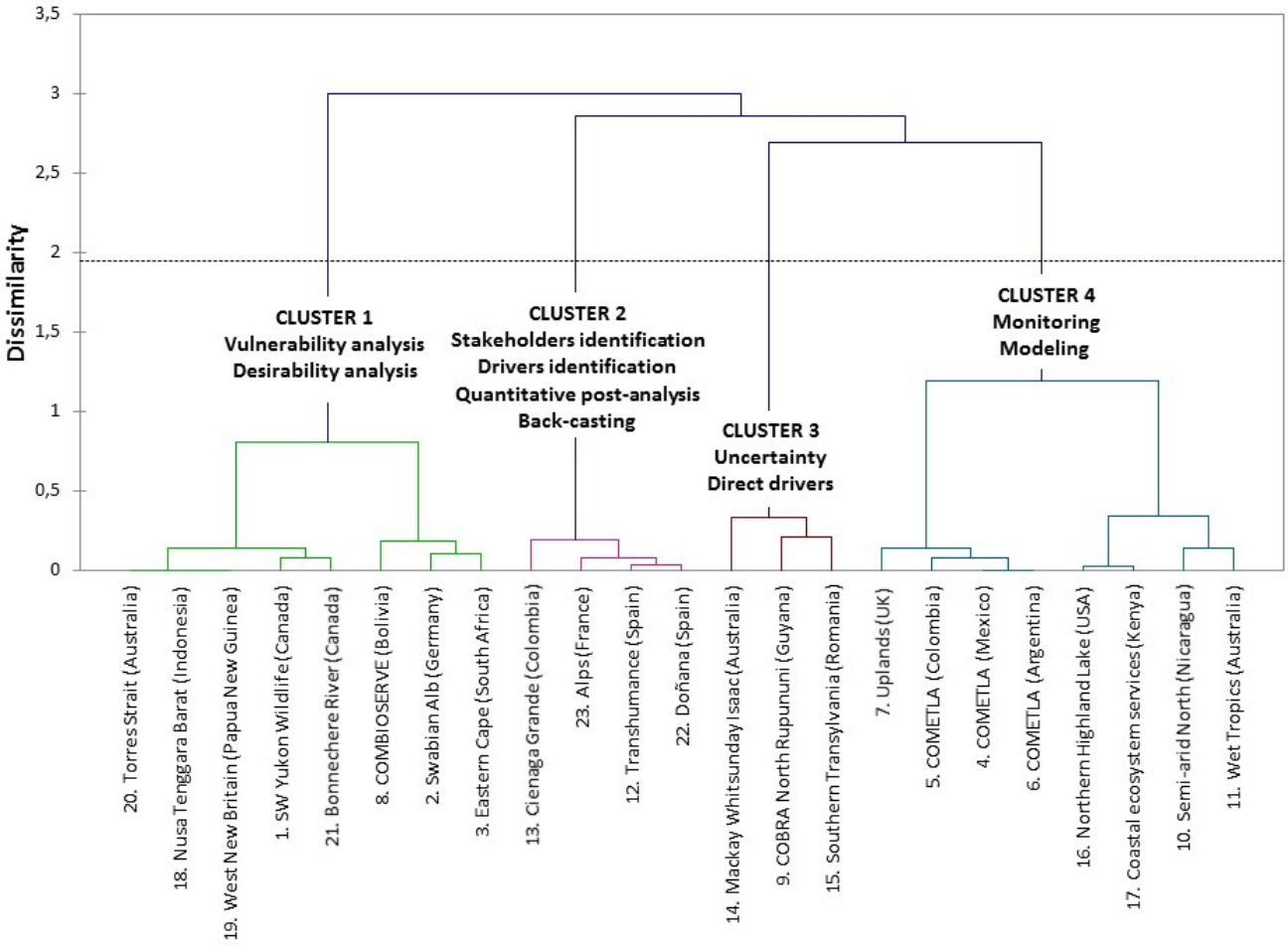
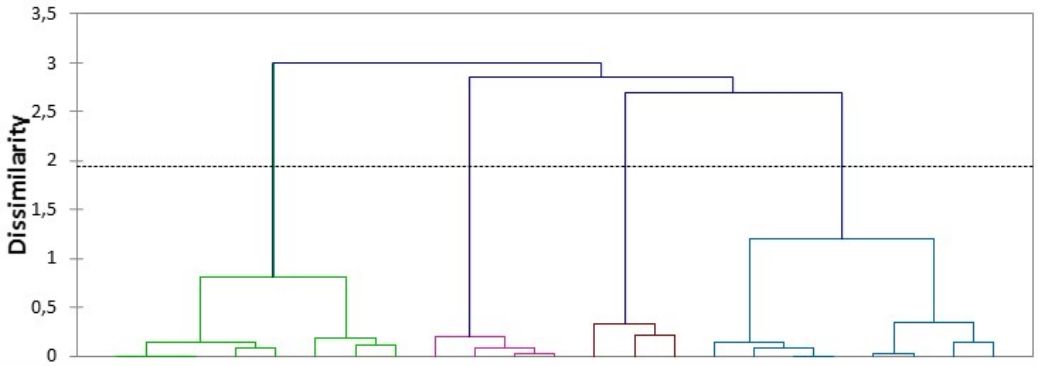


Fig. 6. Clusters resulting from HCA and the related motivation for the PSP process and the strengths identified in each group of case studies.



		Cluster 1	Cluster 2	Cluster 3	Cluster 4
ORIGINAL MOTIVATION FOR PERFORMING PSP		• To generate social learning and knowledge integration amongst multiple stakeholders • To broaden thinking about biodiversity and landscape management	To explore the social and institutional mechanisms underpinning management decisions	• To raise awareness of drivers of change • To promote community owned solutions	• To facilitate the sharing of experiences in a creative and collaborative way • To increase the resilience of governance systems to future changes in the communities
STRENGTHENS	**Learning process**	• Creative thinking • Systems thinking	Dialogue between local knowledge and technical knowledge	Process help to engage women and youth to share visions for the future	• Complex understanding of current situation • Co-learning process between science-society
	Fostering relationships among social actors	New relationships among stakeholders were fostered	Relationships between scientists, local stakeholders and managers were strengthened	Power asymmetries were balanced	Understanding of different stakeholders' viewpoints
	Management outcome	Shared vision about the desired future	Landscape planning		Provide space for discussing about future social change

Appendix 1. Variables explored in all case studies.

Features	Variables	Description
0. Case details	Case study / Title	Please give a title to your case study
	Contributed by	Name of person(s) who filled out this survey?
	Role of contributor	What role did the person(s) who filled out this survey have in the process?
	Reference(s)	DOI or URL of any documentation of the scenarios
1. Context and case identity	Location	Country + area/state/region, village/city/municipality/community
	Scale	At which scale were the scenarios created (e.g., local community, municipality, watershed, regional)? Did you explicitly include processes at multiple scales?
	Definition of scale and boundaries	How were scales and boundaries of system defined? Who defined them?
	Ecological context	Please indicate what is the ecoregion according to Olson, et al. 2001. Terrestrial Ecoregions of the world: a new map of life on Earth. Bioscience 51(11):933-938. What are the main ecosystems present in the SES? Is it included or are there protected areas? If so please indicate name and type of protection.
	Governance/Institutional context	What are the most relevant institutions operating in the SES? (e.g. community council, community non-paid activities, guerrilla and/or paramilitarism, municipality, watershed management institution, regional government, National Park, NGOs, European Common Agricultural Policy, mining/fishery/timber/meat market, REDD+/PES schemes, etc.). This might

	be extremely complex but we do not seek for a detailed institutional description of the SES, therefore please refer to the most relevant institutions within the future scenario context in the study area, taking into account this information is meant to be useful mostly to discuss which kind of approaches might be useful in which institutional contexts.
Socio-economic context	What are the main livelihoods/economic sectors in the SES?
Focus of the scenario planning	Was there a specific focus in the scenario planning? (e.g. Water management, transhumance, biodiversity conservation, problems/challenges, etc.). Distinguish between issue-based, area-based, and institution-based (van Noten et al. (20013)
Main stakeholders in the SES	What are the main stakeholders in the SES? Please specify from local/internal (e.g. the commoners, the mayor, the priest, the president of the shepherds association, the intermediaries buying the meat/timber, etc.) to external and/or global scales (e.g. external logging and mining companies, an international development cooperation agency)?
Definition of main stakeholders in the SES	How where these stakeholders identified and by whom?
Project (Research/Action) context	Was the scenario planning embedded on a wider project or a project on itself? What were the aims of the wider project? (e.g. to evaluate the ES provided by the social-ecological network related to the practice of transhumance, to identify sustainable community-based governance models for the management of natural resources, etc.) How long did the whole project last?
Resource for scenario planning	To what extent did scenario planning count on human and financial resources?

		Extensive (more than 50.000 euro, more than two people hired, more than one year) or limited (less that 50.000 euros, less than two people hired, less than one year).
	Year	When were the scenarios created?
2. Objectives	General objective	What were the overall objectives of the project/process? Please describe. Identify as: descriptive and/or normative, exploratory and/or pre-policy, process and/or product (van Notten, 2005).
	Specific objectives	What objectives had the research team in mind? E.g. scenarios were used to get people to think about relationships and possible future they haven't been including in decisions, to evaluate the robustness of alternative polices across different futures, to give policy insights, etc. What objectives had the stakeholders? Was there any process to build shared objectives?
	Motivation for choosing participatory scenario planning tool?	Why were scenarios chosen to be applied in this case?
3. Methodological approach	Background information sources	How was background information (e.g. Interviews, data bases, surveys… that support the scenario creation) obtained (sources and processes)? How was it used? What was the main reason for obtaining background information?
	Background information use	How did this information support the scenario planning? How was it integrated into the scenarios? (e.g. the drivers of change identified in previous interviews and surveys were used by the research team to select the 3/4 guidelines of each scenario, data about impact of climate change in the area was used as guidelines for scenarios,...). What motivated this

	choices? How long did it take from "data collection" to final scenario created?
Guidelines or examples used by team	Did the team base the process on previous processes or published guidelines? Where did they get inspiration from? Please add references if possible/necessary. What motivated this choice?
Process for the identification of drivers of change	E.g. Surveys, workshop, data bases, experts, research team… (non exclusive). What motivated this choice?
Use of the drivers of change to create the scenarios	How were the drivers identified used? What motivated this choice?
Number of drivers of change identified	How many drivers of change were identified? Were they ranked (e.g. According to their relevance, to the probability that they affect the SES, to the vulnerability of the SES to them, etc.)
Specific drivers of change identified	Please specify (direct and indirect). A direct driver unequivocally influences ecosystem processes. Important direct drivers include climate change, pollution, overexploitation, land conversion leading to habitat change, overexploitation, and invasive species and diseases. An indirect driver operates more diffusely, by altering one or more direct drivers. Important indirect drivers are changes in population/demography, economic activities, socio-political, scientific and technological, and cultural and religious factors (Millennium Ecosystem Assessment definitions).
Type of scenario design	e.g. A priori, driven by participants, with a modelling component, mixed approaches… What motivated this choice?
Criteria for prioritization of drivers	e.g. Vulnerability towards the driver, impact of the driver, likelihood of the

	of change as guidelines for scenarios	driver, uncertainty of the driver, capacity to exert influence on the drive… What motivated this choice?
	Time span (year projected)	What year was the end projection of the scenarios? What was the timespan of the scenarios? What motivated this choice?
	Number of scenarios designed	How many scenarios where created? Where there scenarios created that where not used in the end? Why? What motivated this choices?
4. Methodological process	Previous information given to participants involved in scenario design	Yes/ no. How/when was the information given? E.g. potential modelled impacts of climate change or depletion of resources in the area, influence of the focus practice (in the case of transhumance for instance) on the social-ecological system, brief history of scenario planning and its uses, etc.
	Previous relation of researchers with participants	What engagement did research team have with participants beforehand (e.g. information, scenario co-design, planning co-design with scenarios as part, etc.)
	Duration of the process	How long did the whole scenario process last? How long did the participatory scenario activity last? How many workshops were carried out? How many hours of work of participants? How much time passed between workshops if several? Did the same participants come to all the workshops (continuity)?
	Phases/structure of the participatory design of scenarios (scenario activity)	At what point were stakeholders brought into the process? In which stages of the process were participants involved? E.g. only envisioning, past+envisioning, envisioning+back-casting…
	Methodological tools for each phase during the scenario creation	E.g. Individual reflections, small group discussions, maps, miniatures, cards, collages, drawings, mental models, quantitative models…

Back-casting	Yes/no. How was the back-casting developed?
Presentation of results to participants	Yes/no. When and how were the results presented to participants?
Feedback (Validation)	Yes/no. Was there a validation of scenarios outputs by participants? I.e. were scenarios checked to see if participants/stakeholders thought they were credible? If so, how was it carried out? Who did it? Was this taken into consideration (e.g. scenarios updated)?
Storyline type	Qualitative/quantitative/mixed? How were the narratives built?
Storyline spatially explicit	Yes/no. How?
Storyline with intermediate time-frames	Yes/no. What timing?
Conflicts emerged	Were there any conflicts during the participatory process? Did conflicts emerged within/between commissioners/researches/participants/... ? Was the process designed to address conflicts? Did the participatory process help handling the conflicts? How were they handled? Were these conflicts recognised for the first time, or were there any previously-acknowledged conflicts? Did these conflicts affect the outcomes?
Process of participant's selection	How were participants selected (any specific method)? Who decided whom to invite? How were participants invited (email, telephone, letter, personal contact, news advertisement)? Did participants receive any compensation/reward for their participation? If so, what was it? Was there a limit to the number of

	participants?
Number of participants	How many participants were invited? How many participated? Min/Max group size.
Types of participants	Who was (not) invited to participate? Governance level of participants (e.g. Primary/secondary stakeholders, resource users or managers) Was any key stakeholder missing from the process? If so, why?
Number of facilitators	Number of facilitators and ratio of facilitators/participants
Types of facilitators	Were they the researchers or professionals? If the researchers acted as facilitators, were they trained? Did they have previous experience of scenario planning?
Post-workshop data analysis	How was the data obtained from scenario exercise analysed? What role played the research team? What role played the participants? E.g. summaries of storylines (when necessary, for example for a paper), analysis of semi-qualitative information such as trends of ES in the scenarios analysed (e.g. represented in graph), weighted ranking of measures/actions suggested in the back-casting according to the quantitative priority participants have given them...
Uncertainty	Was uncertainty explicitly addressed during the process? If so, how?
Vulnerability	Was vulnerability explicitly addressed during the process? If so, how? E.g. In the evaluation of the scenarios, we addressed the trend followed by ES , the trend in different dimensions of human well-being, the food security of the SES and the vulnerability of the SES in each scenario.

	Desirability	Was desirability explicitly addressed during the process? If so, how? (e.g. was there a completely desired scenario, without guidelines?)
5. Content of scenarios	Guidelines given	If you gave a few guidelines of each scenario from which the participants had to develop the rest of it, what were the guidelines of each of the scenarios? Or you were inspired ("hardly or softly") by previous general/high-level scenarios, please also refer to them.
	Scenario names	Names of each scenario. If there were names given by the research team and names given by participants, please mention both making the difference. How were the names chosen?
	Characteristics of storylines	Briefly summarize each scenario (50 words per scenario)
	Ecosystem Services	Were ES explicitly discussed or was the ES framework somehow used? Yes/no. If so, how? (not all cases might have explicitly addressed ES)
	Biodiversity	Was biodiversity explicitly addressed? Yes/no. If so how? (e.g. Conservation, challenges…)
	Human well-being	Was human well-being explicitly addressed? If so how?
	Trade-offs and synergies	Did the process explicitly explore trade-offs and synergies with participants? Of what? (e.g. between action/policy insights, ecosystem services, human well-being dimensions...)
6. Outputs	Collages	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in

	process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
Drawings	Yes/no. How? Why (motivation to do it)? Who?
Leaflets/postcards	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
Posters	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
Scientific publications	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
Reports	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
Illustrations	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the

		community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
	Videos	Yes/no. How? Why (motivation to do it)? Who did them? Did participants collaborated in the production? If so, how? What was the target: a) the community/stakeholders involved in process? b) external stakeholders relevant to the system e.g. policy? c) scientific audiences?
7. Outcomes	Monitoring of evolution/impacts	Yes/No. How was/is/will be the monitoring developed? What are/were/will be the metrics of success? Who does/has done/will do the monitoring?
	Short-term impacts on local and wider scales	What are/have been the impacts on the local/wider scales in the short term? How were the scenarios used by participants? Has there been any implementation of the scenario results (and therefore an impact in decision-making)? Has there been a process of learning by stakeholders (e.g. making them more oriented to long-term thinking or willing to integrate uncertainty in future thinking/planning)?
	Long-term impacts on local and wider scales	What are/have been the impacts on the local/wider scales in the long term? How were the scenarios used by participants? Has there been any implementation of the scenario results (and therefore an impact in decision-making)? Has there been a process of learning by stakeholders (e.g. making them more oriented to long-term thinking or willing to integrate uncertainty in future thinking/planning)?
	Evaluation	Was there any evaluation of the approach/process of scenario planning?

		What were the criteria/questions used to evaluate? How (methods used) was the evaluation done? Who did the evaluation (only internal within researcher or with participants?)?
8. Lessons learnt	Weaknesses/Limitations	Please mention at least five weaknesses of your approach and process
	Strengths/Potentials	Please mention at least five strengths of your approach and process. E.g. Did the scenarios act as an effective boundary object? Did they lower knowledge asymmetry? Did they build community cohesion?
	General reflections on what scenarios added to this process/project	Perhaps a free text field. This might flag up some fruitful ideas for the discussion. E.g. Has the project enabled system thinking? Did it help build consensus? Changes on collective thinking on the governance system?
	Key insights	
	Other comments	E.g. Did the scenarios act as an effective boundary object? Did they lower knowledge asymmetry? Did they build community cohesion? Was there a tendency for scenarios to gravitate to extremes/simplifications, perhaps due to cognitive biases?

Appendix 2. Case context and identity.

	% of case studies	N
1. Geographical spread and Ecoregions		
World regions		
Latin America	30	7
Europe	26	6
North America	13	3
Australia	13	3
Africa	9	2
Asia	9	2
Ecoregions and protected areas		
Tropical and subtropical moist broadleaf forest	30	7
Tropical and subtropical dry broadleaf forest	9	2
Tropical and subtropical coniferous forest	4	1
Temperate broadleaf and mixed forest	17	4
Temperate coniferous forest	9	2
Boreal forest/taiga	4	1
Tropical and subtropical grasslands Savannahs and shrub lands	13	3
Temperate grasslands, savannahs and shrub-lands	4	1
Flooded grasslands and savannahs	4	1
Montane grasslands and shrub-lands	13	3
Tundra	0	0
Mediterranean forest, woodlands and shrubs	13	3
Desert and xeric shrublands	4	1
Mangroves	4	1

Case study includes protected area	70	16
2. Scales and boundaries		
Scales		
Type of scale (0 = admin; 1 = natural feature)	43	10
Includes local scale	91	21
Includes regional scale and higher	43	10
Multi-scale explicitly addressed	26	6
Boundaries		
Boundaries determined by natural features	43	10
Political boundaries	48	11
Boundaries specifically selected for the research, i.e. neither political nor natural	39	9
3. Governance and institutional context and livelihoods		
Stakeholders part of the governance setting		
Supranational governmental institutions (e.g. international organizations, EU, international trade agreements)	35	8
National & regional institutions involved	87	20
Local & municipal government involved	96	22
Community councils, tribal & indigenous organizations involved	70	16
Conservation groups, NGOs, co-management groups, Natural resources management regulatory agencies (incl. park authorities)	96	22
Resources industries (fishing, mining, palm oil, etc.)	61	14
Criminal groups and guerrilla	9	2
Economic sectors		
Resource industry (fishing, mining, palm oil, timber)	48	11

Services sector (including trade and tourism)	78	18
Agriculture	87	20
Subsistence economy; strong dependence on subsidies	39	9
Illegal economic activities	17	4

4. Background information on the scenario process

Focus of the scenario process

Issue-based only (includes institution-based) (0 = other than issue based or issue based and other, 1 = only issue based)	43	10
Area-based only (0 = other area based or area-based and other ; 1 = only area based)	13	3
Both issue and area based	43	10
Type of issue-based (conservation, biodiversity, wildlife) (0 = no conservation focus, 1 = yes)	52	12
Type of issue-based (natural resources management, development and climate change adaptation) (0 = no management focus, 1 = yes)	83	19

Main stakeholders involved in the scenario process

Main stakeholders involved in the scenario process includes national government	30	7
Main stakeholders involved in the scenario process includes regional government	48	11
Main stakeholders involved in the scenario process includes local government	52	12
Main stakeholders involved in the scenario process includes community council, tribal indigenous leaders	70	16
Main stakeholders involved in the scenario process includes co-management groups, NGOs, natural resources agencies	87	20
Main stakeholders involved in the scenario process includes resources industry	48	11
Main stakeholders involved in the scenario process- other stakeholders	13	3

Who/how stakeholders were identified		
Identification and classification by researchers only (0 = not by the researcher or by researchers with input from others, 1 = by researchers only)	39	9
Jointly identification with (or input from) local stakeholders (0 = identified without input from stakeholders, 1 = with input form stakeholders)	61	14
Specific method was used for identifying stakeholders (e.g. network analysis, snowballing, etc.)	48	11
Project and resources		
Part of larger project	91	21
Resource for scenario planning (0 = limited; 1 = extensive)	61	14
Were resources enough for achieving goals	91	21
End year of the study		
2014	26	6
2013	9	2
2012	30	7
2011	4	1
2010	17	4
2009	4	1
2008	4	1
2003	4	1

Appendix 3. Subject and objectives of the PSP exercise.

		% of case studies	N
1. Objectives according to van Notten's (2003) typology			
Goal			
	Only exploratory	39	9
	Only pre-policy	26	6
	Exploratory and pre-policy	35	8
Values			
	Only descriptive	46	10
	Only normative	18	4
	Descriptive and normative	36	8
2. Objectives according to categories emerging from our data			
	Complementary research	22	5
	Awareness raising	13	3
	Social learning	26	6
	Decision support	39	9
Goal			
	Only exploratory	39	9
	Only pre-policy	26	6
	Exploratory and pre-policy	35	8
Values			
	Only descriptive	46	10
	Only normative	18	4
	Descriptive and normative	36	8

Function			
	Only as a process	36	8
	Only as a product	9	2
	Process and product	55	12

APPENDIX 4. Methodological approach.

Appendix 4. Methodological approach.

	% of case studies	N
1. Background information source		
Was background information collected?		
Yes	100	23
When was background information collected (one case collected information both before and after)?		
Before	87	20
After	17	4
How was background information collected?		
Desk research (e.g. literature search, public sources, census data)	57	13
Part of larger project	22	5
Participatory process (workshops, interviews, focus groups etc.)	52	12
Expert knowledge (e.g. expert workshops)	30	7
Different types of analysis by researchers (e.g. climate projections, morphological analysis, social metabolism analysis)	35	8
How was background information used/reason to use it?		
Fact check	22	5
Expand participants comments, flesh out scenarios	43	10
To prepare researchers/organisations of workshop/design workshop	70	16
Identify key variables/drivers/shocks	52	12
Back-casting	17	4
Map system and change	22	5
Identify stakeholders	22	5
2. Background information use		
How did background information support scenario planning?		
Information, inspiration for organisers of workshop	43	10
Reflect on/select drivers, key-variables, power relations, land change	30	7
Background for stakeholders	17	4
Inspire discussion	43	10

(con'd)

Find stakeholders	4	1
Build/support models	35	8
Context, timeline	30	7
Was background information integrated in the scenario building?		
Yes	78	18
No	22	5
How was background information integrated into the scenario building?		
Using archetypes	13	3
Guidelines	13	3
Context, relationships	30	7
Drivers	43	10
What motivated how/if background information was used?		
Context	43	10
Not constrain creation	9	2
Connect with previous project	26	6
Time	26	6
Inform debate	30	7
Find stakeholders	13	3
Design workshops	22	5
Consistent	30	7
Ensure integrative process	48	11
How long did it take until final scenarios where done (months)?		
0-5	17	4
6-10	35	8
11-15	17	4
16-20	9	2
>20	22	5
3. Did the team base the process on previous processes or published guidelines?		

(con'd)

Did the team base the process on previous processes or published guidelines?		
Previous published guidelines	100	23
Previous process	78	18
4. Process for identification of drivers of change		
Process for identification of drivers of change		
Participatory process:	91	21
Focus groups	30	7
Workshops	74	17
In depth interviews	30	7
Surveys	9	2
External (external to the participatory process):	61	14
Researchers notes, proposed by researchers	43	10
Previous research/lit review	48	11
Predefined by project scope, predefined categories	17	4
5. Use of drivers of change for scenarios[1]		
Use of drivers of change		
Morpho-matrix	13	3
2 axes=4 scenarios	43	10
Uncertainty scenarios	13	3
Hunt's archetypes	13	3
To elicit responses	17	4
Drive models for forecasts	17	4
ABM (agent based models)	4	1
Flesh out storylines, basis and breath of storylines	65	15
NA	9	2
6. How many drivers where identified?		
How many drivers where identified?		
0-10	43	10
11-20	26	6

(con'd)

21-30	4	1
31-40	0	0
41-50	4	1
>50	22	5
Where they ranked?		
Yes	43	10
No	52	12
NA	4	1
How where they ranked?		
q-sort	4	1
Impact, probability of influence, importance, relevance	26	6
Uncertainty	13	3
NA	35	8
7. Type of driver		
Type of driver		
Social driver:	78	18
Health	4	1
Demographics	52	12
Employment	26	6
Poverty/inequality	17	4
Social e.g. values	48	11
Technology	39	9
Development e.g. Energy use	30	7
Urbanisation	17	4
Globalisation	17	4
Economics/market conditions	57	13
Tourism	26	6
Governance	52	12
Legislation/policy	52	12

(con'd)

Climate	152	35
Ecological driver:	48	11
Environmental Change e.g. Land cover, biodiversity loss, coral bleaching deforestation	48	11
NA	22	5
Direct or indirect driver?		
Direct	35	8
Indirect	43	10
Not categorized	57	13
8. Type of scenario design		
Type of scenario design		
Participants/stakeholder driven	61	14
Driven by researchers/project team	26	6
Previous work/literature	43	10
Other (2x2 matrix, morphological matrix)	43	10
9. Criteria for prioritisation of driver		
What was the criteria for prioritisation of drivers of change for guidelines for scenarios?		
Uncertainty	26	6
Relevance, Importance, Impact, Influence	70	16
No prioritization	87	2
Structural analysis	17	4
Contrast	13	3
Likelihood	9	2
Vulnerability	13	3
10. Number of scenarios created		
Was there an end year used?		
Yes	91	21
No	9	2
If yes, what was the end projection year?		
2025	9	2

(con'd)

2030	39	9
2032	4	1
2034	13	3
2035	4	1
2040	4	1
2043	4	1
2050	9	2
2030, 2060, 2090 (three time projections where used)	13	3
Time span		
10-20	61	14
21-30	22	5
31-40	9	2
>40	9	2
Motivation for choosing this time projection		
Data availability	13	3
Drivers	9	2
Generations	26	6
Link to other scenarios	4	1
Stakeholders/local people	30	7
Visionary, non-ficitionary, manageable, far but not to far, imaginable, reasonable, related to current situation, related to current policy and drivers	17	4
Previous experience	17	4
Literature	4	1
Researchers	13	3
Other	17	4
11. Time span (year projected)		
Did the case create scenarios?		
Yes	91	21
No	9	2

(con'd)

How many scenarios where created?		
0	4	1
3	9	2
4	65	15
5	4	1
8	8	2
17	4	1
24	4	1
Where all scenarios created used?		
Yes	70	16
No	30	7
Number of scenarios created and not used		
0	70	16
3	17	4
15	4	1
20	4	1
Motivation to include/not include scenarios		
Implausible, unviable for local people	65	15
Drivers, Positive/Negative, Current/Business as usual	34	8
Minimize overlap, ensure contrast, high variability	13	3
Group size, number of subgroups	13	3
Data availability	13	3
Researchers decided	4	1
Feasibility manageable	39	9

[1] For the classification of drivers of change we adopted the Millenium Assesment framework. However, there are other frameworks available such as STEEP, which is typically used as a prompt for Social, Technological, Environmental, Economic and Policy drivers (Bradfield et al. 2005) and was used by cases #4, #5 and #6. Bradfield, R., G. Wright, G. Burt, G. Cairns, and K. Van Der Heijden. 2005. The origins and evolution of scenario techniques in long range business planning. Futures 37(8):795-812. http://dx.doi.org/:10.1016/j.futures.2005.01.003

Appendix 5. Process.

	% of case studies	N
1. Structure and duration of the process		
Previous information given to participants involved in scenario design:	100	23
Brief introduction about scenario planning	39	9
Scientific information about global change	22	5
Other information about the study area	35	8
Objective of the project and/or exercise	44	10
Other previous exercises (e.g. MedAction)	4	1
Previous relation of researchers with participants	78	18
Local co-researchers	61	11
None	44	8
<3 years	44	8
4-10 years	6	1
>10 years	6	1
Duration of the process (N=22-23)	Min-max	Average
Months	2-60	15.7
Number of workshops	1-18	4.9
Duration of workshops - days	0.5-4	1.4
Duration of workshops - hours	2-15	6.1
Continuity of participants (N=21)	Not complete	Good
Continuity of participants	10	11

	% of case studies	N
Phases/structure of the participatory design of scenarios (scenario activity)	91	21
Method/ process design	52	11
Drivers/guidelines identification and/or selection by participants	86	18
Envisioning	91	19
Modelling	29	6
Back-casting	33	7
Comment/Feedback	52	11

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2. Methodological tools

	% of case studies	N
Methodological tools during the scenario creation	100	23
Interviews	35	8
Individual reflections	48	11
Small groups discussions	74	17
Groups discussions	100	23
Cards	44	10
Rankings	35	8
Collages	22	5
Drawings	48	11
Maps	26	6
Sock flow diagrams	13	3
Mental models	39	9
Wall-mounted time-lines	13	3

Quantitative models/data (e.g. Climate, land-use change, habitat…)	39	9
Fictional newspaper headlines	13	3

3. Back-casting

Back-casting (N=23)	% of case studies	N
Back-casting	17	4

4. Storyline

	% of case studies	N
Storyline type	96	22
Qualitative	82	18
Mixed	18	4
Who did the storylines - participants	46	10
Who did the storylines - research team	36	8
Storyline spatially explicit		
Storyline spatially explicit - maps	26	6
Storyline spatially explicit - partly	44	10
Storyline with intermediate time-frames	36	8
	Min-max	Average
Duration of intervals (years)		5-30

5. Conflicts	% of case studies	N
	100	23
Conflicts emerged during the participatory process	30	

Between participants	26	
Between participants and researchers	4	
Between funders and researchers	4	

6. Presentation of results and feedback processes after the workshops of future scenarios	% of case studies	N
Presentation of results	100	23
In the same process	17	4
Other workshop	48	11
Report	17	4
Video	17	4
Others (e.g. magazine, booklet, art-science event)	26	6
Feedback (validation) process	91	21
Other workshop	43	9
Comments to scenario draft	30	7
Big Meeting	17	4
Participatory video	4	1

7. Participants selection and attendees to future scenarios workshops	% of case studies	N
Process of participation selection		
Use of previous scientific method	70	16
Stakeholder analysis	52	12
Snowball sampling	17	4
Social network analysis	9	2
Ethnographic interviews	9	2
Selection is made with or via local research partners	83	19

	Local stakeholders	65	15
Method for asking for participation			
	E-mail	65	15
	Phone calls	57	13
	Face-to-face	44	10
	Others (local newspapers, radio, post)	26	6
Number of participants			
	14-32 participants	48	11
	33-52 participants	17	4
	53-72 participants	13	3
	73-92 participants	9	2
	more than 93 participants	13	3
Type of participants			
	Local community	96	22
	Local policy-makers	83	19
	Supra-local policy-makers	44	10
	Natural resources management agencies	65	15
	NGOs	61	14
	Academics	35	8
	Business sector	39	9
	Recreation sector	22	5

Appendix 6. Content of scenarios.

	% of case studies	N
1. Source of inspiration for guidelines		
Archetypes Hunt et al.	13	3
Focal issues or drivers	52	12
Grounded theory, emergent	13	3
Risks, extremes, threats	22	5
Mentioned MEA or MED	17	4
2. Choice of scenario names		
Created by participants	30	7
Created by researchers	52	12
Can't recall/not specified	26	6
Only women gave names	4	1
3. Types of scenario names		
More than four (one with 5, one with 10)	9	2
Four (Best case, Worst/BAU, 2 in between)	65	15
Three (Best case, Worst/BAU, 1 in between)	13	3
Others (one matrix, one no-names, one with two)	13	3
4. Ecosystem services		
Included explicitly	57	13
Included but not explicitly	17	4
Not discussed	30	7
Total included	74	17

5. Biodiversity			
	Included explicitly	74	17
	Included but not explicitly	17	4
	Not discussed	9	2
	Total included	91	21
6. Human well-being		91	21
	Included explicitly	74	17
	Included but not explicitly	17	4
	Not discussed	9	2
7. Trade-offs		100	23
	Included explicitly	70	16
	Included but not explicitly	30	7
	Not discussed	0	0

8. Main factors underpinning mixtures in the scenarios

(i) Cases where scenarios were based on mixtures of two main factors

Case #	*Factors*	*Issues addressed*
1	Extent of mining vs. extent of landscape/habitat and wildlife protection	Wildlife management
2	Food production in cultural landscapes with government funding vs. lowest-cost food production, free market	Energy production/consumption
3	Effective government in partnership or central planning role vs. weak government with/without innovators	Urbanization, poverty alleviation, rural development
5	Conservation and development together vs. little conservation and over-exploitation	Violence trigger people movements; environmental management, tourism,

		subsistence
6	Sustainability vs. unfettered growth, pollution, resource depletion	Population, technology, resource usage
7	Intensive land management vs. managing for ecosystem services bundles	Landscape planning and environmental management
8	Traditional land use vs. development	Forest conservation
9	Self sufficiency vs. conflict/divide	Oil discovery, corruption, youth facilities

(ii) Cases where scenarios were based on mixtures of three main factors

Case #	*Factors*	*Issues addressed*
11	Real estate development vs. agricultural intensification vs. habitat conservation	Biodiversity
12	Transhumance vs. extensive/intensive livestock vs. over-exploitation and collapse	Agricultural management
15	Locally driven development vs. mixed/external opportunities vs. intensification	Land use intensification, cultural values
16	Depopulation vs. rapid growth vs. conflicting outcomes	Population, land use
18	Green economy vs. carbon-intensive economy and high human capacity vs. low	Food security, poverty and livelihoods
21	Locally driven vs. global development vs. rich/poor divide	Community values and ecosystem services
23	Mild vs. sever climate change combined with global economic model vs. locally driven development	Grassland management, biodiversity conservation

(iii) Cases where scenarios were based on mixtures of four or more main factors

Case #	*Factors*	*Issues addressed*
4	Market vs. government planning vs. innovation vs. collective governance vs. violent conflict	Forest management, climate change, poverty alleviation, livelihoods
10	Governance fail through	Agriculture, biodiversity,

	fragmentation/stagnation vs. community-based enterprise vs. mixed market/partners vs. neo-liberal	food security
13	Fisheries and water resources decline vs. technological solution vs. productive mosaic vs. armed conflict	Fish, water resources, agricultural systems
17	High vs. low development, high vs. low population growth, high vs. low investment in fisheries, effective vs. ineffective governance and law enforcement	Fisheries
19	Good social development and governance vs. bad social development and governance AND higher projections of climate change vs. lower projections of climate change OR (in other workshops) green economy vs. extractive economy	Food security, poverty and livelihoods
20	Strong vs. weak local culture; regional development models supporting vs. not supporting Torres Strait and managing climate change	Community resilience, self-sufficiency livelihoods and culture
23	Technogarden vs. development and climate change vs. severe climate change effects vs. adapting mosaic and social-ecological system management	MA

Appendix 7. Outputs.

	% of case studies	N
1. Types of Outputs – and who created them		
Collages – using a variety of materials	30	7
Created by researchers	17	4
Created by participants	13	3
Drawings – (some overlap with illustrations)	65	15
Created by researchers	17	4
Created by participants	26	6
Created by (commissioned) artist	26	6
Illustrations	57	13
Created by researchers	9	2
Created by participants	9	2
Created by (commissioned) artist	13	3
Leaflets/postcards	22	5
Created by researchers	17	4
Created by funding organization	4	1
Posters	65	15
Created by researchers	30	7
Created by participants	4	1
Created by funding agent	4	1
Scientific publications	91	21
Created by researchers	26	6
Co-written with participants	4	1
Reports	100	23

	Created by researchers	35	8
Videos		43	10
	Created with professional support	22	5

2. Intended audience and output uses in addition to communications	% of case studies mentioned	N
Intended audience for outputs		
Participants	65	15
Academics	70	16
Policy and decision makers	65	15
Broad audience	17	4
Local community	83	19
Other uses of outputs (and secondary objectives)		
Combined with another research tool (e.g., interviews, board game)	9	2
Used to satisfy funding requirements	9	2
Used to engage stakeholders (inclusive participation)	17	4
Used to capture learning and share with the community	17	4
Used to visualize scenarios	22	5
Used to further discussion	13	3

Appendix 8. Definitions (OECD 2002) and their adaption for scenario planning exercises .
(see http://ec.europa.eu/europeaid/evaluation/methodology/glossary/glo_en.htm)

Term	OECD	Scenario planning adaption
Partners	The individuals and/or organizations that collaborate to achieve mutually agreed upon objectives	The scenario planning participants, including researchers, facilitators and other stakeholders in the social-ecological system, including government and communities
Beneficiaries	The individuals, groups, or organizations, whether targeted or not, that benefit, directly or indirectly, from the development intervention	The stakeholders that are intended to benefit from the scenario planning process, usually with a focus on resource-dependent communities
Outputs	The products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes.	The scenarios, narratives and actions or strategies developed from the process
Outcomes	The likely or achieved short-term and medium-term effects of an intervention's outputs	Enhanced capacity of partners and beneficiaries within 1 year of the scenario planning process. This is manifested as changes in their perceptions, values, learning, social networks, partnerships, institutions and governance.
Impacts	Positive and negative, primary and secondary effects produced by a development intervention, directly or indirectly, intended or unintended	Implementation of alternative policies and strategies that is attributable to the enhanced capacity of partners brought about by the scenario planning process, and targeted at beneficiaries.
Monitoring	A continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing	Systematic collection of data to track the extent of progress and achievement of outcomes and impacts using indicators as a result of the scenario

	development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds. Related term: performance monitoring, indicator.	process.
Evaluation	The systematic and objective assessment of an on-going or completed project, programme or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision–making process of both recipients and donors. Evaluation also refers to the process of determining the worth or significance of an activity, policy or program. An assessment, as systematic and objective as possible, of a planned, on-going, or completed development intervention.	Assessment of the scenario design, implementation and results through a formal methodological approach.
Attribution	The ascription of a causal link between observed (or expected to be observed) changes and a specific intervention. Note: Attribution refers to that which is to be credited for the observed changes or results achieved. It represents the extent to which observed development effects can be attributed to a specific intervention or to the performance of one or more partner taking account of other interventions, (anticipated or unanticipated) confounding factors, or external shocks.	

Appendix 9. Monitoring and evaluation.

1. Monitoring		
Extent of monitoring undertaken by case studies	% of case studies	N
No monitoring	52	12
Some monitoring within project lifespan	35	8
Monitoring beyond project lifespan and/or institutionalisation of monitoring program	13	3
Reasons given for monitoring or not monitoring	% of case studies	N
Monitoring done for contractual obligation	17	4
Research framework	4	1
Foster learning	4	1
Assess learning	17	4
Assess outcomes	17	4
Reasons given for monitoring not done		
Resource constraints	48	11
Not necessary	9	2
Impractical	9	2
2. Evaluation		
Formal evaluation done	13	3
Formal evaluation not done	87	20
Evaluation method used by case studies undertaking evaluation (N = 15)		
Survey/questionnaire	53	8
Interview	60	9
Observation	27	4

Analysis of project outputs	20	3
Discussion	13	2
Team reflection/review	20	3
Multiple methods	53	8
Reasons given for evaluating or not evaluating		
Formal evaluation done for contractual obligation	7	2
Research framework	4	1
Assess learning	26	6
Assess outcomes	4	1
Assess process	17	4
Reasons given for formal evaluation not done		
Resource constraints	39	9
Not necessary	4	1
Impractical	22	5

3. Outcomes and impacts

Short-term outcomes and impacts (<1 year after project)	% of case studies	N
Formal evaluation		
No evidence	0	0
Weak evidence	0	0
Moderate evidence	0	0
Strong evidence	13	3
No formal evaluation		
No evidence	9	2
Weak evidence	52	12

Moderate evidence	17	4
Strong evidence	9	2

Long-term outcomes and impacts (>1 year after project) detected by projects ending more than 1 year ago (N=17)	% of case studies	N
Formal evaluation		
No evidence	0	0
Weak evidence	0	0
Moderate evidence	0	0
Strong evidence	9	2
No formal evaluation		
No evidence	65	15
Weak evidence	0	0
Moderate evidence	0	0
Strong evidence	0	0

APPENDIX 10. Results from Multiple Correspondence Analysis

Appendix 10. Results from Multiple Correspondence Analysis

Table A.10.1. Eigenvalues and percentages of inertia absorbed by the first three axes (F1, F2 and F3) of the Multiple Correspondence Analysis (MCA).

	F1	F2	F3
Eigenvalue	0,247	0,161	0,159
Adjusted Inertia (%)	50,150	12,208	6,620
Cumulative %	50,150	62,358	68,978

Table A.10.2. Principal coordinates of the variables in the first three axes (F1, F2, F3) of the Multiple Correspondence Analysis (MCA). Values in bold correspond to the variables with highest squared cosines.

Variable	F1	F2	F3
Biodiversity conservation	0,210	**-0,**234	-0,318
Climate change	-0,068	**-0,160**	-0,035
Stakeholders identification	**1,271**	0,164	-0,323
Direct drivers	**0,990**	**0,290**	0,212
Indirect drivers	**0,925**	**0,**182	0,165
Quantitative analysis	**0,885**	**-0,**415	-0,188
Uncertainty	0,246	0,**220**	**-0,421**

(con'd)

Vulnerability	0,227	**-0,406**	**0,437**
Desirability	-0,124	-0,220	0,051
Envisioning	0,007	**-0,369**	0,079
Modeling	0,431	-0,527	**-1,072**
Back-casting	**1,014**	**-0,**481	0,321
Monitoring	-0,331	-0,**462**	**-0,636**
	F1	F2	F3

Table A.10.3. Principal coordinates of the case studies in the first three axes (F1, F2, F3) of the Multiple Correspondence Analysis (MCA).

Case studies			
1. SW Yukon Wildlife (Canada)	-0,320	-0,071	0,126
2. Swabian Alb (Germany)	0,033	-0,015	0,677
3. Eastern Cape (South Africa)	0,168	0,076	0,253
4. COMETLA (Mexico)	-0,508	-0,042	-0,357
5. COMETLA (Colombia)	-0,417	-0,178	-0,656
6. COMETLA (Argentina)	-0,508	-0,042	-0,357
7. Uplands (UK)	-0,087	-0,253	-0,383

(con'd)

8. COMBIOSERVE (Bolivia)	0,023	-0,483	0,438
9. COBRA North Rupununi (Guyana)	-0,296	1,151	-0,005
10. Semi-arid North (Nicaragua)	0,391	-0,610	-0,484
11. Wet Tropics (Australia)	0,628	-0,188	-0,694
12. Transhumance (Spain)	0,812	-0,054	0,345
13. Cienaga Grande (Colombia)	1,008	0,195	0,277
14. Mackay Whitsunday Isaac (Australia)	-0,416	0,534	-0,199
15. Southern Transylvania (Romania)	0,322	0,986	-0,046
16. Northern Highland Lake (USA)	0,222	-0,036	-0,298
17. Coastal ecosystem services (Kenya)	0,321	0,138	-0,309
18. Nusa Tenggara Barat (Indonesia)	-0,617	-0,276	0,310
19. West New Britain (Papua New Guinea)	-0,617	-0,276	0,310
20. Torres Strait (Australia)	-0,617	-0,276	0,310
21. Bonnechere River (Canada)	-0,609	0,092	0,332
22. Doñana (Spain)	0,636	-0,197	0,279

(con'd)

23. Alps (France)	0,449		-0,178	0,130

Appendix 11. Strengths and weaknesses.

1. Strengths			
Stakeholders' engagement			
	Social learning	57	13
	Research partnerships	48	11
	Awareness raising	22	5
	Social cohesion	17	4
	Total	91	21
Technical development			
	Collective discussions	39	9
	Adaptable and dynamic process	17	4
	Multiple approach	13	3
	Systematic process	13	3
	Other (training facilitators, interdisciplinarity, emphasize trade-offs, present comprehensive drivers, etc.)	34	7
	Total	83	19
Quality of outcomes			
	Policy relevant	39	9
	Worldviews diversity	30	7
	Other (publishable results, habitat restoration, good models)	17	4
	Total	70	16
Process completion			
	Back-casting	17	4
	Other (monitoring and evaluation, data triangulation)	9	2

2. Weaknesses	% of case studies	N
Stakeholders' engagement		
Participation (extent, continuity)	13	3
Conflicts	9	2
Diversity of participants	35	8
Representativeness of powerful stakeholders	35	8
Representativeness of powerless stakeholders (including gender discrimination)	9	2
Ownership	22	5
Total	74	13
Technical development		
Time, cost and energy constraints	48	11
Accuracy versus social relevance	22	5
Lack of quantitative analysis	39	9
Cultural barriers	13	3
Other (logistic difficulties, facilitation problems, continuity of process, researchers' bias)	26	6
Total	87	20
Quality of outcomes		
Outcomes biased by participants' preferences	22	5
Poor incorporation of specific outputs (e.g. drivers analysis, uncertainty evaluation)	22	5
Scenario polarization	13	3
Limitations to novelty	17	4

	Lack of robust policy-relevant strategies	22	5
	Total	65	15
Process completion			
	Lack of back-casting	4	1
	Lack of communication/dissemination	17	4
	Lack of monitoring and evaluation	22	5
	Total	35	8