UNIVERSITAT POLITÈCNICA DE VALÈNCIA

PhD Thesis

Sustainable and participatory forestry under Mediterranean conditions: criteria and indicators for monitoring in a forest management unit of Comunidad Valenciana (Spain)

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Table of Contents

List of Figures

List of Tables

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Abstract

Sustainable forest management (SFM) considers the social and ecological aspects of forestry apart from the productive ones. However, the relative importance of its principles changes in each type of forest.

Criteria and indicators (C&I) extend the knowledge and understanding of SFM in each different situation. A set of C&I to be applied under Mediterranean conditions is proposed in this thesis. The scope was set for the forest management unit (FMU). The C&I proposed took into account the Spanish context and the Forestry Regional Plan for the region of Valencia (whose Spanish acronym is PATFOR) served as a reference.

The thesis is made of three papers, two of them published and one accepted. The first identified the requirements of SFM under Mediterranean conditions and analysed the Spanish situation. For that purpose, a strengths-weaknesses-opportunities-threats (SWOT) analysis was carried out and strategies for improvement were determined. The results of the SWOT analysis together with the strategies and the requirements identified by means of literature review were verified in a questionnaire sent to experts.

In the second paper, a group of criteria recommended to take into account for the success of a participatory process were established. A review of case studies which had developed decision support systems (DSSs) including elements of participation was completed. Conslusions were considered for the method applied in the third paper and they helped to identify indicators for the criterion “participatory processes”, which is one of the criteria proposed in this thesis. Besides, PATFOR recommends including participation in forestry decision-making.

The third paper started adaptating various ecosystem services frameworks to Mediterranean conditions. PATFOR suggests that forestry is more sustainable if it stems from the provision of ecosystem services, even more in Mediterranean forests because they are not very productive in general. Management criteria which maintain and improve the provision of ecosystem

services were identified. A participatory process took place in *Ayora* (a village in the region of Valencia); participants were asked to rank the criteria identified according their management preferences for *La Hunde y La Palomera*, a FMU near the village. A proposal of indicators was another output of this paper. The thesis includes another chapter which does not correspond to any published paper; it describes the elaboration of a questionnaire that was sent to experts. The questionnaire asked respondents to prioritise the indicators proposed in the third paper following the *Analytic Hierarchy Process* (AHP) methodology.

The result is a proposal of 15 criteria and 90 indicators. Criteria were inspired by the requirements of the first paper and the ecosystem services. 7 out of 15 criteria are social, noticeably increasing the weight of the social pillar in comparison with other existing C&I sets. Nevertheless, participants ranked ecological implications of forestry as the most preferred ones. However, they did not reject any of the criteria and this suggests that considering ecosystem services in forest management is realistic and desirable.

Although the AHP questionnaire sent to experts was different from the participatory process, both in appearance and content, some comparisons can be made. Experts search for feasibility in their answers. It may be recommended from these differences that forestry decision-making takes into account the views of affected people, but their preferences might pass an expert filter before carrying out actions. Regarding the indicators, some more work on them is still necessary, but they show a simple writing and they refer to a specific aspect of each criterion.

Resumen

La gestión forestal sostenible (GFS) tiene en cuenta las implicaciones sociales y ambientales de actividad forestal, más allá de las productivas. Sin embargo, la importancia relativa de sus principios rectores varía en cada tipo de bosque.

Los criterios e indicadores (C&I) se han constituido como herramienta para determinar qué es la GFS en cada situación. En esta tesis se propone un conjunto de C&I para el seguimiento de la gestión en condiciones mediterráneas. Como escala de trabajo se escogió la de monte o unidad de gestión forestal (UGF). Los C&I se particularizaron para el contexto español y sirvió de referencia el Plan de Acción Territorial Forestal de la Comunidad Valenciana (PATFOR).

La tesis se compone de tres artículos, dos publicados y uno aceptado. En el primero se identificaron los requerimientos de GFS en condiciones mediterráneas y se analizó la situación española. Para ello se elaboró primero un análisis de debilidades-amenazas-fortalezas-oportunidades (DAFO) del que se derivaron estrategias de mejora. Los resultados del DAFO junto con las estrategias y los requerimientos derivados de revisión bibliográfica se verificaron a través de un cuestionario enviado a expertos.

En el segundo artículo se establecieron un conjunto de criterios cuyo cumplimiento es recomendable para el éxito de un proceso participativo. Se llevó a cabo una revisión de estudios de caso que habían desarrollado sistemas de ayuda a la decisión (SADs) incluyendo procesos de participación pública. Las conclusiones se tuvieron en cuenta en el método del tercer artículo y también para la identificación de indicadores del criterio “participación pública”, que forma parte del conjunto de criterios propuestos en esta tesis. Además, El PATFOR determina la necesidad de que la gestión forestal incluya procesos participativos en su toma de decisiones.

El tercer artículo comenzó con la adaptación de distintos marcos existentes de servicios ambientales a condiciones mediterráneas. PATFOR sugiere que la gestión forestal es más sostenible si se basa en la provisión de estos servicios,

especialmente en el monte mediterráneo que es poco productivo en general. Se identificaron criterios de gestión para mantener y mejorar la provisión de dichos servicios. Los criterios pasaron posteriormente por un proceso de participación pública abierto a la población de la localidad de *Ayora* (provincia de Valencia) en el que se pidió a los participantes que los priorizasen según sus preferencias de gestión para el monte de *La Hunde y La Palomera*, situado en el mismo municipio. El artículo terminó con una propuesta de indicadores. La tesis incluye un capítulo más que no corresponde a ningún artículo publicado. En él se describe la última etapa de la tesis que consistió en elaborar un cuestionario enviado a expertos. En el cuestionario se les pidió jerarquizar los indicadores propuestos en el tercer artículo siguiendo el procedimiento del *proceso analítico jerárquico* (AHP, por sus siglas en inglés).

El resultado es una propuesta de 15 criterios y 90 indicadores. Los criterios se inspiraron en los requeriemientos del primer artículo y en los servicios ambientales. De los 15 criterios 7 son sociales, incrementando notablemente el peso del pilar social respecto a otros conjuntos existentes de C&I. Sin embargo, los participantes de *Ayora* situaron las implicaciones ecológicas de la gestión como prioritarias. No obstante, no rechazaron ninguno de los criterios propuestos y eso sugiere que una gestión basada en servicios ambientales es realista y deseable.

Aunque el cuestionario AHP fue diferente del proceso participativo, tanto en forma como en contenido, se pueden hacer algunas comparaciones. Los expertos tratan de ser prácticos en sus respuestas. Las diferencias en los resultados sugieren y llevan a recomendar tener en cuenta la opinión de la población afectada a la hora de tomar decisiones, pero pasando posteriormente por el filtro de los expertos. Respecto a los indicadores resultantes, todavía es necesario un mayor trabajo con ellos, pero incorporan como puntos fuertes tener una redacción sencilla y referirse a un aspecto concreto de cada uno de los criterios.

Resum

La gestió forestal sostenible (GFS) té en compte les implicacions socials i ambientals de activitat forestal, a més de les productives. Tanmateix, la importància relativa dels seus principis varia en cada tipus de bosc.

Els criteris i indicadors (C&I) s'han constituït com una ferramenta per a determinar què és la GFS en cada situació. En aquesta tesi es proposa un conjunt de C&I per al seguiment de la gestió en condicions mediterrànies. Com a escala de treball es va triar la unitat de gestió forestal (UGF). Els C&I es van particularitzar per a el marc espanyol i va servir de referència el Pla d' Acció Territorial Forestal de la Comunitat Valenciana (PATFOR).

Tres articles composen la tesi, dos d'ells publicats i un altre acceptat. En el primer es van identificar els requisits de GFS en condicions mediterrànies i es va analitzar la situació en Espanya. Per a la qual cosa es va elaborar en primer lloc una análisi de debilitats-amenaces-fortaleses-oportunitats (DAFO) de la qual van sorgir estratègies de millora. Els resultats de la DAFO juntament amb les estratègies i els requisits identificats mitjançant revisió bibliogràfica es van verificar per mitjà d'un cuestionari enviat a experts.

En el segon article es van establir un conjunt de criteris el compliment dels quals és recomanable per a que un procés participatiu siga exitós. Es va dur a terme una revisió d'estudis de cas en el quals es van desenvolupar sistemes d'ajuda a la decisió (SADs) incloent processos de participació pública. Les conclusions es van tindre en compte en l'aplicació del mètode del tercer article i per a la identificació d'indicadors del criteri "participació pública", que forma part del conjunt de criteris proposats en aquesta tesi. A mès, El PATFOR recomana la inclusió de processos participatius per a prendre decisions de gestió forestal.

El tercer article va començar amb l'adaptació de diferents marcs de serveis ambientals a condicions mediterránies. PATFOR sugereix que la gestió és més sostenible si es basa en la prestació de serveis ambientals, especialment al bosc

mediterrani que és poc productiu en general. Es van identificar criteris de gestió per a mantenir i millorar la prestació dels serveis esmentats. Després es va realitzar un procés participatiu obert a tota la població de la localitat d'*Ayora* (província de València) en el qual es va demanar als participants que prioritzaren els criteris identificats segon les seues preferèncias de gestió per al bosc *La Hunde y La Palomera*, situat al mateix municipi. L'article va terminar amb una proposta d'indicadors. La tesi inclou un capítol més que no es correspon amb cap article publicat. Es descriu l'última etapa de la tesi que va consistir a elaborar un cuestionari enviat a experts. En el cuestionari es va demanar al experts que prioritzaren els indicadors proposats en el tercer article aplicant un procés de comparació per parells anomenat en anglés AHP.

El resultat és una proposta de 15 criteris i 90 indicadors. Els criteris es van inspirar en els requisits del primer article i en els serveis ambientals. Dels 15 criteris 7 són socials. El pes de la part social és notablement superior si es compara amb altres conjunts existents de C&I. Tanmateix, els participants d'*Ayora* van situar les consideracions ecològiques de la gestió com a prioritàries. No obstant això, no van rebutjar cap dels criteris proposats, la qual cosa sugereix que una gestió basada en serveis ambientals és realista y desitjable.

Encara que el cuestionari AHP va ser diferent del procés participatiu, en presentació i contingut, es poden fer algunes comparacions. Els experts tracten de ser pràctics en les seues respostes. Les diferències en els resultats porten a recomanar tenir en compte la opinió de la població afectada a l'hora de prendre decisions, però cal que les seues preferències passen després pel filtre dels experts. Respecte als indicadors resultants, cal encara més investigació per a millorarlos, però, tenen una redacció simple i es refereixen a un aspecte específic de cadascun dels criteris.

Chapter 1-Introduction to a thesis presented as a compilation of papers

This chapter constitutes the beginning of a compilation of papers thesis. The concepts addressed in each of the papers are presented and developed in their respective chapters. In this one, the objective is to introduce thesis issues globally and the papers that compose it.

Sustainable forest management (SFM) has been a central topic in forestry discussions in the last two decades. The concept first appeared at the *Earth Summit* held in Rio de Janeiro (UNCED, 1992) as an extension of the term sustainable development (previously defined in the “Brundtland Report” – WCED, 1987) applied to forestry. SFM is the management of forests that considers the various products offered apart from wood, and the social and environmental implications of forestry (Wijewardana, 2008).

Also, in the early nineties forest certification schemes started to appear. Forest certification consists of labeling those products that come from forests managed in good conditions. Initially, it appeared to fight against illegal logging in tropical forests, but soon became an objective for any forest in the world (es.fsc.org).

But forest certification is a private inititative and requires that the forest owner pays for an audit in order to get the label or certificate (Plana, 2000). Several associations started to create their own standards to promote and to assess the practice of SFM independently of forest certification systems.

An agreement has not been achieved on what exactly constitutes SFM (Varma *et al*, 2000). There are definitions of the concept, but it has been accepted that its principles and the relative importance of each of them may change depending on the conditions under which each forest is managed (Castañeda, 2000; Barbati *et al*, 2007).

To carry out sustainable forestry, forest certification schemes and SFM promoters develop standards or sets of criteria and indicators (C&I) adapted to the different situations. C&I serve for monitoring and assessing forest management performance. Therefore, they have emerged as the way to identify the requirements of SFM in every particular case and contribute to extend a global understanding of the concept (Wijewardana, 2008).

The specific features of each type of forest are especially relevant to have in consideration when managing under Mediterranean conditions (Osem *et al*, 2008). The particular characteristics of the forests of this region are explained in depth in Chapter 2, but generally these are: dry summers that favour the spread of forest fires, heavy rains that favour erosion, low productivity, fragile ecosystems, management abandonment because of an exodus of rural populations to the cities a few decades ago and the use of forest as spaces for recreation and visual enjoyment (the last two characteristics only apply in northern Mediterranean countries) (Scarascia-Mugnozza *et al*, 2000; Fabbio *et al*, 2003; Madrigal, 2003; Marraco, 2004; EFI, 2010).

The characteristics mentioned emphasise the relevance that ecosystems services have generally in forests and in Mediterranean ones in particular. Ecosystem services are the benefits that people get from natural environments. There are three types of ecosystem services: provisioning (related to tangible objects), regulating (in reference to the natural processes that maintain ecosystems and human infrastructures) and cultural (referring to the maintenance of traditions and identification features like landscapes) (MA, 2005). According to the features mentioned in the previous paragraph, relevant ecosystem services in Mediterranean forests are: erosion prevention, forest fires regulation, spaces for recreation or landscape conservation.

Spain represents a case where most of its forests grow under Mediterranean conditions. The central government is in charge of the basic legislation and the development of forestry planning corresponds to the regional governments. In Comunidad Valenciana (a region in the east of Spain), a regional forestry plan has recently been released (PATFOR – Spanish acronym for: *Plan de Acción Territorial Forestal de la Comunidad Valenciana* – Generalitat Valenciana, 2013). This plan establishes the need to reshape forestry in this region taking into account the maintenance and improvement in the provision of the ecosystem services of these forests. In the framework of PATFOR, it has been identified the need to find C&I for SFM under Mediterranean conditions and based in an ecosystem services classification.

There are already C&I standards adapted to Spanish conditions: FSC (Forest Stewardship Council – GTC-FSC, 2007) and PEFC (Program for the Endorsement of Forest Certification Schemes – AENOR, 2007; AENOR, 2007b). However, they are not adapted to an ecosystem services framework. FSC and PEFC focus mainly on resource quantities and ecological issues.

Forestry, and especially SFM, requires thinking about many things, prioritising alternatives and finding a compromise among competing objectives. In this sense, multicriteria analysis techniques (MCA) and decision support systems (DSSs) play a key role (Bennet and Bennet, 2008). MCA techniques help making choices when several criteria apply at the same time (Mendoza and Prabhu, 2000). DSSs are software means that consist of models which process input information and provide different alternative answers through a user interface. C&I constitute in many cases the input data of DSSs (Cain *et al*, 2003). MCA techniques are applied as the method in Chapters 2, 4 and 5. DSSs are briefly introduced Chapter 3.

Another pillar of the aforementioned PATFOR is the inclusion of elements of participation in forestry decision-making. There are many reasons for this; the main ones are to make stakeholders aware and to make them feel responsible for the state and the future of forests. Besides, the monetary revenues of forest management go to the forest owners, but their activitiy provides benefits for all society: landscapes people identify with, spaces for recreation, flood prevention. Forestry and the society interact and these services explain why forest management decisions do not only affect forest managers but stakeholders and local populations as well. Chapters 2, 4 and 5 include participatory processes in their methods and they are also conceptually present in Chapter 3.

The aim of this thesis is to propose a set of C&I for SFM under Mediterranean conditions and applicable at the forest management unit (FMU) level. The particular objectives of the thesis are:

- To ascertain the requirements of SFM for the Spanish situation including the views of experts.
- To find out what features of a participatory process lead to better outcomes.
- To identify criteria and aspects of SFM adapted to an ecosystem services classification and verify them considering stakeholders' management preferences for a FMU of Comunidad Valenciana.
- To identify indicators of SFM and prioritise them with experts.

The methods followed to reach the objectives basicly had to do with literature review, consultation processes and multi-criteria analysis techniques. Several times during the development of the thesis, a review of concepts was carried out; then, these concepts were summarised and a proposal of elements was made; this proposal was checked either through questionnaires to experts or through a participatory process.

The cycle described in the previous paragraph took place three times during the development of the thesis: first, to identify requirements of SFM under Mediterranean conditions and to analyse the Spanish situation; second, to propose criteria of SFM; and finally, to check and adjust indicators of SFM.

In three of them, potential respondents were selected by means of purposive sampling, a kind of nonprobability sampling described by Bernard (2000). It consists of deciding the profile of the individuals that would suit the questionnaire and go out to find them. For the three cases, it was previously thought what groups of people (subpopulations), either experts or stakeholders, would be required and they were approached without a previous estimation of how many members of each group might be in the study.

For the objective of finding out the features of a participatory process that lead to better outcomes, the methods were a bit different. They stemmed from a review of case studies. Then, a framework of criteria to evaluate the case studies was adapted and a principal coordinate analysis (PCO) was carried out to analyse the similarities among case studies.

More details about the methods are provided in the next chapters. Given the presented background, objectives and methods, the thesis is made of the following chapters:

1. Chapter 2 dives into the requirements of SFM in the Mediterranean region and states the particular situation of Spain with the aid of experts.
2. Chapter 3 develops a framework for assessing the process and the outcomes of any participatory process. Based on that framework, a series of case studies, in which DSSs are created including participation in the development process, are assessed in order to check what characteristics of that development process result in better tools and participants' perceptions.
3. Chapter 4 is the last paper; some criteria and aspects of SFM are identified and adapted to an ecosystem services framework. They are verified by asking the local population of a village of Comunidad Valenciana to establish management priorities for those criteria and aspects for a specific FMU near the village. The paper ends with a proposal of indicators.
4. Chapter 5 consists of the process and results of conducting an Analytical Hierarchy Process (AHP) questionnaire with experts, to prioritise and verify the indicators proposed in chapter 4.
5. Chapter 6: general discussion of the results of Chapters 2, 3, 4 and 5.
6. Chapter 7: conclusions of the thesis.
7. Chapter 8: references.

Chapter 2-Paper 1

Sustainability of Mediterranean Spanish forest management through stakeholder views

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Abstract

The management of forests that considers the social and environmental aspects associated to the forest activity is called sustainable forest management (SFM). There is not an agreed definition to be applied worldwide. This study intends to find out the requirements of SFM in the Mediterranean region and takes Spain as a case study. It is also aimed to determine the sustainability of current forest management in Spain, the difficulties to achieve SFM and proposals to do so. An initial diagnosis of the situation in Spain was obtained by means of a SWOT analysis and, then, a questionnaire with forestry experts was carried out to verify and broaden the conclusions of the analysis.

Results show that the key aspects of SFM are management planning, the consideration of the natural resources (biodiversity, habitats, soil and water), and the contribution to

rural development. Management planning and rural development are scarcely considered currently in forest management (12% of the forest area has a management plan). The main difficulties that explain this situation are the low profitability of Mediterranean forests, the lack of economic compensation for the ecosystem services (ES) provided by forests, and the poor coordination between forestry and land planning. The way to SFM goes through the existence of fair mechanisms that pay forest owners for the ES provided and the market promotion of all forest products. For the previous to succeed it is relevant to make society aware of the matter. Finally, it is important to increase inventory and data collection on forests to identify priorities of research and management.

Keywords**:** forest management, sustainability requirements, Mediterranean region, Spain, expert consultation, analysis, proposals.

Introduction

The term sustainable development first appeared in “Brundtland Report” (WCED, 1987) as that which *meets the needs of the present without compromising the ability of future generations to meet their own needs*. Later on, the concept of sustainable forest management (SFM) was introduced at the *Earth Summit* held in Rio de Janeiro (UNCED, 1992), with an aim to recognise the importance of sustaining other significant social and environmental values of the forests apart from wood (Wijewardana, 2008).

At the same time, environmental groups started to think that products coming from sustainably managed forests (mainly wood) should be labelled in a way that consumers knew that they had been produced in suitable conditions. That is how forest certification was born. The certificate allows producers to promote their products and to ask for a higher price, becoming an incentive to SFM. Nowadays, there are different forest certification schemes on a global level, the ones established in Europe are PEFC (Programme for the Endorsement of Forest Certification Schemes) and FSC (Forest Stewardship Council).

Although there is not a universally accepted definition of SFM, some common requirements can be inferred from the different sets of criteria and indicators[1] (C&I) developed by the ongoing international processes (eg., ITTO, 1992; Montreal Process, 1995) for assessing the practice of SFM (Varma *et al*, 2000). There is general agreement that seven thematic areas are involved in SFM: (1) extent of forest resources; (2) the conservation of biological diversity; (3) forest health and vitality; (4) and (5) productive and protective functions of the forest; (6) socio-economic functions; and (7) legal, policy and institutional framework (FAO, 2006).

However, the relative importance of the different topics to be covered by SFM may vary according to the natural and human influences on each type of forest (Castañeda, 2000; Barbati *et al*, 2007). This fact is especially important in the Mediterranean

[1] Through C&I it has been possible to derive a global understanding of what constitutes SFM. They provide means to translate the principles of sustainability into measurable goals and achievements (Wijewardana, 2008).

area as indicated in the work carried out by Osem *et al* (2008) in Israel, which shows the need of considering the forest specific characteristics when assessing the practice of SFM in Mediterranean forests. The present study searches for the requirements[2] of SFM in the Mediterranean region and looks into the particular situation of Spain. The research includes a review of the structure and development of forest management in Spain in order to, by means of a questionnaire to experts, ascertain its level of sustainability, the difficulties to achieve SFM, and proposals for improvement. The development of Spanish forest management is characterized by some particular features:

Decentralization. Forestry regulation in Spain corresponds to the autonomies (regional governments). The central government is in charge of the basic legislation and the coordination among the regional forestry departments (MARM, 1999). The decentralized model allows different forest policies, according to the natural and political situations in each region. But, it also results in an uneven development of forest management. For example, in terms of managed area, while *Catalunya* and *Navarra* have the largest area of forest management units (FMUs) under a management[3] plan with 40% and 43% respectively, *Comunitat Valenciana* has 1.56%. There is also an uneven application of budget and schedule. For instance, the regional forestry programme of *Castilla-La Mancha* was approved in 1994 with a budget of 12 million euros and a validity of 60 years; whereas in *Murcia* it was approved in 2003 with a budget of 227 million euros, and 10 years of validity (MARM, 2008).
Forestry and land planning policies. There is little coordination between policies. The principles of forest management are included in the wording of land planning, but there is a lack of models and procedures to implement

[2] A series of SFM requirements is obtained by looking through the standards for Spain of PEFC (developed by AENOR, 2007a; 2007b) and FSC (GTC-FSC, 2007). They are summarized in *Table 2*, in the next section (*Methodology*).
[3] Forest management in Spain is developed through plans and programmes specific for the different management scales: national level: National Forestry Programme; regional level: regional forestry programme; subregional/county level: forest resources management plan; forest management unit (FMU): forestry management plan. This sentence refers to the last one.

them. The resolutions derived from forest policy are usually integrated into land planning policy as elements of environmental planning (location and planning of protected areas), therefore promoting conservation rather than active management (Montiel and Galiana, 2005).

Property structure. Most of the forest area is private (65%) and the FMUs are normally small-sized (less than 3ha). This fact discourages many owners from managing their lands since they cannot plan a regular time and space harvesting to assure constant revenues (Tolosana *et al,* 2004).

Socio-economic conditions. There has been a depopulation of rural areas a few decades ago, leaving the forests without any management (Marraco, 2004). The main forest product is timber, which together with firewood accounts for a 47.1% of total forest production in Spain (Tolosana *et al,* 2004). Most of the timber produced goes to low added value industries like packing cases. On the other hand, nearly 80% of timber used by furniture and carpentry industries is imported and when not, it comes mainly from plantations (15% of the Spanish forest area), so that Spanish forests hardly provide raw materials for higher added value sectors (Plana and Meya, 1999). To end with the economic scenario, the average price of $1m^3$ of wood in Spain paid to the forest owner in the year 2005 was of 46.49€, which is very low for a small property (MARM, 2010).

The Spanish situation is also affected by Mediterranean conditions. Mediterranean forests represent 1.5% of global forest area. In addition, around 80% of these forests are concentrated in the vicinity of the Mediterranean Sea, and the rest is split among small areas of Australia, South Africa, California and Chile. The special attributes of the forests located around the Mediterranean basin can be summarized as follows (Scarascia-Mugnozza *et al*, 2000; Fabbio *et al*, 2003; Madrigal, 2003; EFI, 2010):

Adaptation to unfavorable conditions. Mediterranean climate is characterised by a pronounced biseasonality with dry and hot summers and moist and cool autumns and winters, occasional heavy rains, happening normally in autumn, a large year-to-year variability of total precipitation and strong and dry winds that favour the spread of forest fires.

Vegetation is adapted to the ecological conditions for individuals to grow and reproduce. The plants are provided with small leafs and deep root systems. In order to better resist fire, broadleaved species include high sprouting ability and thick barks, and conifers produce many seeds in fire resistant cones and can adapt to diverse ecological conditions.

Species richness. Another remarkable feature is the presence of a high diversity of plant and animal species, the Mediterranean area harbors around 25000 plant species whereas in the rest of Europe around 6000 plant species can be found. 50% of the Mediterranean flora is endemic to the region as a result of a long time evolution in specific and highly variable climatic and ecologic conditions.

Anthropogenic influence. Due to diversity of vegetation types and land-use forms, the Mediterranean landscape consists of a mosaic of patches; this variety provides a high value to the landscape of the region. The situation is the result of the addition and superposition of new elements without elimination of the old ones, thus creating every time new landscape configurations. Such an anthropogenic mosaic-like design is a further source of biodiversity. Another consequence of the different forms of exploitation throughout the years is the disappearance of many climax forest types. The remaining ones, incorrectly called natural, correspond to altered woods in different stages of regressive succession from the original forests.

Fragility. Mediterranean forests are quite fragile due to heterogeneity, instability and low profitability: heterogeneity is caused by diversity of species (trees, scrubs and herbs) and habitat conditions (climate, soils)[4]; instability results from summer drought, heavy rains, poor soils, and forest fires; and low profitability is derived from low productivity of Mediterranean forests.

Ecosystem services. Mediterranean ecosystems provide a variety of other products apart from wood. These products include food (fungus, pine fruits), resins, cork or aromatic plants (*Lavandula sp*, rosemary, etc.). The forests in this region also provide environmental and social services (both

[4] Heterogeneity increases resilience of the ecosystem, but it can be a difficulty in terms of forest management because it requires a different silviculture for each species and habitat.

these services and the products mentioned are known as ecosystem services), like protecting soil from erosion, preventing landslides, stabilising slopes, reducing water runoff, improving and conserving the beauty of the landscapes, and serving as spaces for recreation. Such services are crucial for the development of rural areas and for the welfare of urban populations.

Material and methods

A questionnaire was used as a consultation method in this study. Its main purposes were to explain the meaning of SFM, to analyse the situation in Spain and to get proposals for improvement. The items considered in the questionnaire were based on the findings of a previous SWOT (strengths, weaknesses, opportunities and threats) analysis of current forest management in relation to the objectives of SFM. The resulting matrix is shown in *Table 1*; it includes strategies to overcome some of the weaknesses and threats, as recommended by Gómez-Orea (2007).

The SWOT analysis was carried out based on the findings of a review of Spanish and European regulations and documents (see *Table 1* for references) concerning forestry and environmental management. Having in mind principles of SFM and the particularities of Mediterranean ecosystems, the information was grouped in strengths, weaknesses, opportunities or threats. Afterwards, strategies were proposed.

The respondents of the questionnaire were either experts in forest management or environmental sciences. They were selected from six groups: university, central and regional governments, research centres, forest management enterprises, forest associations and forest certification systems. The group "university" refers to teachers from forestry faculties all over Spain. "Central and regional governments" includes forestry planners and decision-makers who work in the authorities either central, for all Spain, or regional. Concerning "research centres", the term covers organisations where a study on the functioning and management of forests is carried out. In "forest management enterprises" there are self-employed people, forest owners or companies who develop a lucrative business in the fields of environmental consulting and exploitation of forest resources. “Forest associations” consists of private organisations that represent the interests of forest owners and forestry professionals. And finally, “forest certification systems” comprises people associated to or who work for the systems that promote forest certification and establish the standards for that, the ones existing in Spain are FSC and PEFC.

Bernard (2000) highly recommends pretesting any survey instrument prepared. A pretest was completed by 8 colleagues. The questionnaire was sent to them by e-mail. Small changes were suggested and applied.

Afterwards, an internet search was carried out to come across organisations existing in Spain that belong to the six groups described. For those organisations whose workers’ profile and contact information were available, a selection was done among their members considering their professional data and they were sent the questionnaire.

STRENGTHS	WEAKNESSES	
S_1: Basic forest management criteria stated in the Spanish forest management guidelines (MA, 1971): *forest cover maintenance, profitability and best use of multiple products and functions* **S_2:** Guidelines for forest protection from forest fires and pests that establish the Spanish forest management guidelines **S_3:** Guidelines for landscape and biodiversity conservation that establish the Spanish forest management guidelines	**W_1:** Lack of interaction between forestry and land planning instruments **W_2:** Lack of economic compensation for the positive externalities **W_3:** Low productivity of Mediterranean forests **W_4**: Small size of forest private property **W_5:** A lot of legislation not well connected and sometimes contradictory	SWOT Analysis for SFM

ST$_3$: Make guidelines of SFM which should be flexible and able to be developed in the different conditions of each region	**ST$_1$**: Establish coordination between forest planning instruments and land planning instruments **ST$_2$:** Create information systems to improve monitoring and assessment of forests **ST$_5$:** Reinforce the paper of central and local governments in forest management issues through legislation or compensating for the externalities **ST$_6$:** Economic incentives and marketing strategies to encourage the management and make forest products and so raise social awareness	**T$_1$:** Increase of management costs due to implementation of sustainability criteria **T$_2$:** Socio-economic context: lack of social awareness, market characteristics or low added value of forest products **T$_3$:** Political context: short-term objectives and forestry subordinated to urban planning **T$_4$:** Little communication and coordination among stakeholders and management organs	**THREATS**
ST$_1$: Establish coordination between forest planning instruments and land planning instruments **ST$_4$:** Improve the practical and theoretical formation in SFM for forest workers, professionals and students	**ST$_2$:** Create information systems to improve monitoring and assessment of forests **ST$_3$:** Make guidelines of SFM which should be flexible and able to be developed in the different conditions of each region **ST$_5$:** Reinforce the paper of central and local governments in forest management issues through legislation or compensating for the externalities **ST$_7$:** Research increase in fields such as SFM guidelines, economic valuation of resources and results assessment	**O$_1$:** Promotion of SFM from Europe and Spanish Government: European Forestry Strategy (Council of the European Union, 1999), Spanish National Forestry Programme (MARM, 2002), Spanish National Forestry Strategy (MARM, 1999) and Spanish Forestry Law (Gobierno de España, 2003). **O$_2$:** The support of rules for the protection of natural resources and landscape at any scale: Habitats Directive (Council of the European Communities, 1992), Spanish law on natural resources and biodiversity (Gobierno de España, 2007), or Valencian regional law on land planning and landscape protection (Generalitat Valenciana, 2004) **O$_3$:** European regulations to promote rural development: EAGGF (Council of the European Communities, 1999) and general provisions on the Structural Funds (Council of the European Communities, 1999b)	**OPPORTUNITIES**

Table 1. Initial diagnosis of management in the Mediterranean Spanish forests with a view to achieve SFM, shown by a SWOT analysis. Main strategies (ST$_i$) are proposed as a result of reinforcing the strenghts (S$_i$) and opportunities (O$_i$) and to overcome the weaknesses (W$_i$) and threats (T$_i$).

The questionnaire was completed in the year 2010 during the months of March, April and May, sent and answered back by e-mail. It covered four topics that give rise to the four following questions (the whole questionnaire, as it was presented to experts, is in *Annex 1*):

1. Requirements of SFM: *how much do you think that the following aspects define the concept of SFM?*
2. Introduction of the requirements in current forest management: *how much do you think that the requirements listed in the previous question are currently considered in forest management?*
3. Difficulties for approaching SFM: *how much do you think that the following aspects make difficult the development of SFM?*
4. Proposals for advancing towards SFM: *how much do you think that the following proposals contribute to the development of SFM?*

A set of items related to the topic was given to the respondents in each question as it is displayed in *Table 2*. In the first one, they were asked to order the requirements according to their importance for the implications of SFM. In the others they had to score the items in a value scale ranging from 1 to 5. Each question included a section for comments where respondents could also add items that had not been considered; this section was especially relevant for the proposals.

Data were analysed according to multicriteria analysis (MCA) techniques. MCA techniques are commonly used tools in the field of SFM for weighting a set of requirements and comparing management alternatives by stakeholders (Wolfslehner *et al*, 2005; Sheppard and Meitner, 2007; Jalilova *et al*, 2012). The methods applied in this study were used for similar purposes by different authors (Mendoza and Prabhu, 2000; Gómez-Orea, 2002). As a result, different values of relative relevance were obtained for each of the items in each question.

Topics	Items	Acronym	Description
Requirements	Forest management planning	**MP**	Existence of planning documents with management objectives and procedures
	Soil protection	**SP**	Measures to avoid soil erosion and degradation
	Biodiversity and habitat protection	**B&HP**	Steps to protect endangered species and their habitats
	Water resources conservation	**WRC**	Surface and underground water quality and quantity conservation
	Contribution to rural development	**RD**	Forestry as a rural economic sector that contributes to local economy
	Forest fires prevention and extinction	**FF**	Existence of firebreaks and appropriate forest structure to avoid the spread of the forest fires
	Improving quality of life	**LQ**	Leisure activities, job opportunities and public participation procedures
	Forest knowledge improvement	**FKn**	Data and cartography storage systems to improve management and research
	Landscape management	**LM**	Landscape conservation, management and improvement
	Pests treatments	**PT**	Biological pest control as far as possible
Difficulties	Lack of SFM guidelines	**Lgu**	Forest regulations do not specify how to carry on SFM
	Not coordination forest-land planning	**NcoF&LP**	Scarce interaction between forest and planning regulations
	Not compensation for externalities (refers to ecosystem services)	**NCE**	Lack of payment for ecosystem services provided: landscape, hydrology
	Small property size	**SPr**	Many private properties have less than 1 ha, so that management costs are higher
	Low productivity	**LoPr**	Low growth annual rate
	Higher costs of applying SFM	**HC**	SFM has more requirements than conventional management
	Human or natural origin hazards	**HoNHz**	Forest fires and floods
Proposals	SFM guidelines	**SFMGu**	Definition of management procedures according to sustainability criteria
	Government paper reinforcement	**GR**	In regulating forestry and mechanisms to achieve SFM
	Training of workers and professionals	**TW&P**	In SFM objectives and procedures
	Knowledge and information systems	**Kn&IS**	Public systems that report forests state to standardise working procedures
	Coordinate forest and land planning	**CoF&LP**	Consistent planning legislation that considers forestry
	Environmental impact assessment (EIA) process	**EIAP**	Environmental assessment for approval of forest plans and programmes

Table 2. Requirements of sustainable forest management (SFM), difficulties and proposals to achieve it, included in the questionnaire held to check opinion of forestry experts on sustainbility of Mediterranean forest management.

The analysis methods used were described by Gómez-Orea (2002). To obtain the aggregated value of each of the items in the first question:

1. All the numbers that each item got, which correspond to the orders assigned by the respondents (1 for the most relevant, 2 for the second most relevant and so on) were summed.
2. The sums obtained in step 1 were summed too.
3. To get the value of one single item, the sum obtained in step 1 was divided by the sum obtained in step 2. To check that the process was right all the final values were added and the result had to be equal to 1.

To obtain the aggregated value of each of the items in the other three questions the process was as it follows:

1. All the scores that each respondent gave to all the items were summed.
2. For each item, each of the scores given by each respondent was divided by the sum (calculated in step 1) of that respondent.
3. The value of each item was the average of the divisions calculated in step 2 (for that item, considering all the respondents). Again, to check that the process was right, the sum of the values had to be equal to 1.

Results and discussion

Respondents

There was a 27% response rate to the questionnaire: 67 answers out of 245 potential respondents. The percentage of respondents belonging to each of the groups stated in the methodology was the following: 33% from “universities” (22 answers), 37% from “central and regional governments” (25 answers), 15% from “research centres” (10 answers), 16% from “forest management enterprises” (11 answers), 9% from “forest associations” (6 answers), and 24% from “forest certification systems” (16 answers). The sum of percentages is higher than 100, this is explained because many of the respondents had a varied profile so that they were included in more than one group. The higher percentage of matches occured between "forest certification systems" and "forest management enterprises", and "forest certification systems" and "central and regional governments". The previous means that some of the people associated to a certification system work normally in an enterprise or in a public organisation.

Concerning age and sex, 21% were women and 79% men. Most of the respondents were older than 40 years, which was an expected value given that the questionnaire was for experts. The percentage of respondents in each age group was: 1.5% for less than 30 years old, 28% between 30 and 40 years old, 37% between 40 and 50 years old, and 33.5% more than 50 years old.

Requirements of sustainable forest management and their introduction into current management

According to the experts, the key requirement of SFM is *management planning* (MP) (*Figure 1*), followed by the protection of natural resources *-soil*, *biodiversity and habitat protection*, and *water resources* (SP, B&HP, WRC). *Rural development* (RD) is also one of the most important requirements, although it is a topic that concerns many sectors apart from forestry. The improvement of social and economic local conditions was perceived as a central issue in SFM. Apart from these requirements, experts suggested that SFM should also consider the adaptation of forest ecosystems and their management to climate change and promote educational and cultural aspects of forests such as the traditional uses.

On the opposite side, *pest treatments* (PT) emerges as the least important requirement for SFM. This low valuation can be explained by the perception of pest control as a matter of a higher planning level that goes beyond the role of the forest manager, reinforced by the existing laws on vegetation health which lay the major responsibility of pest control in the authorities (Gobierno de España, 2002).

Forest fires prevention and extinction (FF) is not considered a key requirement in SFM according to the consulted experts despite the high incidence of forest fires in Spain[5].Forest fires are a major problem in the Mediterranean region. The accumulation of fuel due to abandonment of forest management and summer droughts, combined with the negligence in the use of fire and vandalism from local population and tourists, are good circumstances for forest fire occurence (Martín *et al*, 1998). Forest abandonment is a major trend in European Mediterranean countries. The lack of management results in an enrichment of the understorey and the amount of tree branches, making the forest vulnerable to the spread of fire (Fabbio *et al*, 2003). However, similar to *pest treatments*, the result can be associated to the belief that forest fires are a problem that is mainly managed at a higher scale than the FMU.

With regard to *landscape management (LM)*, it was deemed as one of the least important requirements of SFM. This result agrees with the scarce consideration given by the promoters of SFM in their certification standards[6]. But, at the same time, this fact contrasts with the increasing importance of landscape in the European agenda (Council of Europe, 2000) and with the landscape qualities of the Mediterranean region due to historical modification of the natural environment that has evolved into a mosaic of vegetation types and land uses with ecological and cultural importance (Scarascia-Mugnozza *et al*, 2000).

Concerning the level at which SFM requirements are being considered, *forest fires prevention and extinction* emerges as the most introduced requirement, followed by the protection of natural resources (SP, B&HP, WRC), *management planning* and *pests treatments* (*Figure 1*).

[5] The average number of fires per year in Spain for the period 2000 - 2009 is 6500 (including attempts - <1ha - and disasters - >1ha). The average forest area affected by fires per year in Spain for the same period is 27514ha (MARM, 2010b).

[6] Through the revision of the standards of the certification associations established in Spain, it can be seen that PEFC (AENOR, 2007a; 2007b) slightly considers landscape when assessing at regional level, and not at FMU; FSC (GTC-FSC, 2007) establishes that an environmental impact assessment (EIA) has to be carried out before the forest activity takes place, which has to take into account landscape an any other impacts caused by the activity, but does not have any specific principle or criterion for landscape.

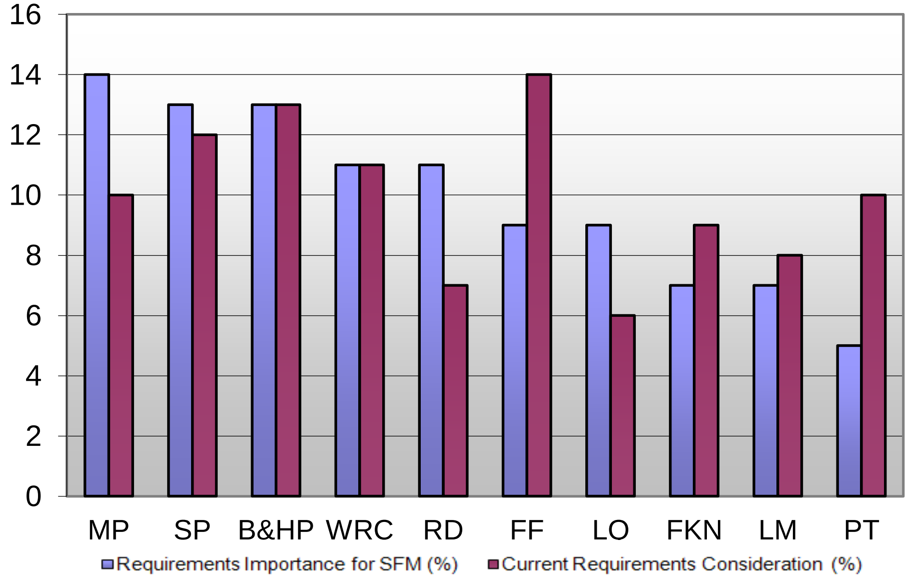

Figure 1. Comparison between the relative importance (left columns) of the requirements for SFM and their current consideration (right columns) in forest management according to the experts' opinion.
Requirements-MP: Management Planning; SP: Soil Protection; B&HP: Biodiversity&Habitats Protection; WRC: Water Resources Conservation; RD: Rural Development; FF: Forest Fires; LQ: Life Quality Improvement; FKN: Forest Knowledge Improvement; LM: Landscape Management; PT: Pest Treatments.

When comparing the results obtained from these first two questions (*Figure 1*), it is found out that the introduction of the requirements mentioned in current forest management does not necessarily correspond with the valuation relative to its importance. In this regard, three situations are identified. Firstly, there are a set of requirements whose importance is much higher than their level of current introduction. This situation is especially noticeable for *management planning*, which is the most important requirement for SFM but only 12% of the forest area in Spain has a forestry management plan (MARM, 2008). *Rural development* and *life quality improvement* (LQ) were also seen as being under-considered in comparison with their perceived importance. Secondly, there are those requirements whose level of current introduction is much higher than its importance such as *forest fires prevention and extinction* and *pest treatments*; this also explains why they did not get high relevance scores, they were not considered a priority. Finally, the third situation corresponds to those requirements whose importance is consistent with its level of introduction, like the protection of natural resources (SP, B&HP and WRC), *forest knowledge improvement* (FKN) and *landscape management*.

Difficulties and proposals for the implementation of sustainable forest management

The relevance of the difficulties provided in the questionnaire according to the experts' answers is shown in *Figure 2*. The main ones have an economic origin. Management does not happen because it is not profitable. Lack of profitability is firstly due to the *small size* of most *private forest properties* (SPr). Secondly, it is due to the *low productivity* (LoPr), typical of fragile and unstable ecosystems like the Mediterranean ones (Scarascia-Mugnozza *et al*, 2000).

The *lack of compensation for the positive externalities* (NCE) that forests provide to society is an additional difficulty considering that there is an increased demand for services like recreation and landscape in urban societies of northern Mediterranean countries (Scarascia-Mugnozza *et al,* 2000). The problem is that it is difficult to give market values to these services and, considering the generally low profitability of Mediterranean forests stated before, this results in a diminished interest of forest owners in managing their lands for such purposes. The recovery of forest management requires the creation of mechanisms to pay for these externalities[7] (Merlo and Rojas, 2000).

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[7] An externality is an unwished byproduct (positive or negative) from an economic activity that has an effect on a person different from the user or consumer of the outputs of that economic activity. In forest management refers to the ecosystem services (ES) derived from forests: landscape, spaces for recreation, soil erosion prevention or habitat conservation.

Another relevant difficulty is the *lack of coordination between forestry planning and land management* (NCoF&LP). Forestry and land management planning programs are in charge of different departments and, up to the present time, there has been neither a good communication nor a will of coordination. It is worth encouraging the interaction between both programs considering the essential role that land management plays in Mediterranean forests (Montiel and Galiana, 2005).

Other difficulties suggested by the experts are mentioned next. There is a lack of social awareness, which results in low valuation of the forest and low demand of its products. The economic context of the forest sector involves difficulties such as lack of enterprises, low added value of forest products, and the global economic crisis; this last one is a difficulty due to the reduction of resources, so that the available ones go to other sectors and not the environment. The political context consisting of short-term objectives and the fact that the forest sector is subordinated to urban planning implies another barrier. Moreover, forestry actors (stakeholders and management organisations) do not communicate well. Finally, there is a lot of legislation which is not always well connected, it is contradictory and sometimes very protectionist.

To overcome the difficulties and improve management, some proposals are suggested. They are based on the fact that to achieve SFM it is required that both production capacity and provision of ecosystem services are preserved. Flexible management procedures need to be identified together with a good comprehension of dynamics and functional processes of forests (Fabbio *et al*, 2003). The proposals refer to four main topics: economic proposals; forest research and inventory; payment for ecosystem services (PES); and awareness and training. These four blocks are a mix of the proposals of the questionnaire which got the highest scores and the ones suggested by the experts.

The economic proposals received a high emphasis because Mediterranean forests need to be more profitable, so that management takes place. It is inferred from the results that actions may come from both the public and the private sides, because forestry is a combination of actions from the FMU (private side), which acts as an enterprise that generates revenues to its owners, and the authorities (public side), since it provides societal benefits (ecosystem services). More precisely, concerning the private side, experts recommended to develop marketing strategies for the forest products which are underexploited (forest fruits or aromatic plants), and to search for new markets (bioenergy was suggested). On the other hand, even though it was not explicitly mentioned by the experts, the public side could perhaps focus on developing policies that consider the interaction between forestry and land planning and which provide subsidies. According to the answers, it would be desirable to adopt a policy tools mix that allows the use of regulatory and voluntary approaches. Voluntary approaches are based on financial incentives, market means and persuasion-communication measures. This mix would require involvement of central and local authorities, and a great degree of people participation.

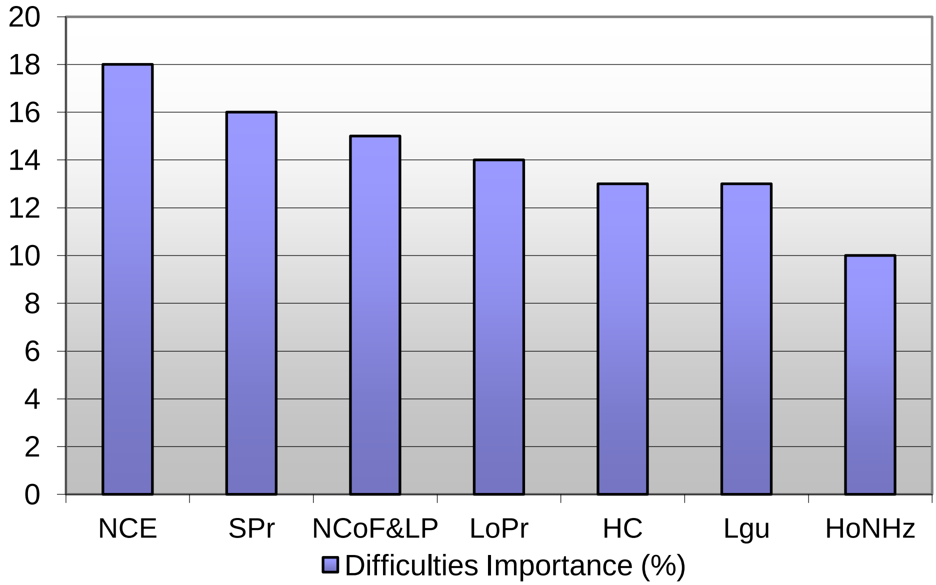

Figure 2. Relative importance of the difficulties that current forest management presents towards the implementation of sustainable forest management (SFM) according to the experts answers. Difficulties-NCE: Not Compensation for Externalities; SPr: Small Property Size; NCoF&LP: Not Coordination Forest-Land Planning; LoPr: Low Productivity; HC: Higher Costs of Applying SFM; Lgu: Lack of SFM Guidelines; HoNHz: Human or Natural Origin Hazards.

In reference to forest research and inventory, respondents proposed to increase economic resources for forest research with the objectives of improving the efficiency (mechanisation, silvicultural treatments) and increasing data on the forest ecosystem. Therefore, it would be advisable to start this creating forest knowledge systems as well as local and regional information systems in order to easily identify necessities by monitoring and assessing the development of the management. Some authors point out the importance of quality data availability: *lack of information in a usable form and efficient transfer of data to appropriate users have been barriers to utilizing the best available knowledge in Mediterranean ecosystem management and to identifying priorities for research* (Ribeiro *et al*, 2004).

An important proposal is the implementation of PES. These are mechanisms which are getting extended and consist of an agreement between the ecosystem service producer (the forest owner in this case) and the group of people benefiting from it. If the group of people benefiting from the service is big enough, then a public entity pays for it; if it is a specific group, its members pay for it (Generalitat Valenciana, 2010).

Experts recommended the need to raise social awareness on forests and environmental issues in order to increase forest products demand and people's willingness to pay for the ecosystem services provided. It could be furthermore recommended the promotion in the media and through education in high schools. It was also suggested by the experts to include training programs in good practices for forest workers and professionals.

No specific proposal was made by the respondents to improve connection and harmonisation between forestry planning and land management. However, it seems important to find a way because Montiel and Galiana (2005) suggest reinforcing this component in the regional forest programmes in order to minimise some of the problems introduced, such as the land owner conflicts that originate forest fires. In their own words: c*onflicts found in Mediterranean forests are more closely related to land use planning than to the harmony of forest uses* *and functions*. The coordination between both disciplines would help to increase contribution of forestry to rural development since the last one is a topic covered not just by the forest sector but by others such as agriculture or industry.

Conclusions

SFM is a central topic in forestry discussions. It is the management of forests according to principles of sustainability in order to maintain and enhance long-term health of forest ecosystems, while providing economic, social and cultural opportunities for the benefit of present and future generations. But the approach to the matter is not universal, so it is important to define principles and criteria for every region as well as for each particular management unit.

This research investigated the requirements of SFM in the Mediterranean region, analysed the situation of forest management in Spain, and explored ways so that forestry happens according to sustainable practices. By means of a review and an expert consultation the objectives were met.

Results indicate that the most important requirements of SFM are *forest management planning*, *conservation of natural resources* (biodiversity, habitats, soil and water resources), and *contribution to rural development*. But the introduction in current management of these requirements does not correspond to their relevance for the implications of SFM: few FMUs have a forestry management plan, *contribution to rural development* is also scarcely considered; on the other hand, *forest fires* and *pest treatments* have a medium relevance compared to their degree of introduction, which is high.

There are several reasons that explain the situation described above. Mediterranean forests have little profitability, because of their *low productivity* and in the private forests the *small size of the properties*. Mediterranean forests provide society with *ecosystem services* that *are not economically compensated* to the owners. Additionally, the *lack of coordination between forestry and land management* leaves the sector as a marginal issue that is subordinated in most cases to urban planning. All this has led to a progressive abandonment of forest management. If one also considers that SFM implies *higher costs* than traditional management, it is highly unlikely to be implemented widely in Spain given the current situation.

Some actions can be proposed in order to change the present situation. The core of the proposals is economic, and they focus on looking for new markets, PES mechanisms, and subsidies. To achieve this, steady and flexible policies to build new management models in coordination with land management are required. It is also important to reach a higher social awareness and interest in forest issues and products; publications, newsletters, conferences, school education and professional training can play an important role in completing this. Another important matter is the generation and access to information that reports on forests state, which shows the issues where research is needed and the management priorities.

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Chapter 3-Paper 2

Participatory development of decision support systems: which features of the process lead to improved uptake and better outcomes?

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Reference:

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Abstract

Decision support systems (DSSs) are important in decision making environments with conflicting interests. Many DSSs developed have not been used in practice. Experts argue that these tools do not respond to real user needs and that the inclusion of stakeholders in the development process is the solution. However, it is not clear which features of participatory development of DSSs result in improved uptake and better outcomes.

A review of papers, reporting on case studies where DSSs and other decision tools (information systems, software and scenario tools) were developed with elements of participation, was carried out. The cases were analysed according to a

framework created as part of this research; it includes criteria to evaluate the development process and the outcomes.

Relevant aspects to consider in the participatory development processes include: establishing clear objectives, timing and location of the process; keeping discussions on track; favouring participation and interaction of individuals and groups; and challenging creative thinking of the tool and future scenarios. The case studies that addressed these issues show better outcomes; however, there is a large degree of uncertainty concerning them because developers have typically neither asked participants about their perceptions of the processes and resultant tools, nor have they monitored the use and legacy of the tools over the long-term.

Keywords: decision support systems, decision tools, participatory development process, process features, outcomes.

Introduction

Decision support systems (DSS) provide much needed organisation to make decisions within complex systems (Bennet and Bennet, 2008). Such tools consist of a data and model management system and a user interface (Cain *et al*, 2003). The increasing focus on multi-purpose forestry and the resulting wide ranging and often competing demands placed upon forests means that the potential for DSSs to assist in decision-making processes has been heightened (Lawrence and Stewart, 2011).

A range of DSSs have been developed, but only a few have actually been adopted. Some authors argue that the needs and requirements of users have frequently not been met (Lawrence and Stewart, 2010); others suggest the cost of the tools is very high or that they are irrelevant, unreliable and inflexible (Breuer *et al*, 2008; Evers, 2008; Kizito, 2008; van Meensel *et al*, 2012). To overcome these deficiencies, changes are required. More specifically, the participation and feedback of potential users and other stakeholders is necessary throughout DSS~~s~~ development processes (Breuer *et al*, 2008; van Meensel *et al*, 2012).

Participation improves uptake and DSS effectiveness because the process and outputs better meet stakeholders' expectations and address problems relevant to decision-makers (van Meensel *et al*, 2012). For example, in *AgClimate*, participation guided the development of a DSS developed in the US for rainfall prediction. The involvement of farmers and extension agents increased their awareness and interest in climate forecasts and improved the value of the DSS (Breuer *et al*, 2012). Similarly, in *WaterSense*, a DSS designed in Australia for scheduling limited water supplies, participants emphasized learning as an important outcome; changes in stakeholder values and behaviour are also considered to be valuable outcomes by many developers that use participatory processes (Jakku and Thorburn, 2010).

More positive attitudes towards DSSs and higher uptake levels are fostered when the potential users are involved in the development process. However, what is less well understood is which particular features of the participatory development process are most significant in terms of improving outcomes. In a review of these issues, Lawrence and Stewart (2010) found that much more has been written about the process of stakeholder participation, and less about the outcomes. Nevertheless, they note that evidence does exist, but that it is scattered across the scientific literature, and therefore somewhat hidden. The aim of this research is to analyse that literature rigorously, in order to find out these characteristics.

Material and methods

A systematic review of case studies reporting on DSSs developed in a participatory way was carried out. In order to get a bigger number of papers, other decision tools were included: information systems (IS), and scenario and software development tools. Also, the search was not restricted to forestry case studies to come up with as many cases as possible; the literature on the topic was found to be scarce. Three weeks were spent on this, looking into these search engines: *Web of Knowledge, Google Scholar, Scopus, Scirus and Taylor and Francis*. 24 articles were selected for meeting the requirement of reporting on decision tools developed by means of participation and for providing enough information that allows carrying out an assessment according to a framework whose development and content is explained later in this section. Some articles included two case studies which were analysed separately, resulting in a total of 29 case studies as described in *Table 3.*

A framework for the analysis of case studies was also developed, drawing on a wider participatory evaluation literature. This highlighted the need to distinguish between evaluation of the development process, and evaluation of the outcomes (Rowe and Frewer, 2000; Lawrence, 2006; Blackstock *et al*, 2007). A two part framework was therefore designed. Framework criteria were assessed based on relating information contained within each paper: either quotations from participants or statements from developers of the process. The evaluation was carried out by the first author of this paper and a score of low, moderate or high was given to each criterion depending on the degree to which it was met; an uncertain category was also used where evidence was missing or unclear. The evaluation of each criterion was accompanied by the evidence from the text that supported it, as it can be seen in *Annex 2*, so that it can be verified and judged by the reader. *Tables 4, 5, 6* and *7* show the criteria employed, their definitions and their sources.

Based on the authors' own experience and a general overview of the papers, four stages of tool development process were identified: scope, prototype, usability, and testing. Scope covers the initial meetings where the objectives and context of the tool are established. Prototype is the stage in which an early concept of the look and feel of the tool is developed and tested by the stakeholders. The usability stage involves the tool being improved in terms of its appearance and ease of use. In the testing stage a trial of the tool is undertaken before its release. The assessment of the development process of each of the case studies involved considering the same criteria (*Table 4*) for each of the four stages of development. It was also assessed in each stage the degree of involvement of stakeholders according to the scale presented in *Table 5*, this concept refers to the degree to which stakeholders are engaged in the process (Reed, 2008), also described as a ladder of participation that ranges from passive information to active engagement (Arnstein, 1969).

Concerning the outcomes, two sets of criteria were used to evaluate them. 1) Criteria evaluating personal outcomes: attitude changes and stakeholders' perceptions towards the decision tool, its context and the decision problem, and the participatory development process (*Table 6*). And 2) criteria evaluating factual outcomes: changes the tool and the development process have brought or influenced (*Table 7*).

Case study	**Topic area**	**Type of tool**	**Sources**
1	Agriculture	DSS	Breuer *et al*, 2008.
2	Agriculture	DSS	Jakku and Thorburn, 2010.
3	Water management	DSS	Schielen and Gijsbers, 2003.
4	Water management	DSS	Bunch and Dudycha, 2004.
5	Medicine	DSS	Peleg *et al*, 2009.
6	Land management	DSS	Reed and Dougill, 2010.
7	Land management	DSS	Barac *et al*, 2004.
8	Agriculture	DSS	Cain *et al*, 2003.
9	Agriculture	DSS	van Meensel *et al*, 2012.
10	Forestry	DSS	von Geibler *et al*, 2010.
11	Agriculture	DSS	Newman *et al*, 2000.
12	Medicine	DSS	Thursky and Mahemoff, 2007.
13	Water management	DSS	Kizito, 2008.
14	Land management	IS	Drew *et al*, 2004.
15	Business	IS	Jiye and Wenmo, 2008.
16	Medicine	IS	Byrne and Sahay, 2007.
17	Medicine	IS	Driedger *et al*, 2007.
18	Water management	Software development	Kautz, 2011.
19	Business	Software development	Iivari, 2011.
20	Business	Software development	Iivari, 2011.
21	Land management	Scenario development	Chakraborty, 2011.
22	Land management	Scenario development	Chakraborty, 2011.
23	Agriculture	Scenario development	Atwell *et al*, 2011.
24	Land management	Scenario development	Kowalski *et al*, 2009.
25	Land management	Scenario development	Kowalski *et al*, 2009.
26	Water management	Scenario development	Cinderby *et al*, 2011.
27	Water management	Scenario development	Cinderby *et al*, 2011.
28	Water management	Scenario development	Jessel and Jacobs, 2005.
29	Agriculture	DSS	Cain *et al*, 2003.

Table 3. Case studies revealed by the literature review.

Criteria	Definition	Sources
Structured group interaction	Control of the meeting is with the planners of the process, who allow participation and interaction of all participating individuals and groups and keep discussions on track.	Tuler and Webler, 1999; Rowe and Frewer, 2000; Menzel *et al*, 2012.
Representation	Diversity of views and spread of representation from affected interests.	Rowe and Frewer, 2000; Blackstock *et al*, 2007; Menzel *et al*, 2012.
Opportunity to influence process development and outputs	Participant's opportunity to influence, express their preferences and values. This is achieved considering the following: enough time to participate, stakeholders involved early enough, clear structure of the process, etc.	Sheppard and Meitner, 2005; Blackstock *et al*, 2007; Menzel *et al*, 2012.
Quality and selection of information and resources	Adequacy, quality and quantity of information provided. Necessary resources include: (1) information resources (summaries of the pertinent facts), (2) human resources (access to scientists, witnesses or decision analysts), (3) material resources (overhead projectors, whiteboards) and (4) time resources (participants should have sufficient time to make decisions).	Rowe and Frewer, 2000; Blackstock *et al*, 2007; Menzel *et al*, 2012.
Challenging status quo and fostering creative thinking	Process encourages questioning the status quo and challenges the imagination of alternative futures.	Innes & Booher, 1999; Menzel *et al*, 2012.
Clear mandate and goals	The nature and scope of the participation tasks are clearly defined at the beginning of the process: scope, time and place of the meetings, expected output, mechanisms for the process, and expectations towards participants.	Duinker, 1998; Rowe and Frewer, 2000; Menzel *et al*, 2012.
Transparency	Participants understand how decisions are made.	Blackstock *et al*, 2007; Menzel *et al*, 2012.
Independence and neutrality of the process	The process is conducted in an independent manner. Participants are free to conduct themselves in a voluntary and self-directed manner, without coercion. The process seeks the common good, not just accommodating specific interests.	Rowe and Frewer, 2000; Sheppard *et al*, 2004; Menzel *et al*, 2012.
Conflict resolution	The way conflict among participants is resolved during the process.	Blackstock *et al*, 2007.
Develop a shared vision and goals	The creation of an agreed vision, objectives and goals for the process/project.	Blackstock *et al*, 2007.

Table 4. Criteria to evaluate each stage of the development process of the decision tools (scope, prototype, usability and testing). The table also shows the definition of the criteria and their sources.

Level	Definition	Sources
Inform	To provide participants with objective information to help them understand the problems, alternatives, and solutions. Suitable for more knowledge-base decisions (e.g., technical risks assessments).	Rowe and Frewer, 2000; Blackstock *et al*, 2007; Forestry Comission, 2011.
Consult	To obtain public feedback on analysis, alternatives or decisions. It is used when decisions are being shaped and information can improve them. Developers are not obliged to take participants' views into account.	Pretty, 1995; Blackstock *et al*, 2007; Forestry Commission, 2011.
Involve	To work directly with the public throughout the process to ensure that public concerns and aspirations are understood and considered. Involvement may be interactive and include some kind of shared decision making, but major decisions are made by developers.	Pretty, 1995; Forestry Commission 2011.
Partnership	To partner with the public each aspect of the decision including the development of alternatives and the identification of the preferred solution. Participation is perceived as a right, not just as a means to achieve project goals.	Pretty, 1995; Forestry Commission 2011.
Empower	To place final decisions in the public. To achieve this, developers have to support people with information. Suitability towards this degree increases the less knowledge-based and the more value-based the decisions are.	Rowe and Frewer, 2000; Lawrence, 2006; Forestry Commission, 2011.

Table 5. In each stage of the development process of the decision tools (scope, prototype, usability, testing) the degree of involvement of stakeholders according to the scale presented in this table (which is adapted from *The International Association for Public Participation* and presented in Forestry Commission 2011, and State of Victoria 2005) is evaluated.

Frequency tables for the number of times each criterion was given a certain score were developed and then transformed into graphical outputs (see *Figures 3*, *4*, *5*, *6*, *7* and *8* in the results section). The aim of this step was to see the predominant scores in each criterion. Then, the criteria score profile of each case study (that means, the score that all the criteria get in each case study) was written down in an excel file. This information was used to complete a PCO in order to visualise the similarities within the criteria scores of the 29 case studies.

Criteria	Definition	Sources
Relationships and social capital building	Creation of new social networks and reinforcement of existing ones as a result of the process.	Blackstock *et al*, 2007; Menzel *et al*, 2012.
Acceptance of process and outputs	Different parties involved (developers, participants) report that the process or the resultant outputs address their needs, concerns, expectations or values.	Moote *et al*, 1997; Rowe and Frewer, 2004; Blackstock *et al*, 2007; Menzel *et al*, 2012.
Recognised impacts	Participants perceive their recommendations from the process in the outputs.	Blackstock *et al*, 2007.
Social learning	The way that the process has changed individual and group values and behaviour.	Blackstock *et al*, 2007.

Table 6. This table displays the criteria, their definitions and their sources, to evaluate the personal outcomes of each case study.

Criteria	Definition
Objectives met	The objectives of the participatory process have been met (usually the development of certain decision tools).
Uptake of the tool	The created decision tools are demanded/used.
Legacy	Long lasting use or continuity in the use of the tools.
Impact on policy making	Whether tool helps making policy, or decision-makers informing policies.
Impact on users' practice	The tool improves users activity (reduced times, better outcomes, etc.).

Table 7. This table displays the criteria, and their definitions, to evaluate the factual outcomes of each case study.

PCO takes a similarity matrix constructed between every possible pair of case studies. To estimate the similarity between two case studies, a score and weight were calculated for each criterion: the weight prioritises when a criterion gets a score in both case studies (low, moderate or high), compared to when one or both of them are categorised as uncertain; the score prioritises the closer the evaluation of any criterion in both case studies is (it will be higher if both case studies are categorised as uncertain than if just one does, and it will be higher if both are scored low than if one scores low and the other high). The final similarity score for each pair of case studies was obtained by adding the scores of all the criteria together and dividing by the sum of the weights, resulting in a value between 0 and 1. For the calculation of the similarity matrix, a single number for the four development process stages was used for each development process criteria; it corresponded to the last chronological score (chronology: scope, prototype, usability and testing stages), for example, if a criterion was evaluated the following way across four development stages: low, uncertain, high, uncertain, it would be scored "high" for calculating the matrix. These were the equations used for calculating the scores and the weights:

1. If both case studies (*i*, *j*) were given a score for development criteria *k*, then:
   $\text{Score}_k = 1 - [\text{abs}(\text{score}_{ik}\text{-score}_{jk})/2]$
   with $\text{Weight}_k = 1$
2. If both case studies (*i*, *j*) were uncertain for development criteria *k*, then:
   $\text{Score}_k = 0.2$ with $\text{Weight}_k = 0.2$
3. if one case study was uncertain whilst the other was given a score for development criteria *k*, then:
   $\text{Score}_k = 0$ with $\text{Weight}_k = 0.2$

Afterwards, the PCO algorithm was used to estimate coordinates for each case study in such a manner that most of the variance in the data was captured in the first axis, with each subsequent axis containing progressively less information. It was then possible to visualize the main structures in the data by plotting the first two axes against each other (see *Figures 9* and *10* in the results section). Case studies that were positioned close together in the PCO plot would be expected to have a similar criteria score profile. Further interpretations of case study clusters were required: groupings might occur where most criteria were scored high, uncertain, or a group may exist where a specific subset of criteria was constantly scored high with other criteria scored low.

Figures 9 and *10* (see results section) highlight different features of the case studies and it can be seen that the ones in the lower left quadrant perform better than those in the others. More details are given in the next section, but considering this fact two groups of case studies were created for comparing their criteria score profiles: those in the lower left quadrant (LL), against those in the upper right (UR). The UR group was broadened by adding cases out of both quadrants that develop a DSS. It was done like this so that the two groups had a similar number of cases (LL: 14; UR: 12) and because DSSs were the tools originally aimed to look at in this study. Therefore, the following case studies form the LL group: 2, 4, 5, 8, 14, 16, 18, 21, 22, 23, 25, 26, 27, 28; and form the UR group: 1, 3, 6, 7, 9, 10, 11, 12, 13, 19, 20 and 29 (see *Table 3* for a complete reference of the case studies). For the comparison, the score profiles of the case studies of each group were put together (see *Tables 8*, *9*, *10*, *11*, *12* and *13* in the next section), separating development process and outcomes for both groups.

Results

Not all case studies included information on the four process development stages: 26 cases included the scope stage, 6 discussed the prototype stage, 7 explored the usability stage and 5 described the testing stage. However, this is not reflected in *Figures 3*, *4*, *5* and *6*, the uncertainty shown in their graphs corresponds to case studies showing evidence on that stage but categorised as “uncertain” for that specific criterion.

In the scoping stage (*Figure 3*), the criterion with the lowest degree of uncertainty is *representation*, and the one with the highest is *conflict resolution.* For all the criteria, the score “high” is the most frequent. *Structured group interaction, opportunity to influence outputs and process development,* and *challenging status quo* are found to be the criteria with strongest evidence of impact after *representation*. In relation to the degree of stakeholder involvement (see *Table 5*), “involve” is the most frequently recorded (50% of the case studies).

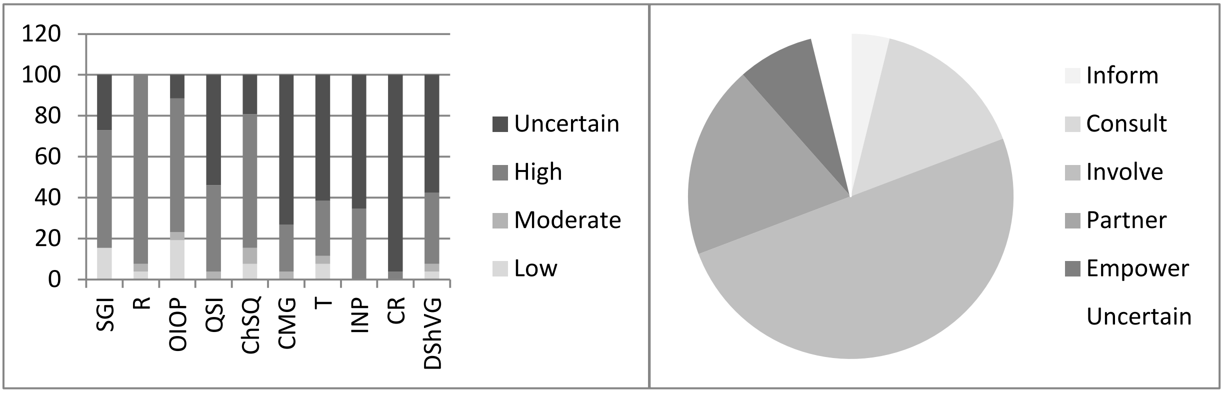

Figure 3. This figure shows, on the left, what percentage of case studies in each criterion has been scored as “low”, “moderate”, “high” or “uncertain” in the scope stage. On the right, it shows the percentage of case studies that fit the different degrees of stakeholder involvement in the scope stage.

SGR: structured group interaction; R: representation; OIOP: opportunity to influence outputs and process development; QSI: quality and selection of information; ChSQ: challenging status quo; CMG: clear mandates and goals; T: transparency; INP: Independence and neutrality of the process; CR: conflict resolution; DShVG: develop a shared vision and goals.

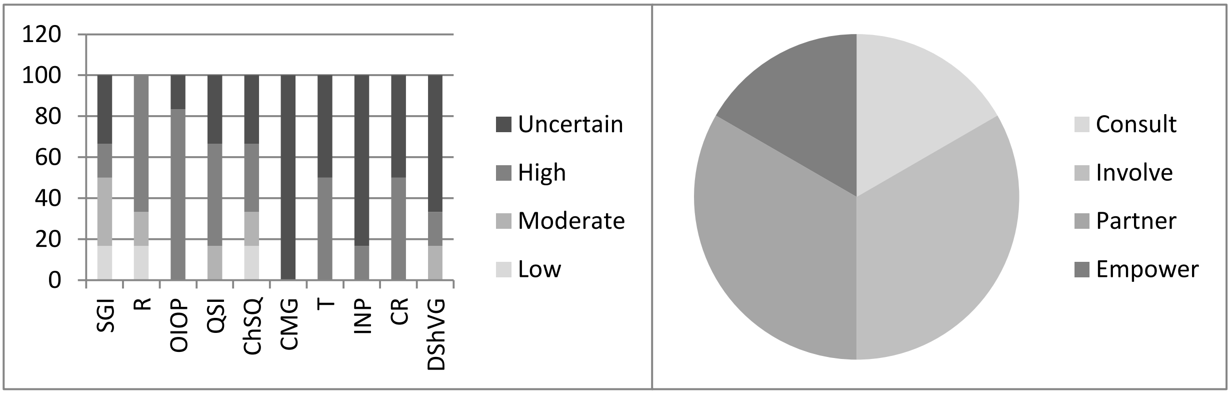

Figure 4. This figure shows, on the left, what percentage of case studies in each criterion has been scored as “low”, “moderate”, “high” or “uncertain” in the prototype stage. On the right, it shows the percentage of case studies that fit the different degrees of stakeholder involvement in the prototype stage.

SGR: structured group interaction; R: representation; OIOP: opportunity to influence outputs and process development; QSI: quality and selection of information; ChSQ: challenging status quo; CMG: clear mandates and goals; T: transparency; INP: Independence and neutrality of the process; CR: conflict resolution; DShVG: develop a shared vision and goals.

The level of uncertainty remains about the same in the prototype stage (*Figure 4*). The score “high” reduces in favour of more “moderate” and “low” scores. Concerning the degree of involvement, there is a slight reduction of “involve” cases and an increase of “partner” and “empower”.

The results for the usability stage criteria remain similar to previous stages (*Figure 5*); *structured group interaction* is an exception because the amount of uncertainty increases noticeably. The score “high” remains frequent. In this stage, the main type of stakeholder involvement is “consult”.

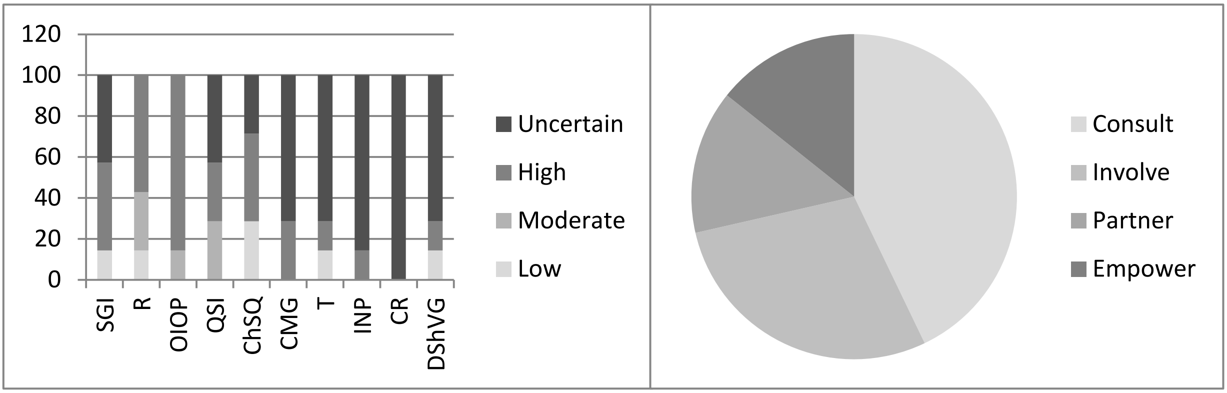

Figure 5. This figure shows, on the left, what percentage of case studies in each criterion has been scored as “low”, “moderate”, “high” or “uncertain” in the usability stage. On the right, it shows the percentage of case studies that fit the different degrees of stakeholder involvement in the usability stage.
SGR: structured group interaction; R: representation; OIOP: opportunity to influence outputs and process development; QSI: quality and selection of information; ChSQ: challenging status quo; CMG: clear mandates and goals; T: transparency; INP: Independence and neutrality of the process; CR: conflict resolution; DShVG: develop a shared vision and goals.

In the testing stage (*Figure 6*), it is interesting to note that there is an increase in the number of cases which can be described as fitting “empower” degree of stakeholder involvement (40%).

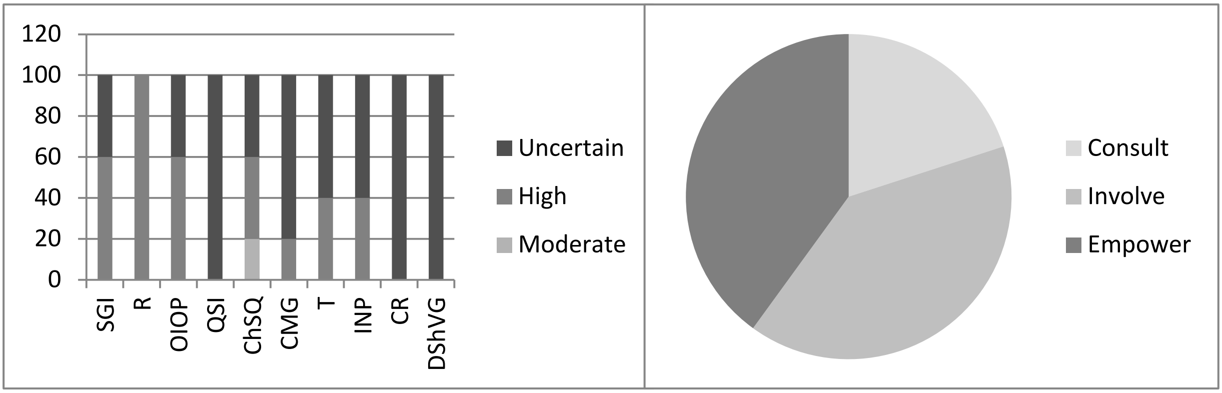

Figure 6. This figure shows, on the left, what percentage of case studies in each criterion has been scored as "low", "moderate", "high" or "uncertain" in the testing stage. On the right, it shows the percentage of case studies that fit the different degrees of stakeholder involvement in the testing stage.

SGR: structured group interaction; R: representation; OIOP: opportunity to influence outputs and process development; QSI: quality and selection of information; ChSQ: challenging status quo; CMG: clear mandates and goals; T: transparency; INP: Independence and neutrality of the process; CR: conflict resolution; DShVG: develop a shared vision and goals.

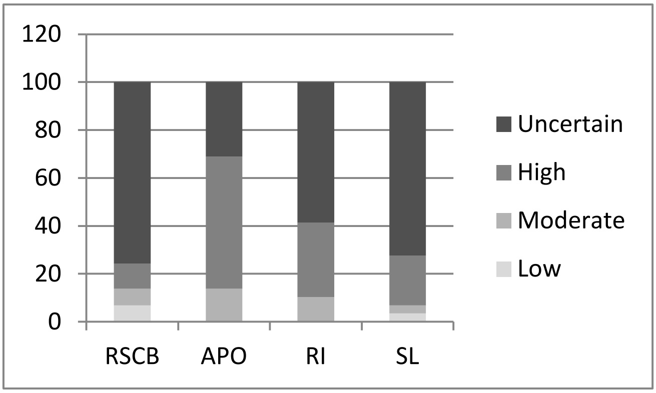

Figure 7. This figure shows what percentage of case studies in each personal outcome criterion has been scored as "low", "moderate", "high" or "uncertain".

RSCB: relationships and social capital building; APO: acceptance of process and outputs; RI: recognised impacts; SL: social learning.

In relation to personal outcomes (*Figure 7*), the criterion with the lowest uncertainty is *acceptance of process and outputs*. The other criteria (see *Table 6*) score predominantly “high”, but they show high levels of uncertainty (more than 50%). The factual outcomes (see *Table 7*) reveal “high” scores but, with the exception of the criterion *objectives met*, the others have more than 70% of uncertainty (*Figure 8*).

Figure 9 shows that case studies in the lower left quadrant have between 6 and 10 development criteria scored and an average score between 2.6 and 3, whereas the cases in the upper right one have between 2 and 6 criteria scored and average scores between 2 and 2.5. Regarding the outcomes, the graph shows that most of the case studies having a high average score (over 2.6) are concentrated in the lower left quadrant; these average scores include the factual and personal outcomes together.

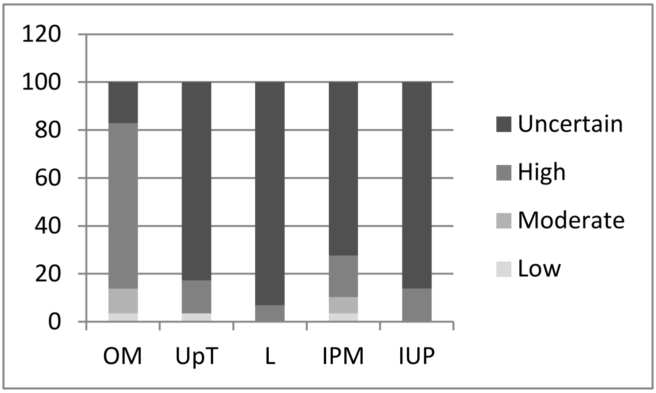

Figure 8. This figure shows what percentage of case studies in each factual outcome criterion has been scored as “low”, “moderate”, “high” or “uncertain”.
OM: objectives met; UpT: uptake of the tool; L: legacy; IPM: impact on policy making; IUP: impact on users’ practice.

Figure 10 shows that in the lower left quadrant 10 out of 14 cases carry out an “involve” degree of stakeholder involvement, there is also one “partner” case and two “empower”. On the other hand, in the upper right quadrant three case studies are consultative, one informative and only two “involve”. Note that *Figure 10* shows the last chronological degree of involvement of the four development stages, excluding those stages that were not considered in the case study.

The main findings from comparing the criteria score profiles of the LL and the UR groups are now reported. Regarding the development process (*Tables 8* and *9*), *structured group interaction* gets a high average score (2.85) in the LL group and is scored in 13 of the cases, whereas for the UR it gets a medium score (2.2) and is only scored in 5 cases. *Opportunity to influence process development and outputs* and *challenging status quo* also show higher scores and lower uncertainty in LL compared to UR. There is also a contrast between both groups for *clear mandates and goals*: it has 100% uncertainty in the UR group and gets a high score (2.86) in the LL group. It happens in the two groups that the number of case studies that consider the prototype, usability and testing stages is small; thus, these results are based in the comparison of the scores for the scope stage. Note that these scores do not coincide with the ones displayed in *Figure 9*, which are the ones used to develop the similarity matrix as it has been explained in the material and methods section.

Referring to the factual outcomes, *Tables 12 and 13* show good scores in both groups for the criterion *objectives met*, which also has the lowest uncertainty. There is diversity in scores for the other factual outcome criteria: LL gets high scores for all of them, whereas UR has moderate or low scores; however, they show a high level of uncertainty in both groups. The personal outcomes (*Tables 10* and *11*) *acceptance of process and outputs* and *recognised impacts* get high scores in both groups but there is higher uncertainty in the UR group. *Relationships and social capital building* and *social learning* have a high degree of uncertainty in both groups and moderate results, except for *social learning* that gets a high score in LL.

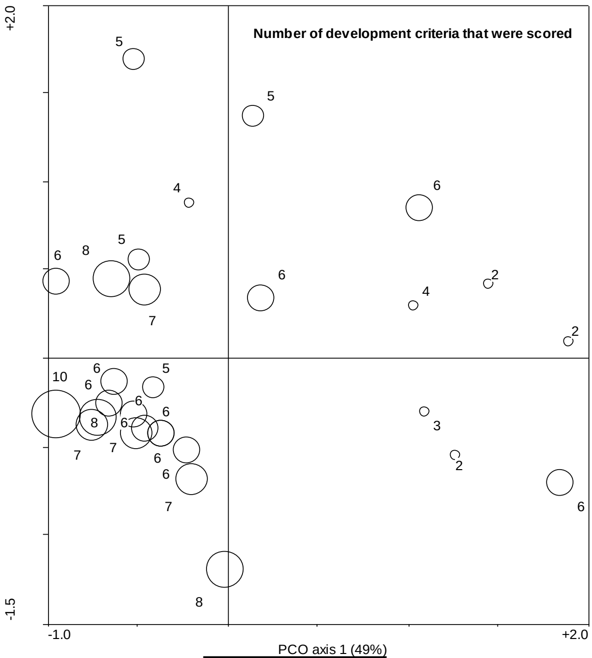

Figure 9a

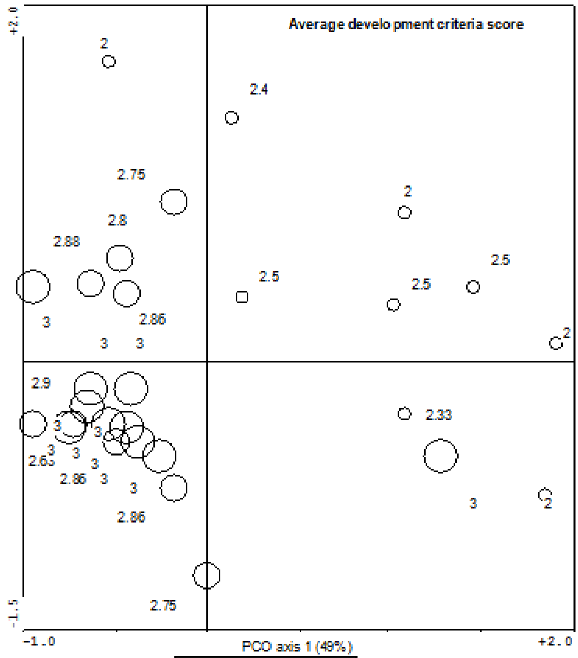

Figure 9b

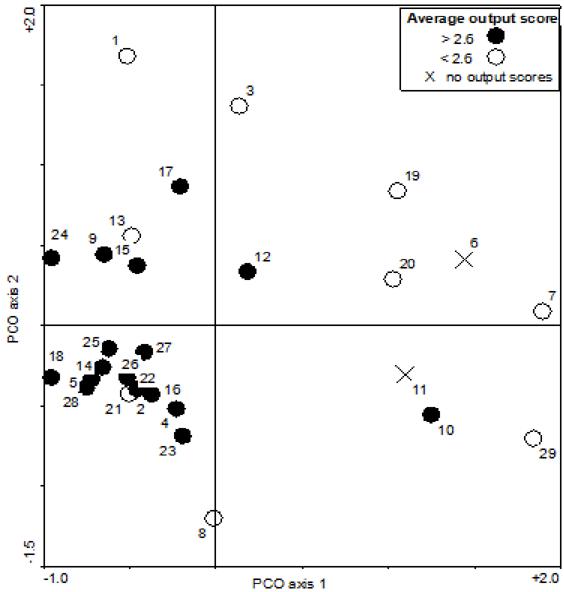

Figure 9c

Figure 9. These figures display for all the case studies their coordinates, which result from applying the PCO algorithm and plotting the first two axes (capturing most of the variance) against each other. *Figure 9a* shows the number of criteria that get a score ("low", "moderate" or "high") in the development process for each case study (each case study is represented by a circle). *Figure 9b* reflects the average score of the criteria not categorised as uncertain in the development process for each case study (low=1, moderate=2, high=3). *Figure 9c* presents which case studies get an average outcome score above and below 2.6; again only for the criteria not categorised as uncertain and according to the same scale of *Figure 9b*.

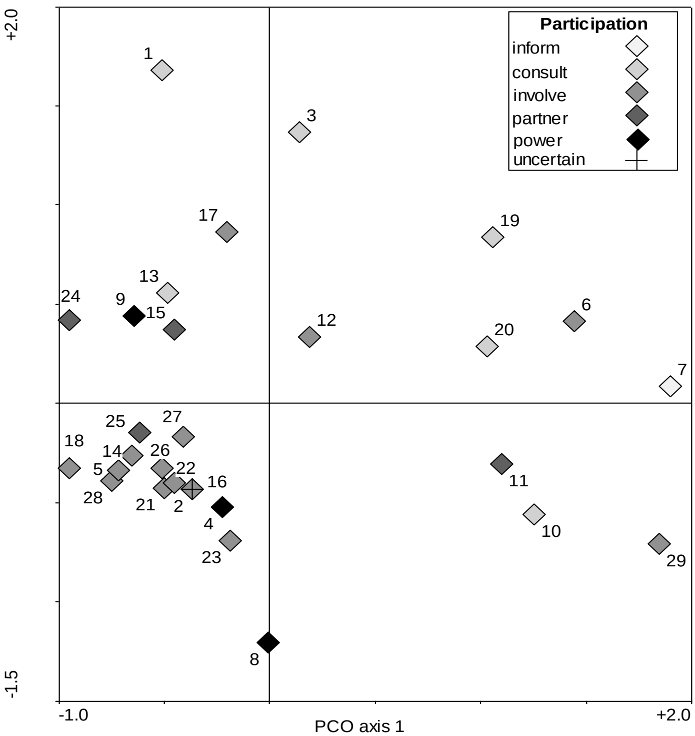

Figure 10. This figure displays for all the case studies their coordinates, which result from applying the PCO algorithm and plotting the first two axes (capturing most of the variance) against each other. It tells the degree of stakeholder involvement in each case study.

Case study	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
18	1	3	3	3	0	3	3	3	0	1
28	3	3	3	0	3	3	0	3	0	0
14	3	3	3	3	3	0	0	3	0	0
25	3	3	3	3	3	0	3	0	0	0
27	3	3	3	3	3	0	0	0	0	0
5	0	2	1	0	1	0	1	0	0	0
21	3	3	3	3	3	2	0	0	0	3
22	3	3	3	3	3	0	0	0	0	3
26	3	3	3	3	3	3	0	0	0	0
2	3	3	3	0	3	0	0	3	0	3
16	3	3	3	0	3	0	0	3	0	3
4	3	3	3	0	3	3	0	0	0	3
23	3	3	2	3	3	3	3	3	0	0
8	3	3	1	3	3	3	0	3	0	3
Average	**2.85**	**2.93**	**2.64**	**3**	**2.85**	**2.86**	**2.5**	**3**	**0**	**2.71**
Uncertainty	**1**	**0**	**0**	**5**	**1**	**7**	**10**	**7**	**14**	**7**

Table 8. Evaluation that case studies of the LL group get in each criterion of the scope stage of the development process (0=uncertain; 1=low; 2=moderate; 3=high). Uncertainty tells the number of case studies categorised as 0. Average just considers case studies not categorised as 0.

Criteria: 1 (C1): structured group interaction; C2: representation; C3: opportunity to influence process development and outputs; C4: quality and selection of information and resources; C5: challenging status quo and fostering creative thinking; C6: clear mandates and goals; C7: transparency; C8: independence and neutrality of the process; 9: conflict resolution; C10: develop a shared vision and goals.

Case study	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
3	1	3	3	0	2	0	0	3	0	0
12	3	3	1	0	0	0	3	0	0	0
19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	0	3	0	0	0	0	0	0	0	2
7	0	3	1	0	0	0	0	0	0	0
1	1	1	3	0	3	0	0	0	0	0
13	0	3	3	3	3	0	2	0	0	0
9	0	3	0	3	2	0	3	0	3	3
11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	3	3	0	0	0	0	0	0	0	0
29	3	3	1	0	1	0	1	0	0	3
Average	**2.2**	**2.78**	**2**	**3**	**2.2**	**0**	**2.25**	**3**	**3**	**2.67**
Uncertainty	**7**	**3**	**6**	**10**	**7**	**12**	**8**	**11**	**11**	**9**

Table 9. Evaluation that case studies of the UR group get in each criterion of the scope stage of the development process (0=uncertain; 1=low; 2=moderate; 3=high). ND (no data) refers to case studies that have not considered the scope stage. Uncertainty tells the number of case studies categorised as 0 or ND. Average just considers case studies not categorised as 0 or ND.

Criteria: 1 (C1): structured group interaction; C2: representation; C3: opportunity to influence process development and outputs; C4: quality and selection of information and resources; C5: challenging status quo and fostering creative thinking; C6: clear mandates and goals; C7: transparency; C8: independence and neutrality of the process; C9: conflict resolution; C10: develop a shared vision and goals.

Case study	C1	C2	C3	C4
18	3	3	3	0
28	1	2	3	0
14	0	3	3	0
25	0	3	2	3
27	0	3	0	0
5	0	3	0	0
21	0	3	0	0
22	0	0	0	3

26	0	3	0	0
2	3	3	3	3
16	1	0	0	0
4	0	0	0	0
23	0	3	3	0
8	0	2	0	0
Average	**2**	**2.82**	**2.83**	**3**
Uncertainty	**10**	**3**	**8**	**11**

Table 10. Evaluation that case studies of the LL group get in each criterion of the personal outcomes (0=uncertain; 1=low; 2=moderate; 3=high). Uncertainty tells the number of case studies categorised as 0. Average just considers case studies not categorised as 0.
Criteria: 1 (C1): relationships and social capital building; C2: acceptance of process and outputs; C3: recognised impacts; C4: social learning.

Case study	C1	C2	C3	C4
3	0	2	2	0
12	2	3	0	3
19	0	0	0	0
20	0	0	0	0
6	0	0	0	0
7	2	0	0	1
1	0	2	3	0
13	0	0	0	2
9	0	3	3	0
11	0	0	0	0
10	0	3	0	0
29	0	3	0	0
Average	**2**	**2.67**	**2.67**	**2**
Uncertainty	**10**	**6**	**9**	**9**

Table 11. Evaluation that case studies of the UR group get in each criterion of the personal outcomes (0=uncertain; 1=low; 2=moderate; 3=high). Uncertainty tells the number of case studies categorised as 0. Average just considers case studies not categorised as 0.
Criteria: 1 (C1): relationships and social capital building; C2: acceptance of process and outputs; C3: recognised impacts; C4: social learning.

Case study	C1	C2	C3	C4	C5
18	3	3	0	0	3
28	3	3	0	3	3
14	2	0	0	0	0
25	3	0	0	3	0
27	3	0	0	0	0
5	3	0	0	0	0
21	0	0	3	1	0
22	3	0	3	3	0
26	3	0	0	0	0
2	3	0	0	0	3
16	3	0	0	0	0
4	3	0	0	0	0
23	3	0	0	0	0
8	2	0	0	0	0
Average	**2.85**	**3**	**3**	**2.5**	**3**
Uncertainty	**1**	**12**	**12**	**10**	**11**

Table 12. Evaluation that case studies of the LL group get in each criterion of the factual outcomes (0=uncertain; 1=low; 2=moderate; 3=high). Uncertainty tells the number of case studies categorised as 0. Average just considers case studies not categorised as 0.
Criteria: 1 (C1): objectives met; C2: uptake of the tool; C3: legacy; C4: impact on policy making; C5: impact on users' practice.

Case study	C1	C2	C3	C4	C5
3	1	3	0	3	0
12	3	3	0	0	3
19	0	0	0	2	0
20	3	0	0	2	0
6	0	0	0	0	0
7	3	0	0	0	0
1	0	0	0	0	0
13	3	1	0	0	0
9	3	0	0	0	0
11	0	0	0	0	0

10	3	0	0	0	0
29	2	0	0	0	0
Average	**2.63**	**2.33**	**0**	**2.33**	**3**
Uncertainty	**4**	**9**	**12**	**9**	**11**

Table 13. Evaluation that case studies of the UR group get in each criterion of the factual outcomes (0=uncertain; 1=low; 2=moderate; 3=high). Uncertainty tells the number of case studies categorised as 0. Average just considers case studies not categorised as 0.
Criteria: 1 (C1): objectives met; C2: uptake of the tool; C3: legacy; C4: impact on policy making; C5: impact on users' practice.

Discussion

This research set out to analyse the literature on participatory DSS development rigorously, by developing a framework of evaluation criteria. This framework builds on recommendations of experts in participatory processes and analyses separately the development process and the outcomes. Therefore, it allows assessing which characteristics of the participatory development process lead to better outcomes. Another noteworthy feature of the framework is the differentiation between personal and factual outcomes: the aim of a participatory process is not just about involving stakeholders to make decisions, but also to infer some changes in their attitudes and knowledge about the topic of the decision.

This discussion is based on the analysis and comparison of the two groups of case studies mentioned in the material and methods section: LL and UR. Not all case studies are included in them, but they are two good samples to look at since they represent different situations of the characteristics intended to study: both for the development and for the outcome criteria scores are higher and uncertainty lower in LL compared to UR; this difference occurs in the development process and in the outcome criteria.

Starting by the degree of stakeholder involvement, looking at LL group case studies in *Figure 10*, 10 out of 14 carry on an "involve" degree, and it is the lowest among all case studies of the group. On the other hand, in the UR group the most frequent degree of stakeholder involvement is "consult" (6 out of

12). Considering the fact that criteria scores are better for LL than for UR, it can be said that the higher the involvement of participants, the better the outcomes. Pretty (1995) supports this statement: *according to the analysis, it was quite clear that as involvement increases, project effectiveness goes from medium to high*; and he bases his argument in a previous study of 121 participatory water supply projects in Africa with different degrees of involvement.

Concerning the development process, *Tables 8* and *9* reveal contrasts for criteria *Structured group interaction*, *opportunity to influence process development and outputs*, *challenging status quo and fostering creative thinking* and *clear mandates and goals*, so, these are important criteria to consider in the development process. It does not mean that these criteria have the best results in LL and the worst in UR, but that results vary between groups: for example, *clear mandates and goals* has medium level of uncertainty in LL (scored 7 times), but it has a total level of uncertainty in UR. On the other hand, *representation* gets a high score and a low uncertainty in both groups.

The analysis of the outcomes reflects high uncertainty. Apart from the fact that paper authors report on the tools developed more than on the outcomes, an explanation for this uncertainty in the case of the factual ones is that these criteria (*impact on policy making, uptake of the tools, legacy* and *impact on users' practice*) require long-term monitoring of the tools and the case studies included in this research are generally reported shortly after the development of the tools. Personal outcomes have to be directly obtained from participants after the process and it does not usually happen. Nevertheless, the scores are better in the LL group and this suggests that when considering the development criteria of the framework, especially the ones highlighted in the previous paragraph, outcomes are improved.

This research analyses reports of various authors and the quantity and quality of information provided differs among papers, depending on what their authors want to emphasise, which implies that the evaluations carried out for this study might be slightly different if more or other kind of data relative to the accomplishment of the criteria had been given. But, the objective was to answer the research question by means of analysing the scientific literature. However, to get a better answer, further research is recommended to include other sources apart from literature review, like direct interviews with both developers and participants of tool development processes and participatory processes.

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Chapter 4-Paper 3

Criteria and indicators for sustainable forestry under Mediterranean conditions applicable in Spain at the forest management unit scale

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Abstract

Aim of study: to identify criteria and indicators (C&I) of sustainable forest management (SFM) under Mediterranean conditions. The indicators are meant to monitor changes in the provision of ecosystem services at a local scale (forest management unit, FMU). The hypothesis is that if a forest provides a bundle of ecosystem services its management can be considered sustainable; thus, C&I are adjusted to an ecosystem services classification.

Area of study: La Hunde y La Palomera, a public FMU in the region of Valencia (east of Spain), 100km southwest of the city of Valencia.

Material and methods: first, a literature review of the following themes took place: SFM, features of Mediterranean forests, ecosystem services and C&I. Some C&I were proposed and, later on, a participatory process in Ayora, the municipality where the mentioned FMU is located, was carried out with different

stakeholders (forestry professionals, users for recreation, hunters, environmentalists and professionals of cultural and rural development activities) in order for them to value the C&I proposed according to their management preferences for *La Hunde y La Palomera*.

Research highlights:

- 15 criteria and 133 indicators were identified: a balance has been achieved among economic, social and ecological concerns.
- People value the ecological issues associated with forestry highest and the economic ones lowest.
- Results suggest that SFM under Mediterranean conditions is based on more than one product and on the provision of several ecosystem services.

Keywords: Sustainable forest management, ecosystem services, local scale, literature review, participation.

Introduction

The concept of sustainable forest management (SFM) was first used at the *Earth Summit* held in Rio de Janeiro (UNCED, 1992) in reference to a type of management that considers social and environmental values of forests and other products in addition to wood (Wijewardana, 2008). However, there is not a universal definition of SFM (Varma *et al*, 2000); the relative importance of the different aspects that SFM covers varies depending on the natural and anthropogenic influences on each type of forest (Castañeda, 2000; Barbati *et al*, 2007). Criteria and indicators (C&I) constitute a tool to promote an understanding of SFM: they provide the means to translate sustainability principles into measurable goals and achievements (Wijewardana, 2008).

Monitoring and evaluation processes with C&I depend a lot on the subjectivity of the people who carry out the evaluation, their experience, values and interests. To overcome this weakness of existing C&I standards[8], Pokorny and Adams (2003) suggest that the meaning of C&I has to be clear, which means that their writing should be simple, understandable and specific.

There is general agreement that international C&I standards cover the following thematic areas: (1) area of forest resources, (2) biodiversity conservation, (3) forest health and vitality, (4) and (5) productive and protective functions of forests, (6) social functions, and (7) legal, political and institutional framework (FAO, 2006). They are particularly weak in the social and cultural areas. This fact likely reflects the strong emphasis that forestry has traditionally placed on natural sciences and a perceived division over responsibility for the social elements of SFM (Gough *et al*, 2008).

Context

As already noted, the literature on SFM suggests that its objectives and strategies change depending on the type of

[8] Standard or set refers to a group of criteria and indicators that has been developed to monitor and assess the performance of forest management for specific ecological, social and economical conditions.

forest; this fact is especially relevant under Mediterranean conditions, which have to be kept in mind to evaluate forestry practices (Osem *et al*, 2008). These conditions have been summarised by Scarascia-Mugnozza *et al* (2000), Fabbio *et al*, (2003) and Madrigal (2003), as follows (Valls *et al*, 2012):

Adaptation to a specific climate: a pronounced biseasonality with dry and hot summers, occasional heavy rains, a large year-to-year variability of total precipitation and strong winds that favour the spread of forest fires.

Species richness: the presence of a high diversity of plant and animal species. The Mediterranean area harbors around 25000 plant species whereas in the rest of Europe around 6000 plant species can be found. 50% of the Mediterranean flora is endemic.

Anthropogenic influence: the diversity of vegetation types, land-uses and landforms, results in a landscape that consists of a mosaic of patches. This is the result of a very long history of human occupation and overlaying of new elements without elimination of the old ones

Fragility: due to heterogeneity, instability and low profitability. Heterogeneity is caused by diversity of species and habitat conditions (climate, soils). Instability results from summer drought, heavy rains, poor soils, and forest fires. Low profitability is derived from low productivity of Mediterranean forests.

These forests provide a diversity of goods and services, collectively known as ecosystem services (MA, 2005). The goods include edible products (fungus, pine nuts and other fruits), resins, cork or aromatic plants (rosemary). Forests in this region also provide ecological and social services, like protecting soil from erosion, keeping and improving the visual aspect of landscapes and serving as spaces for recreation (Scarascia-Mugnozza *et al*, 2000). These services are essential for rural development and for the well-being of urban populations (EFI, 2010).

Spain constitutes a case where Mediterranean conditions take place in most of the forests. Besides the features mentioned, forestry in this country presents some peculiarities which are described next:

Decentralization: regional governments have the authority in forest regulation (MARM, 1999). The decentralized model allows for adapted forest policies, but results in an uneven development in terms of budget, schedule and so on (MARM, 2008).

Property structure: most of the forest area is private (65%) and the forest management units (FMUs) are on the average small-sized (less than 3ha). This discourages many land owners from managing their land as they cannot harvest regularly (Tolosana *et al*, 2004).

Socio-economic conditions: there has been a depopulation of rural areas beginning a few decades ago, so that the management of much land including forest has been abandoned (Marraco, 2004). The main forest product is timber, which together with firewood accounts for a 47.1% of the total forest production in Spain (Tolosana *et al*, 2004). Most of the timber produced goes to low added value industries like packing cases (Plana and Meya, 1999). Besides, the average price of one m^3 of wood in Spain to be paid to the forest owner in the year 2005 was of 46.49€, which is very low for a small property (MARM, 2010).

This research develops a case study in the region of Valencia (east of Spain). For this region a forestry plan has been elaborated: *Plan de Acción Territorial Forestal de la Comunitat Valenciana* (PATFOR). This plan proposes a forest management based on ecosystem services. Nowadays, most of the ecosystem services provided by Mediterranean forests do not result in any incomes to the forest owners. Besides, PATFOR states that the forests of this region are going through an economic, social and environmental crisis. The economic crisis derives from the low productivity of these ecosystems. The ecological and the social crisis are connected: the abandonment of forest management increases the density of vegetation favouring the spread of forest fires. The social crisis is also affected by a lack of organisation among the forest actors, poor communication with the society, and conflicting interests between forest owners and users (Generalitat Valenciana, 2011).

The low productivity and the abandonment of forest lands represent a danger for the continuity in the provision of ecosystem services. It becomes then necessary to identify and define C&I for SFM that take into account ecosystem services together with their economic valuation (Generalitat Valenciana, 2011).

Another pillar over which PATFOR builds forest management is the inclusion of participatory processes for decision making. This is to make the forest sector closer to people, to achieve a common vision among stakeholders and to share responsibility with society (Generalitat Valenciana, 2011).

Aim and Objectives

The aim of this research is to answer this research question: “what has to be considered for SFM under Mediterranean conditions?” The specific objectives of this research are:

1. To identify C&I of SFM for Mediterranean forests, applicable at the scale of FMU and adapted to an ecosystem services framework, under the hypothesis that if forestry is oriented to maintain and improve the provision of ecosystem services it can be considered sustainable.
2. To test the realism and comprehensiveness of the issues covered by the C&I identified by means of a participatory process.

Material and methods

In order to adapt a typology of ecosystem services to Mediterranean conditions, different studies proposing them were reviewed. The inputs came mainly from the *Common International Classification on Ecosystem Services* (CICES) document (UN, 2010) and PATFOR (Generalitat Valenciana, 2011). The first of them is a proposal of a United Nations expert committee. PATFOR adapts other existing frameworks to Mediterranean forests. *Tables 14*, *15* and *16* constitute a classification with examples of ecosystem services, and the references consulted. Then, to identify forestry criteria that maintain and improve their provision, those examples and kinds of the classification whose supply was considered that could be improved through management actions[9] were transformed into criteria (*Table 17*).

S. Class	S. Group	Service Type	Examples
Nutrition *(UN, 2010)*	Edibles from terrestrial plants and animals *(UN, 2010)*	Livestock *(UN, 2010)*	Pastures, meat, milk and other edibles coming from animals *(UN, 2010; Chiabai et al, 2011; Generalitat Valenciana, 2011)*
		Plants, wild animals and other wild living beings and their products *(UN, 2010)*	Mushrooms, truffles, honey, snails, wild asparagus, berries and seeds (pine nuts, sloes, acorns, arbutus fruits, blackberries, etc.) *(Generalitat Valenciana, 2011)*
	Freshwater edibles *(UN, 2010)*	Animals *(UN, 2010)*	Macro invertebrates *(UN, 2010)*
		Plants *(UN, 2010)*	Water cress *(UN, 2010)*
Non-edible materials *(UN, 2010)*	Biotic *(UN, 2010)*	Plant origin *(UN, 2010)*	Wood, splinters, paper, cardboard, esparto, cork, resins *(de Groot et al, 2010; Chiabai et al, 2011; Generalitat Valenciana, 2011)*
		Animal origin *(UN, 2010)*	Leather, furs, waxes *(Chiabai et al, 2011)*
		Ornamental resources *(UN, 2010)*	Flowers, stones, gems, ornamental and aromatic plants (moss, holly, mistletoe, rosemary, thyme, lavender, etc.) *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*
		Medicinal resources *(UN, 2010)*	Plants, active ingredients *(de Groot et al, 2002; de Groot et al, 2010; Generalitat Valenciana, 2011)*

[9] Management actions refer to all the procedures and activities of forestry: from planning goals to silvicultural treatments.

	Abiotic *(UN, 2010)*	Mineral resources *(UN, 2010)*	Salt (subsurface assets not included) *(UN, 2010)*
Energy *(UN, 2010)*	Renewable biofuels *(UN, 2010)*	Plant based resources *(UN, 2010)*	Firewood, peat, forest biomass *(UN, 2010; Generalitat Valenciana, 2011)*
		Animal based resources *(UN, 2010)*	Dung, fat, oils *(UN, 2010)*
	Renewable abiotic *(UN, 2010)*		Wind, hydro, solar, thermal *(UN, 2010)*

Table 14. Provisioning ecosystem services: this category corresponds to tangible benefits that people get from forests with either material purposes (food, construction or decoration) or energetic. This table shows in italics the sources where the ecosystem services kinds and examples are taken or inspired from. The ecosystem services examples that are relevant in Mediterranean forests are underlined.

S. Class	S. Group	Service Type	Examples
Flow regulation *(UN, 2010)*	Air flow regulation *(UN, 2010)*		Windbreak, air circulation *(UN, 2010)*
	Water flow regulation *(UN, 2010)*	Natural drainage and irrigation *(de Groot et al, 2002)*	Directing the flow of water towards rivers and ravines *(de Groot et al, 2002)*
		Runoff regulation *(UN, 2010; Generalitat Valenciana, 2011)*	Flood frequency and magnitude reduction and attenuation of discharge rates *(UN, 2010; Generalitat Valenciana, 2011)*
		Water storage *(UN, 2010)*	Wetlands, natural springs, lakes, reservoirs and aquifers *(UN, 2010; Generalitat Valenciana, 2011)*
	Earth flow regulation *(UN, 2010)*	Erosion control *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*	Minimise soil losses *(de Groot et al, 2010; Generalitat Valenciana, 2011)*

		Mass flows regulation *(UN, 2010)*	Landslides, avalanches *(UN, 2010)*
Physical environment regulation *(UN, 2010)*	Noise pollution reduction *(de Groot et al,2002)*		
	Air quality regulation *(de Groot et al, 2010)*		Dust and chemicals capture, air oxygenation *(de Groot et al, 2002; de Groot et al, 2010)*
	Climate regulation *(UN, 2010; Generalitat Valenciana, 2011)*	Global climate *(UN, 2010; Generalitat Valenciana, 2011)*	Greenhouse gases, hydrological cycle *(UN, 2010; Generalitat Valenciana, 2011)*
		Regional and local climate *(UN, 2010; Generalitat Valenciana, 2011)*	Temperature, humidity, rainfall *(UN, 2010; Generalitat Valenciana, 2011)*
	Water quality regulation *(UN, 2010)*	Water purification and oxygenation *(UN, 2010)*	Nutrient retention in buffer strips, nutrient translocation and water purification in wetlands *(UN, 2010)*
	Soils and their formation *(UN, 2010)*	Formation *(de Groot et al., 2010)*	Physical, chemical and biological pedogenesis *(de Groot et al, 2010)*
		Fertility *(UN, 2010)*	Organic residuals, N-fixing plants, activity of soil organisms *(UN, 2010)*
		Structure *(UN, 2010)*	Activity of soil organisms *(UN, 2010)*
	Nutrient cycling *(Costanza et al, 2010)*	Nutrient cycles in the ecosystem *(Costanza et al, 1997)*	Nutrient acquisition, cycling, processing and storage *(Costanza et al, 1997)*
		Regulation of wastes (recovery of mobile nutrients and reduction or removal of excess nutrients or compounds) *(Costanza et al, 1997; de Groot et al, 2010; UN, 2010)*	Plant and microorganism bioremediation, dilution, filtration of particulates and aerosols, and nutrient sequestration and absorption *(UN, 2010)*
Biotic environment regulation *(UN, 2010)*	Life cycle maintenance *(UN, 2010)*	Reproduction *(Costanza et al, 1997; de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*	Pollination, seed dispersal, habitat for reproduction and bringing up *(Costanza et al, 1997; de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*

		Other functions of living beings *(Costanza et al, 1997; de Groot et al, 2010; UN, 2010)*	Refuge and feeding habitat *(Costanza et al, 1997; de Groot et al, 2010; UN, 2010)*
	Pest and disease regulation *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*		Biological control by plants, animals and other microorganisms *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*
	Biodiversity maintenance *(Costanza et al, 1997; de Groot et al, 2010; Generalitat Valenciana, 2011)*		Regulation of species populations, maintenance of species diversity and genetic diversity *(Costanza et al, 1997; de Groot et al, 2010; Generalitat Valenciana, 2011)*
Forest fires regulation *(Generalitat Valenciana, 2011)*			Species, vegetation and landscape structures that avoid fire spread and favour recovery after the fire *(Generalitat Valenciana, 2011)*

Table 15. Regulating ecosystem services: this category refers to different ecosystem processes that are relevant for life itself and for humankind. This table shows in italics the sources where the ecosystem services kinds and examples are taken or inspired from. The ecosystem services examples that are relevant in Mediterranean forests are underlined.

S. Class	S. Group	Service Type	Examples
Symbolic and inspirational *(UN, 2010)*	Cultural heritage and aesthetic *(UN, 2010)*	Visual landscape *(UN, 2010)*	Aesthetic significance and information, outstanding features of the landscape, general appearance *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*
		Cultural landscape *(UN, 2010)*	Sense of place, physical features (natural or manmade) holding a cultural/historical meaning *(de Groot et al, 2002; UN, 2010; Generalitat Valenciana, 2011)*

	Spiritual and religious *(UN, 2010)*	Naturalness *(UN, 2010)*	Tranquility, isolation *(UN, 2010)*
		Sacred character *(UN, 2010)*	Sacred places or species *(UN, 2010)*
		Intellectual development *(Generalitat Valenciana, 2011)*	Experience and spiritual enrichment (meditation, yoga, reflection) *(de Groot et al, 2010; Chiabai et al, 2011; Generalitat Valenciana, 2011)*
		Creativity *(de Groot et al, 2002; de Groot et al, 2010)*	Inspiration for culture, art and design (books, films, paintings, etc.) *(de Groot et al, 2002; de Groot et al, 2010)*
Information and knowledge *(UN, 2010)*	Leisure activities *(UN, 2010)*	Sports *(de Groot et al, 2010; Generalitat Valenciana, 2011)*	Land, air and water sports *(de Groot et al, 2010; Generalitat Valenciana, 2011)*
		Ecological-kind *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*	Fauna, flora and natural habitats observation and enjoyment *(de Groot et al, 2010; UN, 2010; Generalitat Valenciana, 2011)*
		Hunting and fishing *(UN, 2010; Generalitat Valenciana, 2011)*	Small and big game hunting, trout *(UN, 2010; Generalitat Valenciana, 2011)*
		Recreation *(de Groot et al, 2010; Generalitat Valenciana, 2011)*	Use of infrastructures (camping and recreation areas) *(de Groot et al, 2010; Generalitat Valenciana, 2011)*
		Social relationships *(MA, 2005)*	Implicit in all leisure activities when practiced in groups *(MA, 2005)*
	Knowledge *(UN, 2010)*	Scientific research *(de Groot et al, 2002; UN, 2010)*	Pollen records, tree ring records, genetic patterns *(UN, 2010)*
		Education *(MA, 2005; UN, 2010)*	Educational excursions, seminars *(de Groot et al, 2002)*

Table 16. Cultural ecosystem services: this category includes psychological benefits (tranquility, reflection, isolation) and social benefits (group activities, maintenance and improvement of cultural heritage, promotion of science and education). They are difficult to measure and subjective in many cases. This table shows in italics the sources where the ecosystem services kinds and examples are taken or inspired from. The ecosystem services examples that are relevant in Mediterranean forests are underlined.

Ecosystem services are important in most forest types. Some of them apply everywhere. In *Tables 14*, *15* and *16*, those that are relevant under Mediterranean conditions appear underlined. The rationale for their selection was based on the information contained within PATFOR and the references consulted for describing Mediterranean features, which are reported in the introduction section of this chapter and the introduction section of Chapter 2.

It was considered that the provisioning services category could be associated to the economic pillar of sustainable development, the regulating one to the ecological pillar and the cultural category to social issues. The criteria were classified in three groups: economic, social and ecological, according to the ecosystem services categories. The criteria are indicated next:

- Economic criteria: persistence and stability of forest resources, profitability of forest resources, diversified exploitation of forests.
- Social criteria: employment and working conditions, recreation, visual character, historical and cultural heritage, participatory processes, education, research.
- Ecological criteria: biodiversity and habitats, hydrological regulation, mass flows, forest fires, carbon storage.

It can be seen in *Table 17* that the criteria *employment and working conditions* and *participatory processes* were not associated to any ecosystem service kind or example. This is because they constitute requirements of forest management and thus have to be included as criteria, even though they do not maintain or improve the provision of any ecosystem service. On the other hand, no criteria were associated to the following ecosystem service kinds:

- Service group *air flow regulation.*
- Service group *noise pollution reduction*.
- Service group *air quality regulation*.
- Service type *regional and local climate.*
- Service group *water quality regulation*.
- Service group *nutrient cycling.*
- Service type *fishing*.

Ecosystem services	Criteria of SFM
Provisioning services	Economic criteria
Service group *leisure activities*	Recreation
Service types *visual landscape*, *intellectual development* and *creativity*, and the example *sense of place* from the service type *cultural landscape*	Visual character
Service type *cultural landscape*, and service group *spiritual and religious*	Historical and cultural heritage
Service type *education*	Education
Service type *scientific research*	Research
Service class *biotic environment regulation*	Biodiversity and habitats
Service groups *water flow regulation* and *soils and their formation*, and service type *erosion control*	Hydrological regulation
Service type *mass flows regulation*	Mass flows
Service class *forest fires regulation*	Forest fires
The example *greenhouse gases* (only refers to CO_2), from the service type *global climate,* from the service group *climate regulation*	Carbon storage

Table 17. Criteria of SFM identified in this research as a result of the association of management actions to the different classes, groups, types and examples of ecosystem services that appear in the classification adapted for this research. Notice that all of the *economic criteria* are associated to the *provisioning services* category. The rest of the criteria are associated to specific ecosystem services kinds and examples.

The reason for not including them is because they happen either in specific situations or as a result of the management for providing other ecosystem services. The first situation corresponds to *noise pollution reduction*, *air quality regulation* and *fishing.* The first two services are relevant for humans in forests that are close to urban and industrial areas; *fishing* takes place in forests located next to a river, and the management of fish populations is a competence of the Central Government (Gobierno de España, 2001). *Air flow regulation*, *water quality regulation* and *nutrient cycling* occur in forests where vegetation and soils are kept in good conditions; these conditions were taken into account in other criteria, therefore, there was no need to consider them explicitly.

Further references and legislation were reviewed for describing and explaining the criteria (*Table 18*). Later on, some forest management experts were consulted about the criteria and their descriptions. They were invited to participate and they were explained what the research was about and what the objectives of the consultation were. Attached to the e-mail via which they were contacted, a file with the criteria was sent so that they were able to correct and comment on them. Four experts participated: two university academics and two civil servants. They were asked the following questions:

1. *Do these criteria cover the relevant issues of SFM in the Mediterranean region at the FMU level?*
2. *Are these criteria applicable?*
3. *Rephrase or comment on the writing of the criteria and their definitions if you think they could be improved.*

Next, to identify indicators of SFM, existing international C&I standards were reviewed: FAO, 1997; FAO, 1999; UNDP/FAO/SADC, 1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; ATO/ITTO, 2003; ITTO, 2005; Montréal Process, 2007; Kotwal *et al*, 2008; AENOR, 2007; AENOR, 2007b; GTC-FSC, 2007; SFI, 2010. Other studies that propose C&I were also consulted (*Table 20*).

All the indicators taken from the review were classified according to the criteria identified. After this, indicators were rephrased to be simple and easily understandable, as recommended by Pokorny and Adams (2003). The last task consisted of proposing new indicators in the issues for which less attention had been paid in the literature.

Later on, a participatory process in *Ayora*, a village located 100km southwest from the city of Valencia, was carried out. Its objective was to test if the topics included in the C&I identified were comprehensive and realistic. For this step, and in order to facilitate the process for participants, the indicators were grouped into aspects, which were defined as the specific issues covered by a criterion. Their meaning is broader and their writing less technical than the indicators.

The process was open to anyone living in the village. Participants were asked to value the criteria and, for each criterion, the aspects that it covered. They valued according to their management preferences for a public forest located in the municipality of the village, which is called *La Hunde y La Palomera*. Several authors of academic papers propose to identify and pre-select C&I based on relevant literature, followed by a process of verification or refinement by stakeholders (Kurka and Blackwood, 2013).

The participatory process was publicly announced by notices on walls and shop windows, and it was advertised in the local radio. Some days before the process, local associations whose interests were related to forest management or forest conservation were personally contacted (via telephone or face-to-face) in order to get a representation of the different stakeholders involved.

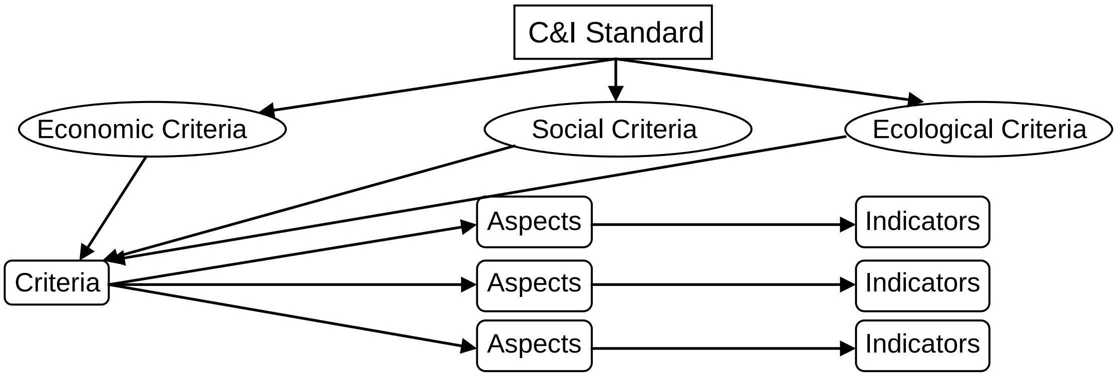

Figure 11. General structure of the criteria and indicator standard developed in this research. There are three criteria groups: economic, ecological and social; each group consists of several criteria, every criterion is made of various aspects, and a few indicators correspond to every aspect.

Figure 11 displays the structure of the proposed standard for this research. Every participant received a questionnaire with 19 questions, each containing a list of elements to value: 15 questions to value the aspects of each criterion, 3 questions to value the criteria of each group, and 1 question to value the three groups of criteria.

The weighting method selected corresponds to a multi-criteria analysis (MCA) technique described by Gómez-Orea (2002) that is applied when participants are asked to value the elements of a list according to a predetermined scale whose values can be repeated. The elements of any question were valued giving a 1 to the most important for the participant and so progressively. As mentioned, the weighting method allowed participants to repeat values: for example, in a question comprising 7 elements, these could be valued 3-4-2-2-1-5-1; this would mean that for that participant there are two elements in the first order of importance and two in the second.

The aggregated weights of every aspect and every criterion, which take into account the values from all participants, were calculated following the method recommended by Gómez-Orea (2002). This method implies that the higher the value the better. However, in this research the lowest value (1) is the best. Therefore, the scale of the answers was inverted like this: value 1 changed into the number of elements of the list and it reduces progressively (this way the answers looked like participants had valued according to a scale that equals the number of elements of the list). In the example aforementioned, it would be like asking participants to value 7 elements in a scale from 1 to 7, the inverted scale would be:

1→7
2→6
3→5
4→4
5→3
6→2
7→1

The previous scheme shows for this example how the values of the answers would change when inverting the scale: on the left are the old values and on the right the new ones. The result would be 5-4-6-6-7-3-7. The inversion of the scales was done for all the questions of all the participants. Next, aggregated weights were calculated according to the method indicated, which consists of the following steps:

1. In every question it was made a table that puts the elements in rows and the participants in columns. The

table was filled with the inverted values from participants.
2. The sum of the inverted values of each participant was calculated at the bottom of each column.
3. Every number that filled the table was divided by the sum of the inverted values that corresponds to its column.
4. The aggregated weight of each element was calculated summing all the new numbers in a row (calculated in step 3) and dividing this sum by the number of participants. The sum of the weights of all the elements in a question should be equal to 1.

Results

SFM criteria

A brief description of the resulting criteria and the bibliography consulted is provided in *Table 18.* A complete description appears in *Annex 3*.

Criteria	Descriptions
Persistence and stability of forest resources	Management guarantees that a certain quantity of the forest resources stays in the FMU all the time and that it continues when biotic or abiotic disturbances occur (pests, fire).
Profitability of forest resources	Income generation (in-kind or money) as a result of the management, annual or periodic, variable or regular.
Diversified exploitation of forests	Inventory and determination of best use of present and potential forest goods and services.
Employment and working conditions	The number of job posts in the FMU is suitable to the activities necessary to carry out for the management, workers receive suitable training and there exist health and safety measures.
Recreation	There are infrastructures for the social use in its different kinds: taking a rest, trekking, fauna observation, camping, sports or hunting.
Visual character	Maintenance of the identifying visual properties of the FMU that make it attractive and improvement of them if they have been degraded.
Historical and cultural heritage	Management preserves the features and places of the FMU holding a historical or cultural meaning, either tangible (charcoal kilns) or intangible (pilgrimages), natural or artificial.
Participatory processes	Take account of stakeholders and affected people’s experience and points of view in forest management decisions.

Education	Forest management favours society's education and awareness on the cultural, environmental and economic significance of forestry and natural areas.
Research	The use of forests as an object of scientific studies, either to improve the management (and the information on its goods and services) or to increase the knowledge of other disciplines (ecology).
Biodiversity and habitats	Management keeps species and habitats diversity and habitats conectivity in order to maintain and improve forest capacity to recover after disturbances.
Hydrological regulation	An important element of the hydrological cycle is vegetation that increases infiltration and reduces the quantity and speed of runoff. This attribute of vegetation offers important services: controls erosion, reduces the number and magnitude of floods and refills aquifers. The aim of this criterion is to maintain and improve these services through the management of vegetation structure and composition.
Mass flows	Management prevents landslides and avalanches.
Forest fires	Management prevents forest fires and facilitates extinction, so as to keep the frequency, intensity and consequences of forest fires in an ecologically sustainable and socially acceptable level.
Carbon storage	Forest management contributes to global climate change mitigation through maximising biomass synthesis and maintaining soil carbon storage capacity.
References consulted	
- AENOR, 2007. - Ayala *et al*, 2006. - Council of Europe, 1992. - Council of Europe, 2000. - Deshler, 1979. - European Union, 2010. - Euroquality and ASEMFO, 2002. - FAO, 2002. - FAO, 2005. - Generalitat Valenciana, 1993. - Generalitat Valenciana, 2004b. - Generalitat Valenciana, 2009. - Generalitat Valenciana, 2010.	- Generalitat Valenciana, 2011. - Generalitat Valenciana, 2011b. - Gobierno de España, 1985. - Gobierno de España, 2003. - Gobierno de España, 2007. - Gobierno de España, 2011. - ILO, 1998. - ILO, 2005. - Mackay, 1949. - Madrigal, 2003. - MARM, 2002. - MESS, 2006. - Pemán and Navarro, 1998. - Ruano, 2003. - Thompson, 2011.

Table 18. Description of the criteria identified and references consulted for the identification.

15 criteria were identified: 3 economic, 7 social and 5 ecological. They take account of the multiple products (*diversified exploitation of forests*) and services of forests (*recreation*, *historical and cultural heritage, biodiversity and habitats*). Mediterranean features are considered in criteria like *forest fires* or *biodiversity and habitats.* The applicability of the criteria at the FMU scale can be seen in the fact that no consideration was given to rural development and regular revenues, which are desirable outcomes of SFM but have to be considered at a regional level because they require association and coordinated actions among several forest owners (Madrigal, 2003). Besides, rural development needs the input of other sectors in addition to forestry.

Indicators and aspects of the criteria

133 indicators were identified, from which 24 were proposed. The indicators have a simple writing, and a specific content. There are both quantitative and descriptive indicators. Many indicators serve to evaluate the state of the forest, but there are also indicators saying how to carry out certain management actions. Finally, there are indicators that encourage managers to innovate, like the ones referring to thinking of potential recreation activities and studying their demand.

The aspects that resulted from grouping the indicators to facilitate the participatory process are displayed in *Table 19*; this table allows an overview of what issues this research proposes to be relevant for sustainable management of Mediterranean forests. The indicators proposed together with the bibliography reviewed are in *Table 20.* In *Annex 4* appears next to each indicator the references consulted for its identification.

Criteria	Aspects	Descriptions
Persistence and stability of forest resources	*New plants*	Management facilitates the establishment and growing of new tree individuals.
	Tree layer	Maintenance and improvement of its quantity and quality.
	Species diversity	Tree layer made of more than one species if possible.
	Genetic diversity	Among the individuals of any tree species population present in the forest.
	Non-wood products	Management for their persistence and stability: honey, fungi, etc.
	Pest treatments	Preventative and healing treatment of pests, diseases and other disturbances.
Profitability of forest resources	*In-kind incomes*	Management increases the quantity of forest resources in a given amount of time.
	Money incomes	Forest management products are sold and generate revenues to the owner.
	Demand	Study local demand and possible buyers of forest products prior to management.
Diversified exploitation of forests	*Diversification*	Forest incomes have to come from more than one product.
	Efficiency	Management based in the more profitable product combination.
Employment and working conditions	*Job posts*	The number of workers in the forest is suitable to the activities carried out.
	Training	Of workers and managers suitable to job post and to SFM objectives in general.
	Contract conditions	Timetables, responsibilities, salary, contract length, etc. have to be specified.
	Health and safety	Work risk prevention plans and measures.
Recreation	*Social use*	Users and frequency of use of recreational infrastructures.
	Infrastructures	Existence and quality of recreational infrastructures.
	Diversity	Recreational activity focused in more than one kind of activity.
	Demand	Study demand of new activities prior to their introduction.
	Hunting fauna	Provide proper habitats for this fauna as well as sustainable captures per year.
Visual character	*Outstanding elements*	Conservation of attractive elements due to their natural or human induced aspect.
	Watching areas	Existence of places where people can enjoy the visual landscape.
	Views	Quality of the views from the watching areas.
	Diversity	Visual landscape diversity in all the forest, which increases its quality.
	Visual integration	Human new affections on the visual landscape have to be integrated to keep the visual character.

Historical and cultural heritage	*Elements*	Human made items that lost their function and so represent traditional past activities (charcoal kilns, etc.).
	Traditions	Intangible items that people are used to practice regularly in specific moments.
	Places character	Conservation of the character of certain places holding a sacred or inspirational singnificance.
Participatory processes	*Representation*	All the stakeholders are represented.
	Leadership	Developers keep discussions on a track and make sure that input is evenly distributed among participants.
	Information	Participants have enough context information to give valuable and documented opinions.
	Objectives	Time, location and objectives of the process are clarified before it takes place.
	Transparency	Participants know and understand how decisions are made during or after the process.
	Acceptance	Participants accept the results of the process.
	Impacts	Participants perceive their input in the results.
	Social relationships	New relationships (work, friendship) or reinforcement of existing ones as a result of the process.
Education	*Activities*	Promoting formative actions: excursions, information sessions.
	Infrastructures	Panels, information points to promote forest ecologic, economic and social values.
Research	*Monitoring*	Periodic monitoring and reporting on the state of the forest and the management.
	Research projects	Promote research to improve management and science knowledge.
Biodiversity and habitats	*Flora diversity*	Maintenance and improvement of the number of flora species in the forest.
	Fauna diversity	Maintenance and improvement of the number of fauna species in the forest.
	Endangered species	Maintenance and improvement of the populations of endangered species in the forest.
	Alien species	Control the entrance and propagation of exotic species.
	Habitats	Variety and conservation of existing habitats in the forest.
	Ecological connectivity	Connectivity among habitats and vegetation formations.
Hydrological regulation	*Erosion*	Minimise soil losses.
	Soil productivity	Maintenance and improvement of this soil capacity.
	Soil pollution	Avoid pollution due to fertilisers and pesticides.
	Aquifer filling	Vegetation structure that favours aquifer filling.
	Floods	Vegetation structure and infrastructures that avoid or control floods and reduce their devastating effects.
Mass flows	*Infrastructures*	Number and conservation state of preventative infrastructures (contention walls, etc.).
	Vegetation	Vegetation structure that prevents mass flow.
Forest fires	*Preventative silviculture*	Horizontal and vertical fuel discontinuities.

	Extinction aid silviculture	Creation of firebreak areas.
	Extinction infrastructures	Water deposits, tracks and other infrastructures that help fire extinction.
Carbon storage	*Vegetation*	Vegetation structure and composition that favour biomass synthesis.
	Soils	Maintain and improve soil capacity to store carbon.

Table 19. Aspects of the criteria and their descriptions.

Criteria	**Aspects**	**Indicators**
Persistence and stability of forest resources	*New plants*	Number of new plants in harvested area a certain time after harvesting.
	Tree layer	Number of tree plants per area unit.
		Vigour/vitality of the trees of each species.
	Species diversity	Number of trees of each tree species per area unit.
	Genetic diversity	Number of individuals of the population of each tree species.
		In case of reforestations and enrichment plantations, the trees or seeds employed must be labelled and authorised.
		In case of reforestations and enrichment plantations, trees or seeds come from the same region where the forest is located.
		In case of reforestations and enrichment plantations, the origin of trees or seeds must be varied.
		Thinnings are not focused just on fast-growing individuals or those with a favourable morphology.
	Disturbances	Area affected by disturbances.
		Species are adapted to site conditions (soil and climate).
		A maximum time for harvest remainders

		is to stay in the forest is detrmined.
		Integrated pest management: chemical treatments are not used in a preventative manner and always used when there is no possible alternative way.
		Forest managers notice and inform on the existence of pests and diseases in their forests.
Profitability of forest resources	*In-kind incomes*	Current value of resources present in the forest.
		Percentage of forest managed for production.
	Money incomes	Incomes resulting from selling forest resources produced.
		Expenses resulting management operations.
		Incomes due to subsidies and other sources different from forest resources produced.
	Commercialisation	Demand estimation for the forest resources produced.
		Existing selling contracts.
Diversified exploitation of forests	*Diversification*	Forest area managed for the provision of each of the existing forest resources.
		Identification of potential resources to manage and sell.
		Demand estimation of potential resources to manage and sell.
	Efficiency	The exploitation of forest resources respects the maximum quantity per period that management plans establish.
		Estimation of the exploitation of potential resources to manage and sell.
		Estimated value of potential resources to

		manage and sell.
Employment and working conditions	*Job opportunities*	Number of employees in the forest.
		Number of job posts is suitable to the activities required for the management.
	Training	Workers' training is suitable for their posts.
		Training programs for workers and managers.
	Contract conditions	Salaries and incentives respect collective agreements and are in accordance with regional standards.
		Working hours and extra work incentives are established in the contract.
		Types of contracts depending on contract length and number of contracts of each type.
	Health and safety	There is a work risk prevention plan.
		Number of working accidents in a certain time period.
		Number of working diseases produced in a certain time period.
Recreation	*Hunting fauna*	Hunting species inventory.
		Captures number per species and time period.
		Hunting fauna infrastructures inventory.
	Social use	Forest area managed for recreational use.
		Number of visits for recreational purposes.
	Infrastructures	Recreational infrastructures inventory.
	Diversification	Types of recreational activities offered in the forest.

	Demand	Study potential recreational activities.
		Estimate demand of potential recreational activities.
Visual character	*Outstanding elements*	Visual outstanding elements inventory.
	Watching areas	Main watching areas inventory.
	Views	Watching areas views valuation by means of participatory processes.
	Diversity	Total forest area harvested the previous year.
		Length of tracks and firebreaks in the forest.
		Inventory of human elements (aerials, constructions, surveillance towers).
		Forest area not covered by trees.
		Forest area covered by trees.
		Forest area covered by scattered trees.
	Visual integration	Visual integration of recent human activities soon after they have taken place.
		Unpleasant visual contrasts inventory.
Historical and cultural heritage	*Elements*	Tangible heritage elements inventory (natural o artificial).
	Traditions	Customs, traditions and resource rights of use inventory.
		Customs, traditions and resource right of use maintenance valuation by means of participatory processes.
	Places character	Inventory of places holding a religious, spiritual or inspirational value.
		Valuation by means of participation of the maintenance of the character of the places holding a religious, spiritual or

		inspirational value.
Participatory processes	*Representation*	Number of participating stakeholder groups.
		Participants number (total and by stakeholder groups).
		Management issues whose decision making includes participatory processes.
	Leadership	Conflicts and their causes.
		Solved conflicts.
		Topics addressed in the participatory process.
		Stakeholder groups or participants that have actively participated in the discussions.
		Agreements achieved.
	Information	Quality of the information on the topics to decide that participants have received.
	Objectives	Quality of the information on the objectives and expected development of the process that participants have received.
	Transparency	Participants understand how decisions are made when they do not take part in the final decision.
	Acceptance	Participants' level of acceptance of decisions made, once different points of view and process difficulties are understood.
	Impact	Participants perceive their input in the final decisions.
Education	*Activities*	Number of visits per time period with educational objectives.
		Number of informative sessions per

		period time.
		Existing agreements for educational visits and informative sessions.
	Infrastructures	Forest educational infrastructures inventory.
Research	*Monitoring*	Regularity in data gathering for monitoring.
		The information on the monitoring process is publicly reported.
	Research projects	Forest area where research projects take part.
		Existing agreements for research projects.
Biodiversity and habitats	*Flora diversity*	Flora species inventory (diversity and abundance).
		Vegetation layers in each vegetation formation.
	Fauna diversity	Wild fauna species inventory (diversity and abundance).
	Endangered species	Rare, endangered and endemic species inventory (species and abundance).
		Biodiversity conservation sites inventory.
	Alien species	Exotic species inventory.
		Study on the convenience and dangers of introducing exotic species.
		Inventory of species affected or disappeared because of exotic species.
	Habitats	Habitat conservation sites inventory.
		Forest habitats inventory.
		Forest prioritary or relevent habitats inventory.
		Motor vehicles and forest machinery

		circulation restrictions.
		Presence of wood, dead trees and other habitat elements (stumps) where harvesting activities have occurred.
	Ecological connectivity	Vegetation formations and their limits inventory.
		Continuity/naturalness of vegetation formations limits determination.
		Fauna movement limitations exist to protect new plants or other justified cases.
Hydrological regulation	*Erosion*	Forest area affected by compaction.
		Forest area affected by erosion.
		Determination of the erosion types that occur in each case.
		Erosion vulnerable areas identification.
		Compaction vulnerable areas identification.
		Forest area managed for protection functions.
	Soil productivity	Nutrient inventory in plots regularly distributed in the forest every certain time.
		Pollutants inventory every certain time where fertilisers or pesticides have been applied.
		Restrictions for the application of fertilisers and pesticides: quantity, composition, time of the year and allowed products.
	Aquifer filling	Forest area managed to generate water surpluses for aquifer filling.
		Forest area suffering from soil infiltration problems.

	Floods	Human infrastructures (tracks, bridges) allow free water circulation in hillsides and natural water channels.
		Flood control infrastructures inventory.
		Vegetation quality in areas managed for protection functions.
Mass flows	*Infrastructures*	Mass flow regulation infrastructures inventory.
	Vegetation	Forest cover state in areas managed to prevent mass flow.
	Cartography and inventory	Mass flow risk areas identification.
		Inventory of mass flow events that have taken place.
		Forest area managed to prevent mass flow.
Forest fires	*Preventative silviculture*	Fuel discontinuities (including harvesting remainders) between vegetation layers.
		Bush density.
	Extinction aid infrastructures	Extinction aid infrastructures inventory.
	Affected forest	Forest area per time unit affected by forest fires.
		Types and magnitude of forest fires occurred.
		Forest fires causes.
Carbon storage	*Vegetation*	Total biomass in the forest (trunk, branches and leaves).
		Number of trees in young vegetation formations in areas managed to maximise biomass synthesis.
		Number of trees in adult vegetation formations in areas managed to maximise biomass synthesis.

		Bush density in bush formations in areas managed to maximise biomass synthesis.
		Forest area managed to maximise biomass synthesis.
	Soils	Forest area showing dry and cracked soils.
		Forest area where soil structure has been broken or altered.
References consulted		
- AENOR, 2007. - AENOR, 2007b. - ATO/ITTO, 2003. - Blackstock *et al*, 2007. - Commonwealth of Australia, 1998. - Eriksson and Lindhagen, 2001. - FAO, 1997. - FAO, 1999. - FAO, 2002. - Generalitat Valenciana, 2011. - GTC-FSC, 2007. - International expert meeting on monitoring, assessment and reporting on the progress towards sustainable forest management, 2001. - ITTO, 2005.	- Kotwal *et al*, 2008. - Madrigal, 2003. - Menzel *et al*, 2012. - Montréal Process, 2007. - Moote *et al*, 1997. - Mrosek and Balsillie, 2001. - Mrosek *et al*, 2006. - Pokharel and Larsen, 2007. - Rowe and Frewer, 2000. - SFI, 2010. - Thompson, 2011. - Tuler and Webler, 1999. - UNDP/FAO/SADC, 1999.	

Table 20. Indicators identified for each criterion and references consulted for the identification.

Results of the participatory process

A group of 34 people participated. Their profiles were analysed and they were classified in the following groups: users for recreational purposes (14 participants), environmentalists (9), hunters (2), forestry professionals (4, both with and without a university degree) and professionals of cultural and rural development activities (5). Although the number of participants differs a lot between groups, it is considered that relevant stakeholders are represented. However, hunters and foresters are not seen to be represented enough. Therefore, results for each of the groups are not comparable and all 34 participants' answers were aggregated together.

The aggregated weights of the elements in most of the questions are similar. None of them receives a very low weight compared with the others of the same question. In this chapter only the answers to the questions showing meaningful differences for the aggregated weights of their elements are shown and analysed; these are presented in *Figures 12*, *13* and *14*. Graphs showing the aggregated weights for the elements of all the questions are in *Annex 5*. Besides, participants have not suggested adding any new elements to the standard.

Generally, the results show that participants value ecological issues highest and economic ones lowest. This is visible in the question in which they are asked to value the *groups of criteria* (*Figure 14*), but also in questions like the ones to value the aspects of the criteria *mass flows* and *profitability of forest resources* (*Figure 12*). In the case of *mass flows*, participants value prevention through *vegetation* (60%) more than through *infrastructures* (40%); whereas in the other case, they value *in-kind incomes* (43%) more than *money incomes* (24%). This preference towards ecological concerns is also visible in the valuation of the *economic criteria* (*Figure 13*), for which the highest aggregated weight corresponds to *persistence and stability of forest resources* (44%) and the lowest one to *profitability of forest resources* (22%).

Concerning the criterion *employment and working conditions* (*Figure 12*), *training* is the aspect that gets the highest aggregated weight (31%) and *job opportunities* stays at a very similar level (28%). *Recreational activity* obtains high values for *social use* (25%) and *infrastructures* (24%). Finally, even though the three aspects of *forest fires* do not differ much, *extinction aid silviculture* has the lowest weight (27%) and *preventative silviculture* the highest one (39%). *Ecological criteria* (*Figure 13*) do not show big differences in their weights, but it can be noticed that *biodiversity and habitats*, *forest fires* and *hydrological regulation* are slightly higher valued (23%, 22% and 21% respectively) than *mass flows* and *carbon storage* (16% and 18%).

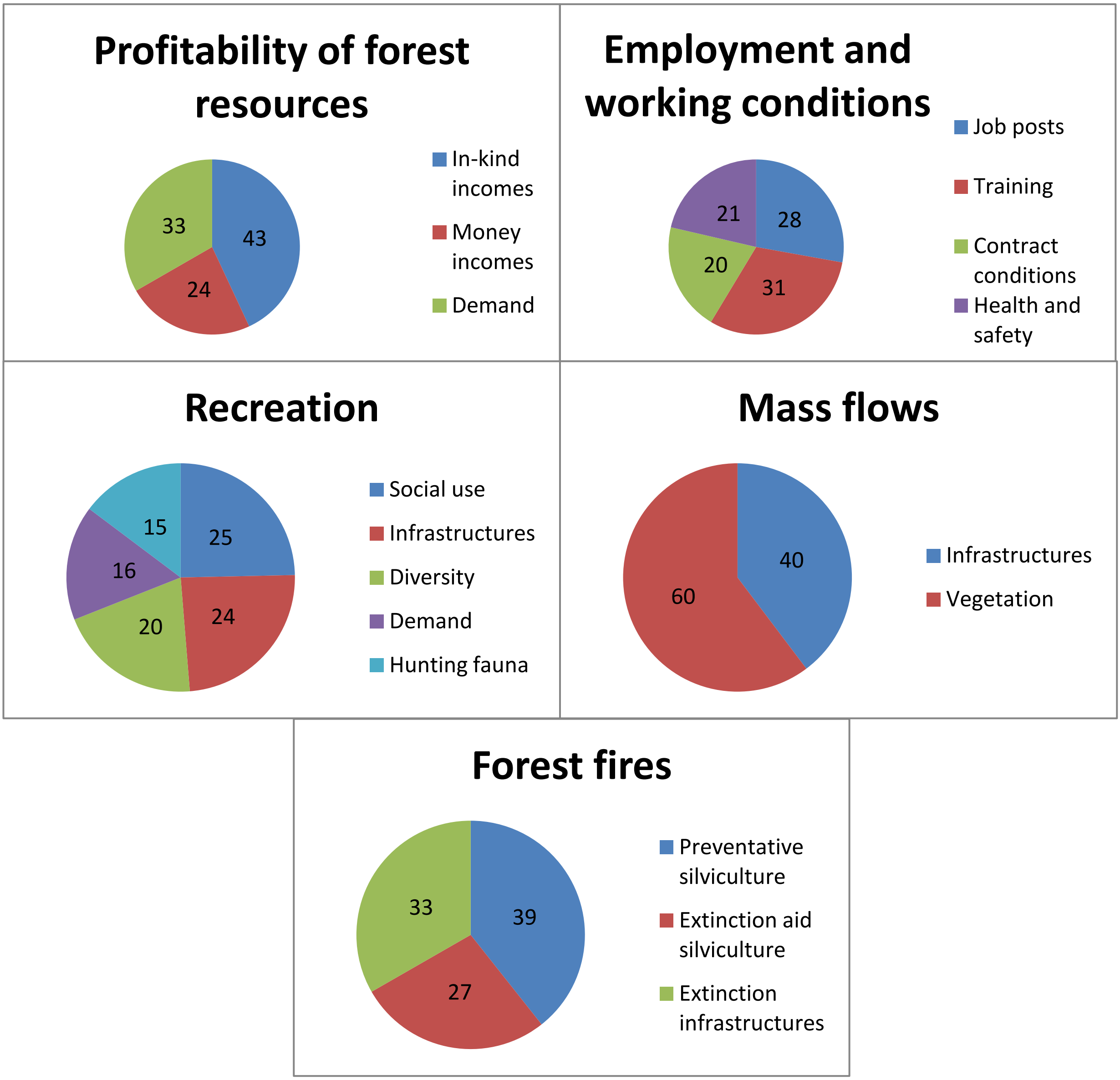

Figure 12. Aggregated weight (%) of the aspects of the criteria *profitability of forest resources*, *employment and working conditions*, *recreation*, *mass flows* and *forest fires.*

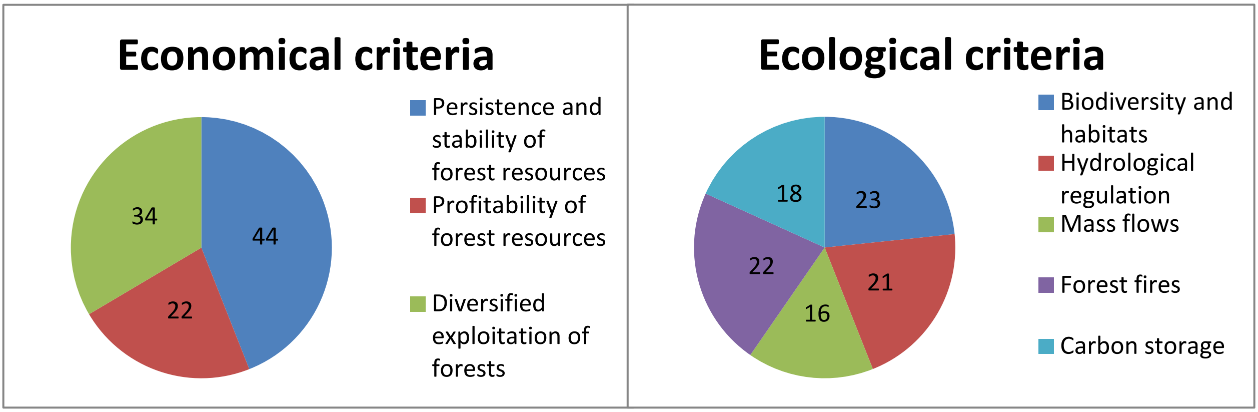

Figure 13. Aggregated weight (%) of the criteria of the groups *economic* and *ecological*.

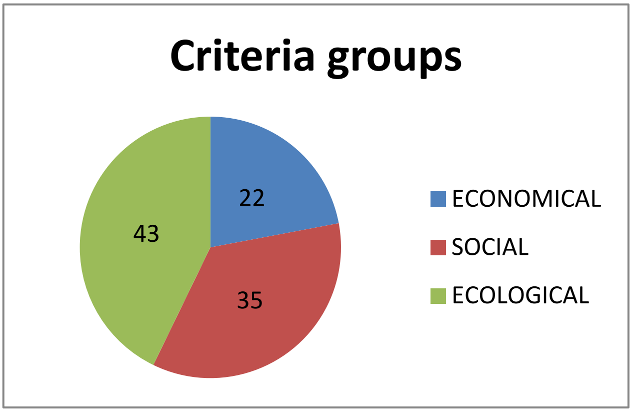

Figure 14. Aggregated weight (%) of the three groups of criteria.

Discussion

This research explores the considerations of SFM under Mediterranean conditions. 15 criteria applicable at the FMU level are identified. These criteria intend to maintain and improve the provision of ecosystem services and cover the three pillars of SFM: economic, social and ecological. The existing C&I standards treat mainly ecological and resource quantity topics.

7 out of the 15 criteria identified in this research are social. The relevance of this type of issues is emphasized by other works. A similar study developed by Maroto *et al* (2013) in the same region as this research (Valencia), but applied at a regional scale, highlights that social criteria of SFM are more important than economic ones for most stakeholder groups. Likewise, in a Mexican local community case study, the health of the forest was highly respected because the forest represented community pride, spiritual enjoyment, personal health and family cohesion. The researchers of this case study argue that the social dimensions of sustainability are more important where the economic role of forestry activities is marginal, like in most Mediterranean forests (Rodriguez-Piñeros and Lewis, 2013).

Ecosystem services are important in forests under all type of conditions. However, in Mediterranean forests they gain relevance because their productivity is low but the society appreciates and benefits from these services. Besides, the special characteristics of these forests make some of the ecosystem services, and therefore their associated criteria, very relevant:

- Heavy rains and scattered canopies increase the risk of erosion, mass flows and floods. These issues are considered in the criteria *hydrological regulation* and *mass flows.*
- The risk of big fires and pests makes it necessary to manage resistant and resilient forests. This is mainly achieved through biodiversity, which is also worth maintaining because of its high value in Mediterranean forests. These concerns are tackled in the criteria *forest fires*, *persistence and stability of forest resources* and *biodiversity and habitats.*
- The cultural character of the landscape due to many years of intervention, addressed in the criterion *historical and cultural heritage.*
- Diversified exploitation as another means to overcome low profitability and because of the different products offered by Mediterranean forests: resins, truffles or cork; referred to in the criterion *diversified exploitation of forests.*

Apart from the benefits mentioned, applying an ecosystem services classification to the thinking of SFM has the advantage of encouraging an integrated approach with other land uses: a common language across sectors and more explicit focus on trade-offs and synergies. Nevertheless, it could happen that an incomplete valuation of the services pushes attention on the ones that are already quantified and monetised. Besides, emerging markets for single services may discourage from managing forests for the provision of a wide range of ecosystem services. Therefore, this forestry paradigm requires a cautious implementation so that most services are properly valued and considered in management (Quine *et al*, 2013).

Regarding the indicators, an effort was made for them to be simple and easy to understand what has to be measured or considered. These two characteristics are hardly found in existing standards. For example, the indicators of *FSC-Spain* (GTC-FSC, 2007) are perceived as clear in what they refer to but made of very long sentences. On the other hand, the indicators of *PEFC-Spain* (AENOR, 2007; AENOR, 2007b) are seen as having a simpler wording, quite clear in their objectives, but less clear on what variables or qualities to look at. The standard proposed in this work intends to offer another option for forest managers, which overcomes these perceived weaknesses, but not to ruin the work developed by others.

Concerning the participatory process developed to verify that the issues addressed by the C&I proposed are sensible, the groups of participants are representative of the stakeholders related to the forest. However, the amount of members in each group is not even but, on the whole, the total number of participants is considered enough to draw conclusions. Results reveal that participants value ecological issues most, followed by social ones, and noticeably economic ones least. The study by Maroto *et al* (2013) also acknowledges the lesser relevance of economic criteria and the greater importance of ecological criteria in sustainable and participative management of Mediterranean forests.

In relation to the valuing and aggregation method, Mendoza and Prabhu (2000) conclude that MCA techniques are excellent for prioritising a list of C&I. They describe two similar methods (*ranking* and *rating*) for establishing a hierarchy among principles and criteria (similar to criteria and aspects, as done in this research). The aggregated weights that result from the participatory process show that participants could not establish preferences easily. Therefore, few priorities can be made among criteria and aspects but, on the other hand, it suggests that the standard proposed is applicable. Similarly, Mendoza and Prabhu (2000) propose the use of the *Analytic Hierarchy Process* (AHP) as the one *most involved and also providing the most information but also most complex and time consuming*. They recommend the use of AHP to examine the relative weights at the indicator level because *it is there where the principles and criteria are measurable and observable*, and this is how it is intended to proceed with this research in next stages.

A similar study to this one shows that the method followed is quite common and that the indicators presented here constitute a starting point from which more work is needed. Maes *et al* (2011) developed an indicator framework to be applied at stand level in Flanders (Belgium). Their framework was set up by the authors and a few experts, resulting in 19 criteria and 157 indicators, which were selected from literature and assigned to a criterion. Later on, a validation step was carried out. In words of Maes *et al* (2011), only a validation procedure can transform a potential set of indicators into a suitable set. Future steps of this research will consider the performance of the indicators in a specific FMU for different management scenarios.

Conclusions

This research set out to identify C&I of SFM under Mediterranean conditions, adapted to an ecosystem services framework, and applicable at the FMU level. The process followed for the identification included a literature review of themes related to the research topic, an expert consultation to improve a set of criteria previously proposed and a participatory process to verify the issues considered in the C&I set. A standard comprising 15 criteria and 133 indicators is developed as a result.

SFM is based on the multifunctional use and exploitation of forests and it considers the social and environmental implications and consequences associated to forestry. The concept of SFM and its application have to be adapted to the particular conditions of each case; this is especially relevant in Mediterranean forests due to their specific characteristics.

Existing C&I standards and studies focus on the ecological and productive issues of SFM; social and cultural ones usually appear all together in a single criterion. The development of a C&I standard based on the maintenance and enhancement of the provision of ecosystem services searches for a balance among the three pillars of sustainability: economic, social and ecological. The criteria identified in this research adapt to an ecosystem services classification and so they cover these three pillars. The indicators proposed overcome another shortfall of existing C&I standards, whose wording is ambiguous and long. A large effort was made for the indicators to have a simple and specific writing.

The results of the participatory process do not reveal big differences for most of the aggregated weights of the elements of the different questions. This finding makes it difficult to establish priorities among criteria and aspects, but also suggests that the topics covered by the C&I proposed are suitable to Mediterranean conditions and that a standard adapted to ecosystem services is applicable.

This work was conceived as an exploratory research. It has included top-down and bottom-up approaches to develop a proposal of C&I, which serves as a checklist of “what to look at” when managing Mediterranean forests sustainably. However, it remains to be seen whether the selected C&I can be successfully employed for decision making processes, by testing them in different scenarios in a specific case study. Besides, more case studies are needed to develop a general set applicable in Spanish forests under Mediterranean conditions. Nevertheless, this proposed set can serve for similar research or decision making situations as a starting point for C&I pre-selection. C&I constitute a piece of the puzzle; a sustainable management based on ecosystem services depends upon many drivers, not all of them coming from the forest sector (subsidies, payments for ecosystem services).

Acknowledgements

This work has been possible thanks to the Spanish Ministry of Economy and Competitiveness that supports the project *Multicriteria Techniques and Participatory Decision-Making for Sustainable Management* (Ref. ECO2011-27369) and thanks to the Regional Council of Education, Culture and Sports (Valencia, Spain) that finances a research fellowship (Ref. ACIF/2010/248).

Chapter 5-Eliciting indicator preferences through expert consultation by means of an Analytical Hierarchy Process (AHP) questionnaire

Introduction

This chapter represents the last step of this thesis, which has not been published as part of any paper. The methodology carried out is explained and the results are described and discussed.

Once a proposal of indicators had been developed as an output of the last paper, it was intended to verify those indicators. The reason why indicators had not been tested with the stakeholders when completing the participatory process of Chapter 4 was that they were too technical for a face-to-face interview with people who were not professionals. Therefore, it was thought that indicators would be better prioritised in a later step by people with experience or knowledge in forest management.

In words of Mendoza and Prabhu (2000), ranking and rating comparisons are more appropriate for principles and criteria; whereas, for indicators pairwise comparison methods like the analytical hierarchy process (AHP) are more accurate. AHP consists of establishing all possible paired combinations of all the elements in the same level of a hierarchy and determining the relative importance of one of the elements of each pair according to a given scale. The rationale behind the method is that considering these pairwise comparisons all these elements can be prioritised (Saaty, 2006). Therefore, it is suitable for the indicators because their wording is clearer and more specific and the respondent understands what is being compared (Mendoza and Prabhu, 2000).

The last part of this thesis consists of asking experts in forest management to prioritise the indicators of each criterion following the AHP methodology. For this purpose, a questionnaire was developed. The objective of this step is to assign different weights to the indicators of every criterion, so that the indicators proposed can be verified according to the weights received, some of them can be deleted if they get a very low weight, and new ones can be added if proposed by the respondents of the questionnaire.

Method

There are 15 criteria and 133 indicators to compare in pairs. In order to shorten the questionnaire, it was decided to compare only one indicator against the others of the same criterion. The results should not be different from applying the AHP method purely. For example, given three elements (A, B and C), if a respondent said that A is two times more important that B and that A is five times more important than C, if the person was consistent, he/she should say that B is three times more important than C. Thus, it was assumed that respondents were consistent in their valuations and all the other comparison values were inferred from weighting only one indicator against the others.

The complete questionnaire can be seen in *Annex 6*. The questionnaire was made of fifteen questions, one for each criterion. In each question, experts were asked the following:

- *State the relative importance of one indicator of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management <u>persistence and stability of forest resources</u>* (and the same question was repeated for every criterion).

Then, *n-1* pairs of indicators were shown (being *n* the number of indicators contained within the criterion), one indicator of each pair was repeated in all the pairs. Next to each pair of indicators a valuation scale was provided to respondents. That scale ranged from *9* to *1/9*. If the first indicator of the pair was considered more important by the respondent, then a value of *2*, *3*, *4*, *5*, *6*, *7*, *8* or *9* would be given, meaning *2* two times more important the first indicator compared to the second, and

9 nine times more important. If a *1* was given, the respondent thought that the first indicator was as important as the second one. Finally, if the values *1/2*, *1/3*, *1/4*, *1/5*, *1/6*, *1/7*, *1/8* or *1/9* were selected, the second indicator of the pair was considered more important, being the scale the same than when the first indicator was believed to be more relevant (more details of the valuation scale are provided in *Annex 6*).

After the questions, a whole page was left for respondents to make comments on the indicators proposed, on their valuations or to add or propose new indicators of their own. It was optional to complete this part of the questionnaire.

The indicators were arranged for the questionnaire. Saaty (2006) establishes that a person can compare a maximum of nine things. Most of the criteria had more than nine indicators. Even though an abbreviated version of the method was applied, it was considered that experts would better compare a reduced number of indicators. Therefore, either a selection was done or similar indicators were joined in one. The selection affected indicators that were seen as difficult to measure or not providing information relevant enough to assess the performance of SFM. In the end, 99 indicators were presented to experts.

Later on, the questionnaire was sent to the potential experts to answer it. It was previously decided that they should belong to the following groups: university, central and local governments, research centres, public and private enterprises and forest owners. Then, they were contacted via e-mail, they were sent the questionnaire and they were asked to complete it. 343 potential respondents were contacted.

Figure 15 explains how the weights of the indicators were elicited for each respondent, and how they were aggregated to obtain the global weights of the indicators of each criterion. The steps carried out are described next (Saaty, 2006):

1. For each criterion of each respondent, an “answers matrix” was created. This matrix put all the indicators in a criterion against all the others in the same criterion.
2. The matrix should be filled with the answers of the respondents. However, given the way it was asked, only

the information concerning the first row of the matrix was provided.

3. Then, the first column of the matrix was calculated. This column is made of the reciprocal values of the first row; this means that if I1-I2 gets *1/2* in the row, then I2-I1 in the column gets *2*. The reciprocal of *1* is *1*. According to Saaty, when a respondent is consistent, all the columns of the “answers matrix” are equal, and each column represents the weight of the elements to prioritise. So, it is not necessary to calculate all the columns.

	I1	I2	I3
I1	1	6	1/4
I2	1/6		
I3	4		

	P1	...P_i	...P_n	Geom Mean	Weights
I1	1	1	1	1	1/3.9=0.26
I2	1/6	5	7	1.8	0.46
I3	4	3	1/9	1.1	0.28
			SUM	3.9	1

Figure 15. Process followed to calculate the weights of the indicators of each criterion for a given example of a criterion that contains three indicators. The table on top represents the valuations of one single respondent in the row; the column values are the reciprocal of the row values and the local priorities (or weights) of the indicators for that particular respondent (I_i are the indicators). The second table puts together the local priorities of all the respondents, calculates the geometric mean of each row and the final weights of the indicators by dividing each geometric mean by the sum of the geometric means (Saaty, 2006).

4. Thereafter, all the first columns calculated for each respondent were put next to each other and the geometric mean was calculated for each row.
5. Finally, the values of the geometric mean column were summed and, in order to obtain the weights of each indicator of the corresponding criterion, each value of the geometric mean column was divided by this sum. To check that the process was well done, the sum of the weights had to be 1.

The resulting weights serve to describe the preferences of the experts, but some indicators were deleted as a result of the low weight obtained. With respect to the comments part of the questionnaire, no special analysis was carried out. All the comments of the respondents who had made some were put together and if similar suggestions had been made by more than one respondent or the suggestion was considered relevant for improving the indicators, changes were made. These comments were very useful for the final selection and phrasing of the indicators.

Results

Respondents

47 out of the 343 experts who were sent the questionnaire completed it. However, 3 questionnaires were rejected because respondents did not answer all the questions. Therefore, there were 44 questionnaires to carry out the quantitative analysis. From these 44, 8 of them belonged to the central and local governments group, 11 of them to the universities, 10 of them to research centres, 12 of them to public and private enterprises, 4 of them were freelance, 9 were forest owners and 1 belonged to a forestry association. It has to be said that these groups are not mutually exclusive: a respondent can belong to more than one group. Besides, 14 of the respondents made comments in the end of the questionnaire. The comments referred to the indicators proposed, new ones were also suggested or comments were made on the global appearance of the proposal.

Quantitative analysis

In this section, the weights that the indicators of each criterion receive after applying the AHP method are commented question by question (or criterion by criterion). Figures show these weights. A short version of the indicators appears in the legend of the figures, to see the complete version of them go to *Annex 6*.

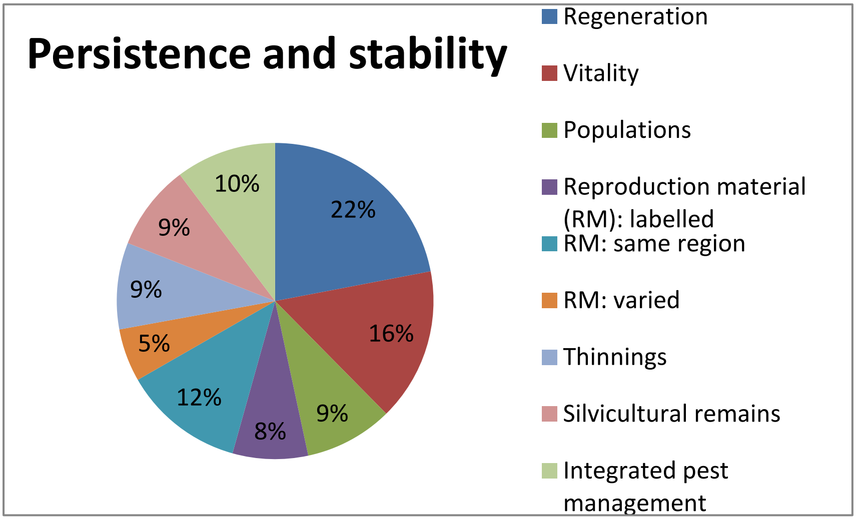

Figure 16. Weights assigned to the indicators of the criterion *persistence and stability of forest resources* as a result of the experts' valuation in the AHP questionnaire.

Figure 16 displays the weights of the indicators of the criterion *persistence and stability of forest resources*. The weights vary between 5% and 22%. The highest weight clearly corresponds to the evaluation of *regeneration*. The *vitality* of the tree layer also receives a high weight. More or less, the rest of the indicators get a similar weight. The *varied* origin of the *reproduction material* gets the lowest weight.

The weights of the indicators of the criterion *profitability of forest resources* appear in *Figure 17*. The range of variation goes between 8% and 19%. The indicator related to *incomes* gets the highest value, whereas the lowest one goes to *subsidies*. In relation to their weight, there are two groups of indicators: those with a weight around 18%: *incomes*, *costs*, *demand* and *selling contracts*; and those with a weight around 10%: *present value*, *productive area* and *subsidies*.

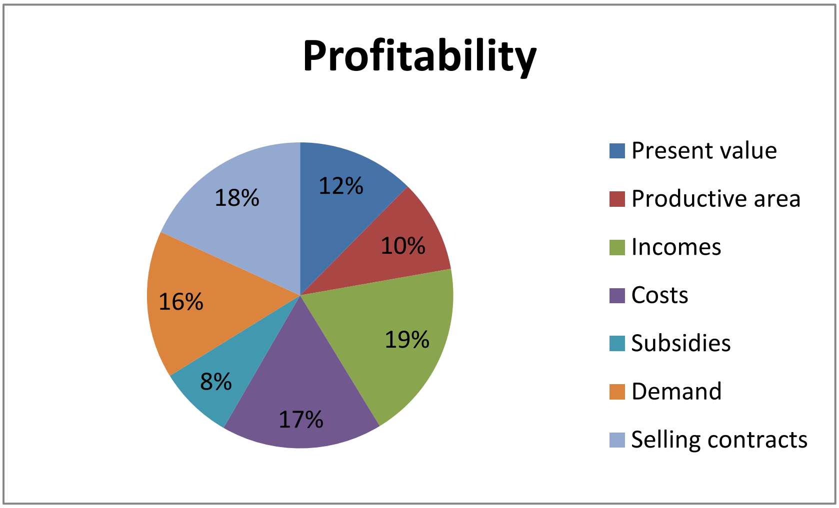

Figure 17. Weights assigned to the indicators of the criterion *profitability of forest resources* as a result of the experts' valuations in the AHP questionnaire.

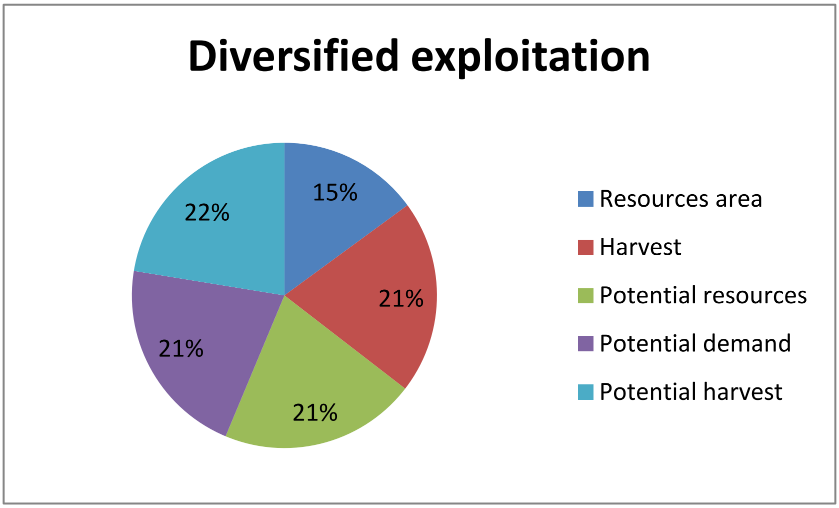

Figure 18. Weights assigned to the indicators of the criterion *diversified exploitation of forests* as a result of the experts' valuations in the AHP questionnaire.

The indicators of the criterion *diversified explotation of forests* present weights that range between 15% and 22%. All of them are very similar; three of the indicators get a 21%. The highest weight corresponds to the estimation of the *harvest* of *potential resources* to exploit in the forest. The lowest one goes to the *area* devoted to manage each of the forest *resources*. These results can be seen in *Figure 18*.

Figure 19 shows the results for the criterion *employment and working conditions*. Weights fluctuate between 6% and 16%. There are three groups of indicators: one showing a weight of 6%, three around 11% and three around 15%. The number of *workers* employed in the forest gets the lowest weight and appropriate *salaries* gets the highest one.

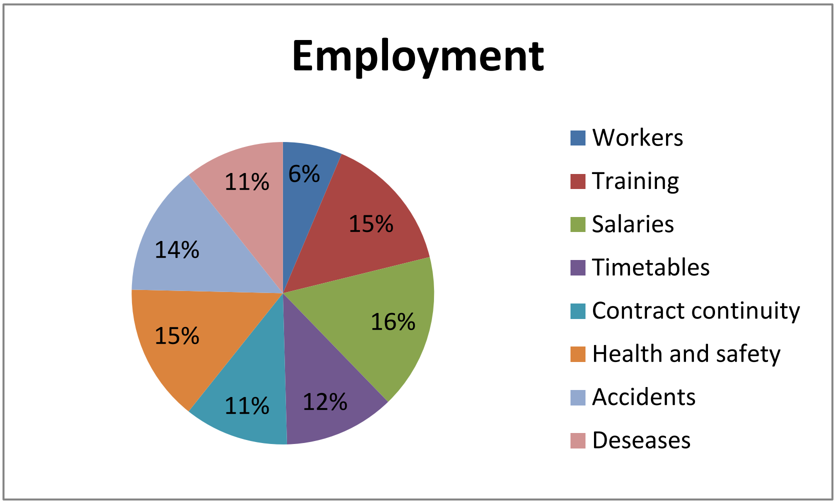

Figure 19. Weights assigned to the indicators of the criterion *employment and working conditions* as a result of the experts' valuations in the AHP questionnaire.

The results for the criterion *recreation* are presented in *Figure 20*. The variation is between 5% and 18%. According to their weights, there are three groups of indicators: those under 10%, those between 10% and 15%, and those above 15%. The indicators related to hunting get the lowest weights: inventory of *hunting fauna populations* (5%), state of conservation of *hunting* fauna *infrastructures* (5%) and *captures* of hunting fauna per period of time (6%). The following indicators get the highest weights: number of *visits* for recreational purposes (18%), state of conservation of *recreational infrastructures* (17%) and diversity of recreational or *leisure* activities offered in the forest (16%). Indicators related to *potential recreational activities* and their *potential demand* get a medium weight. The *area* of forest managed for *recreation* receives a low weight (8%).

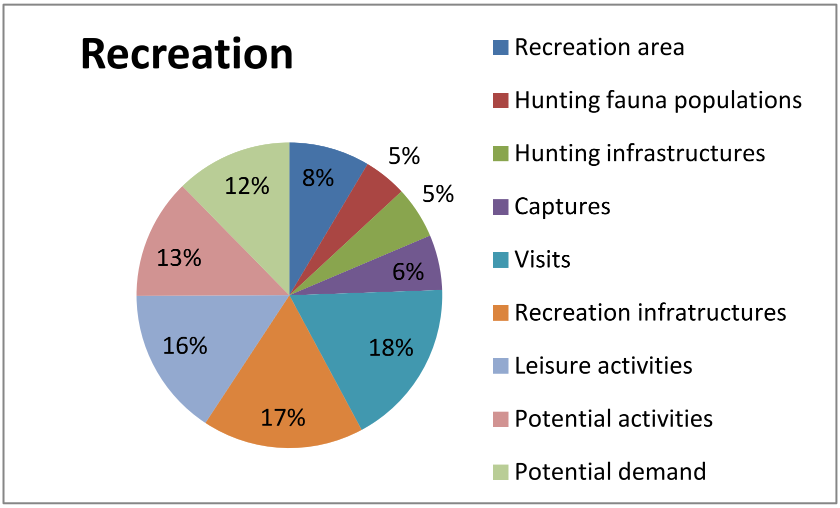

Figure 20. Weights assigned to the indicators of the criterion *recreation* as a result of the experts' valuations in the AHP questionnaire.

See *Figure 21* to consult the weights of the indicators of the criterion *visual character*. They differ between 7% and 17%. The lowest weight corresponds to the indicator *harvest area*. The *integration* of activities with a visual *impact* gets the highest weight.

The indicator related to the conservation of the inspirational or spiritual character of certain *places*, which belongs to the criterion *historical and cultural heritage*, receives the lowest weight (25%). The other two indicators receive a similar weight: 35% for the conservation of *traditions* and 40% for the conservation of tangible *elements* holding a cultural meaning. These values can be seen in *Figure 22.*

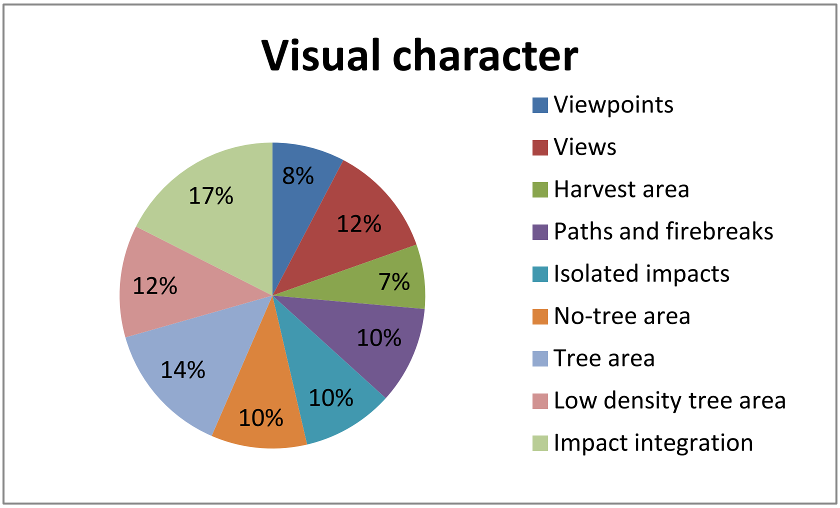

Figure 21. Weights assigned to the indicators of the criterion *visual character* as a result of the experts' valuations in the AHP questionnaire.

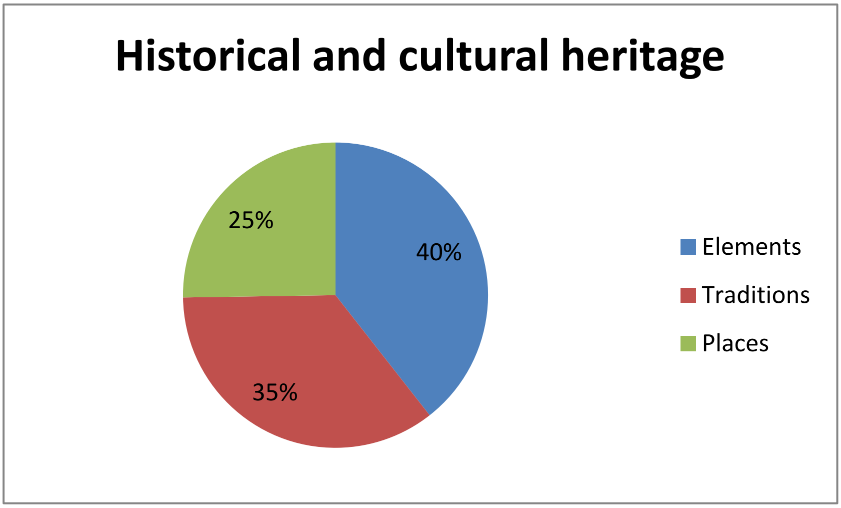

Figure 22. Weights assigned to the indicators of the criterion *historical and cultural heritage* as a result of the experts' valuations in the AHP questionnaire.

The weights of the indicators of the criterion *participatory processes* are exhibited in *Figure 23*, varying between 5% and 16%. The lowest weights go to number of *participants* in each participatory process (5%), management *decisions* including participatory processes (9%) and *conflicts* occurred and solved in each process (9%). On the contrary, the highest weight goes to participants *perceiving* that their input in participatory processes has had an *impact* in the final decisions.

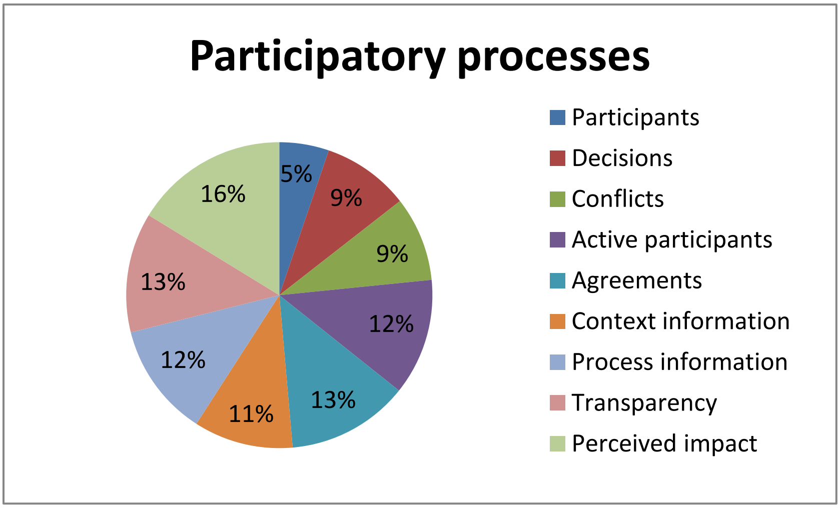

Figure 23. Weights assigned to the indicators of the criterion *participatory processes* as a result of the experts' valuations in the AHP questionnaire.

All four indicators of the criterion *education* get the same weight, so that few comments can be made in this regard. This can be checked in *Figure 24*.

With almost half of the weight (47%), the highest valued indicator of the criterion *research* is the existence of research *agreements* (*Figure 25*). With a weight of 37% appears the indicator about *publishing* the results of monitoring and assessment processes in the FMU. The lowest weight (16%) corresponds to *area* of the forest where *research* activities take place.

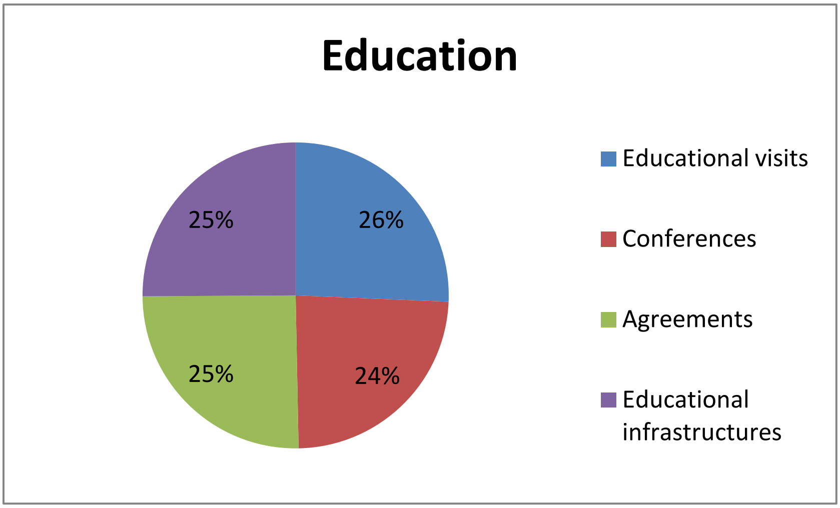

Figure 24. Weights assigned to the indicators of the criterion *education* as a result of the experts' valuations in the AHP questionnaire.

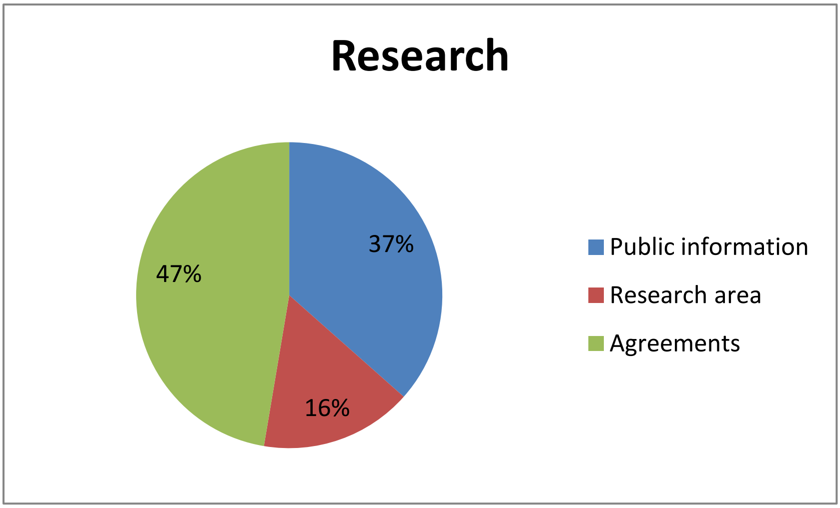

Figure 25. Weights assigned to the indicators of the criterion *research* as a result of the experts' valuations in the AHP questionnaire.

The weights assigned by the respondents to the indicators of the criterion *biodiversity and habitats* are shown in *Figure 26*. They change between 4% and 29%. There are three groups of indicators: those whose weight is below 10%, those with a weight between 10% and 20%, and the one with 29% of weight. The lowest weights go to *restrictions* to *vehicle* circulation (4%) and the presence of *silvicutural remain*s in the forest (6%). *Habitat conservation* gets notably the highest weight. *Endangered species inventory*, *alien species inventory* and *ecological connectivity* receive medium weights. There are also low weights (8%) for the indicators *flora species inventory*, *fauna species inventory* and *vegetation layers* in each vegetation formation.

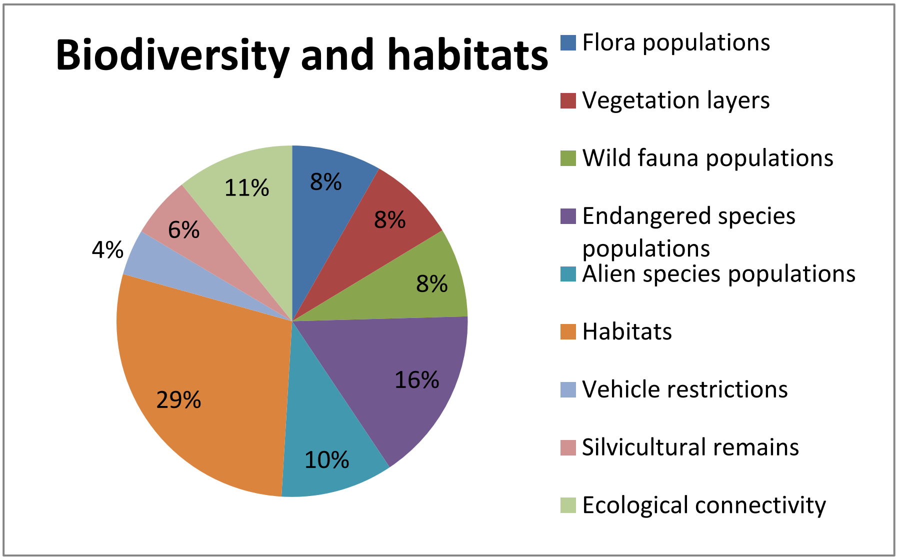

Figure 26. Weights assigned to the indicators of the criterion *biodiversity and habitats* as a result of the experts' valuations in the AHP questionnaire.

The weights of the indicators presented in *Figure 27* relate to the criterion *hydrological regulation*. Their range goes between 6% and 19%. Again there are three groups of indicators inrelation to their weight: the ones below 10%, the ones between 10% and 15%, and the one with the highest weight (19%), which corresponds to forest area affected by *erosion* processes. The lowest weights (6%) go to soil *nutrient* determination and area of forest whose soils have infiltration problems (*impervious soil area*). There are also low weights for *area* of forest managed for *aquifer filling* (9%) and *fertiliser restrictions* (7%).

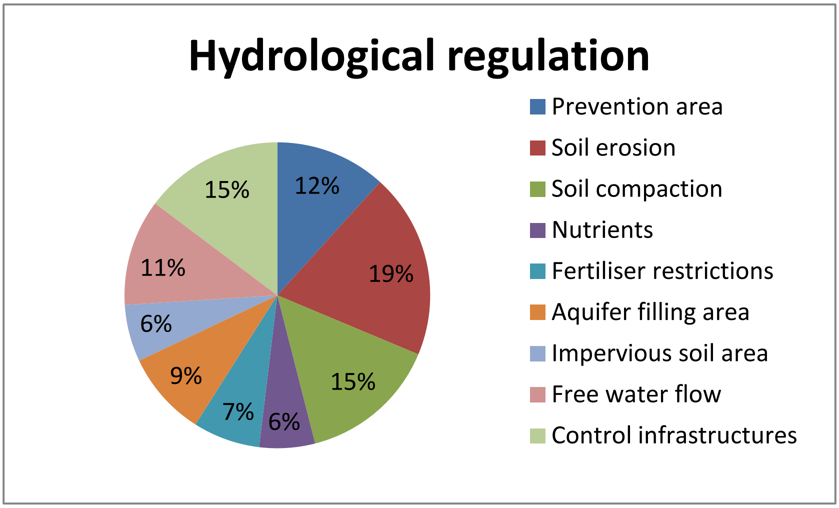

Figure 27. Weights assigned to the indicators of the criterion *hydrological regulation* as a result of the experts' valuations in the AHP questionnaire.

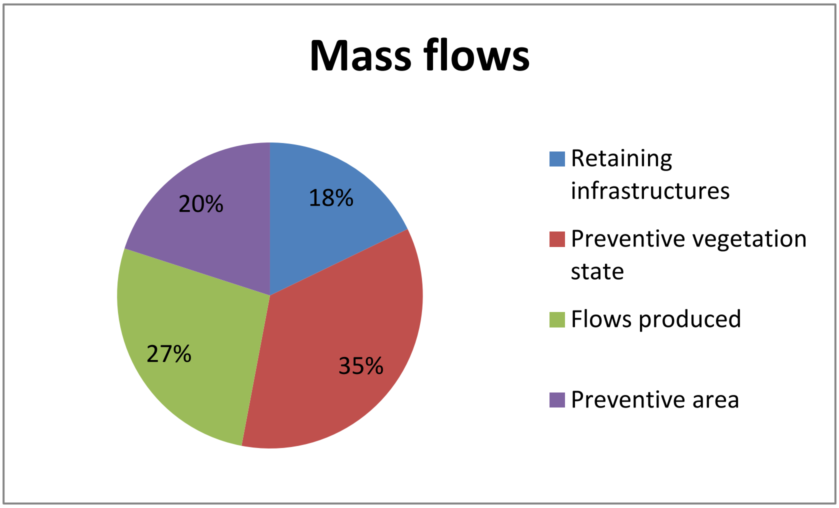

Figure 28. Weights assigned to the indicators of the criterion *mass flows* as a result of the experts' valuations in the AHP questionnaire.

The lowest weight (18%) of the criterion *mass flows* corresponds to the state of conservation of *retaining infrastructures*. On the other hand, presents a weight of 35%

the indicator related to *state of vegetation* cover in areas managed to *prevent* mass flows. This information appears in *Figure 28*.

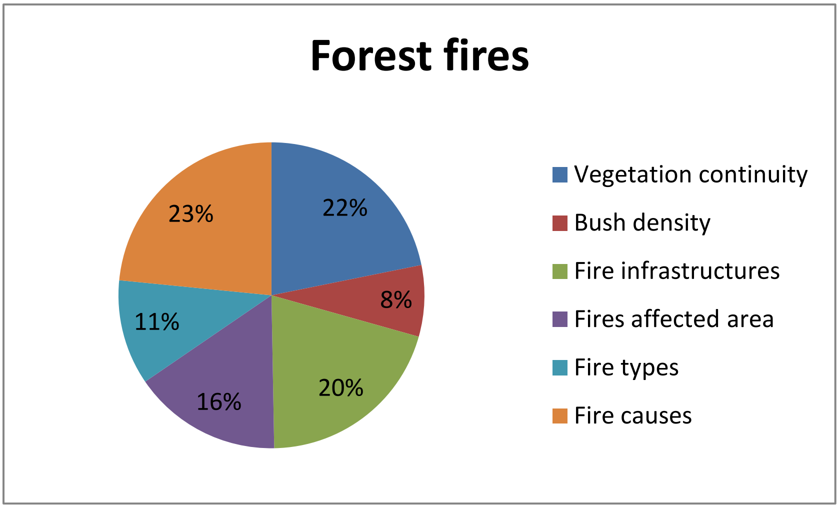

Figure 29. Weights assigned to the indicators of the criterion *forest fires* as a result of the experts' valuations in the AHP questionnaire.

The weights given by respondents to the indicators of the criterion *forest firest* are displayed in *Figure 29*. The weights vary between 8% and 23%. The lowest weight is for *bush density* and the highest one for determining the *causes of forest fires*. Vertical fuel (*vegetation*) *continuity* and state of conservation of *infrastructures for fire* prevention and extinction aid also get high weights (22% and 20% respectively).

Finally, in *Figure 30* are presented the weights of the indicators of the criterion *carbon storage*, ranging from 7% to 16%. The lowest weights correspond to the indicators referring to the state of the soil in relation to carbon storage (the ones showing a weight of 7%). Also gets a low weight the area under an *adult tree canopy* in areas managed for this criterion (8%). The highest weight (16%) is for *tree species* composition in areas managed for this criterion.

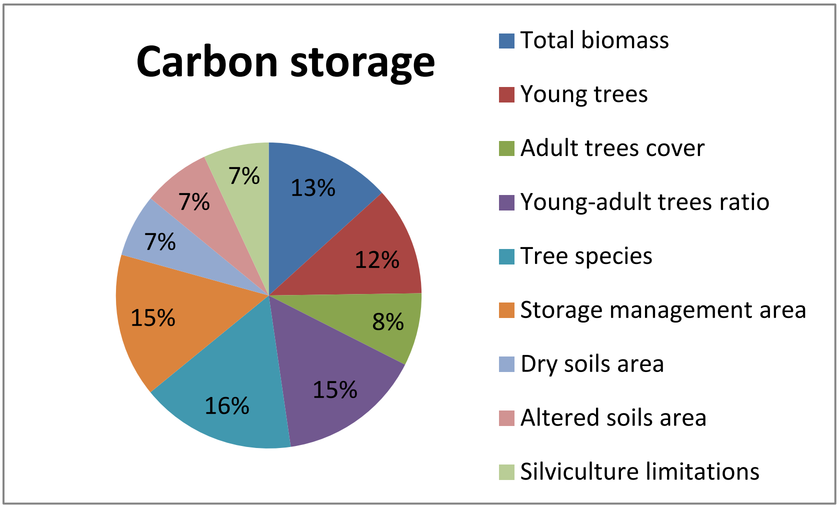

Figure 30. Weights assigned to the indicators of the criterion *carbon storage* as a result of the experts' valuations in the AHP questionnaire.

Because of getting a low weight and showing a noticeable difference with the other indicators of the same criterion, the following indicators are deleted (the numbers of the criteria and the indicators refer to *Annex 6*):

- Criteria 8, indicator 3: *Conflicts that have been solved in each participatory process.* It is deleted becuse of its low valuation, because it only applies when conflicts happen and because the relevant thing of a participatory process are the agreements achieved.
- Criteria 11, indicator 7: *Motor vehicles and forest machinery circulation restrictions*. Apart from its low weight, it is deleted because if a regulation exists, it does not mean that people is going to comply with it; also, because an indicator like this makes sense in a place where many visitors might be expected, like a protected area whose regulation mechanisms will incorporate these restrictions.
- Criteria 15, indicator 8: *Forest area where soil structure has been broken or altered because of reforestations or paths or small roads construction.* It gets a low valuation and it is considered as difficult to determine when, where and how much is soil structure altered.

Qualitative analysis

In this part, the changes to the indicators due to the comments from the respondents are described. The explanations refer to the indicators that appeared in the questionnaire (*Annex 6*):

Criterion 1-*persistence and stability of forest resources*:

- Indicator 4: deleted because it is compulsory by law (Gobierno de España, 2003b).
- Indicator 5: rephrased into *in case of reforestations and enrichment plantations, area of forest where trees or seeds come from the same region where the forest is located.* The aim is to make it more quantitative.
- Indicator 6: rephrased into *in case of reforestations and enrichment plantations, area of forest where the origin of trees or seeds is varied.* The aim is to make it more quantitative.
- Indicator 7: rephrased into *area of forest where thinning is not focused just on fast-growing individuals or those with a favourable morphology.* The aim is to make it more quantitative.
- Indicator 8: rephrased into *area of forest where the maximum time determined for harvest remainders to stay in the forest has been respected.* The aim is to make it more quantitative.
- Indicator 9: rephrased into *area of forest where integrated pest management takes place: chemical treatments are not used in a preventive manner and they are always used when there is no other possible way.* The aim is to make it more quantitative.
- New indicator: indicator 5 from criterion 12 is moved into this criterion because it refers to soil quality, which also plays an important role in the persistence and stability of forest resources. It is rephrased into *records of fertilisers and pesticides that have been used in a period of time: quantities and composition of the products and timing of the application.* The new writing of the indicator takes into account what products are used and not whether restrictions exist or not.

Criterion 4-*employment and working conditions*:

- Indicator 1: rephrased into *number of employees in the forest per period of time.*
- Indicator 7: rephrased into *percentage of employees who have suffered from working accidents in a certain period of time.*
- Indicator 8: rephrased into *percentage of employees who have suffered from working diseases in a certain period of time.*

Criterion 7-*historical and cultural heritage*:

- Indicator 2: the part that refers to rights of use of forest resources is eliminated because, according to one of the respondents, it is compulsory to comply with those rights of use by law.

Criterion 8-*participatory processes*:

- Indicator 4: deleted because it is difficult to measure and very similar to indicator 1 of this criterion.
- Indicators 6 and 7: these indicators are joined because they refer to similar things. They are also rephrased to be more quantitative. The resulting indicator is: *percentage of participants who perceive that they have received enough information on the topics to make decisions and on the objectives and expected development of the participatory process.*
- Indicator 8: rephrased into *percentage of participants who know and understand how final decisions are made.* The aim is to make it more quantitative.
- Indicator 9: rephrased into *percentage of participants who perceive that the final decision-making has considered their contributions during the process.* The aim is to make it more quantitative.

Criterion 11-*biodiversity and habitats*:

- Indicator 9: rephrased into *number of barriers to fauna movements and to seed dispersal, except when it is* *necessary to protect new plants or for other justified reasons*. The aim is to make it more quantitative.

Criterion 12-*hydrological regulation*:

- New indicator: *estate of vegetation cover in areas managed to prevent erosion and floods.* Because vegetation is an important part of flood prevention and there was no indicator referring to it.
- Indicator 4: deleted because it is not easy to measure and, presumably, if fertilisers are properly applied and erosion is controlled soil quality will be kept.
- Indicator 5: is moved to criterion 1 and slightly rephrased.
- Indicator 7: deleted because soils suffering from infiltration problems are as natural as other types of soil, and because forest management acts mainly on vegetation and not so much on soil structure.
- Indicator 8: rephrased into *Human infrastructures (paths and small roads, bridges) allow free water flow in hillsides and natural water channels. Except terraces and other infrastructures built to retain water.* The last part is added because previously it was not taken into account those infrastructures which may exist and whose purpose is the opposite to allowing free water flow.

Criterion 15-*carbon storage*:

- Indicator 7: deleted because dry and cracked soils are natural and depend mainly on the type of soil and climate, both factors out of the forest manager's control.
- Indicator 9: deleted because it is necessary to cut trees periodically in order to renew the forest cover (young trees absorb more carbon than adult ones). If silvicultural treatments are carried out in a suitable way, they should not favour erosion or any other process that could lead to a significant soil organic carbon loss.

In view of these changes, the final set is made of 90 indicators.

Discussion

In view of the graphics, some features are worth commenting. Indicators referring to *forest area managed for…* are normally among the lowest valued of the criterion, meaning that it is not the quantity but the quality what matters. Exception to the previous are the indicators *forest area managed for protection functions (avoid erosion and floods)* (*Figure 27*) and *forest area managed to maximise biomass synthesis* (*Figure 30*). Protective functions and carbon storage seem to be criteria to take care of under Mediterranean conditions, so that the more area managed for them the better.

Regarding employment, it is usually argued that forestry should be a source of job opportunities (AENOR, 2007; AENOR, 2007b; GTC-FSC, 2007). However, *number of employees in the forest* gets notably the lowest weight of the criterion (*Figure 19*). It is possible that this indicator becomes more relevant when planning forestry at a national, regional or county level. At the FMU level, as long as there is forest management, there will be employees and if management is efficient there cannot be more employees.

In relation to *recreation*, all three indicators related to hunting get low values (*Figure 20*). This can be either because respondents think that hunting is a forest resource and it should be included in the economic criteria or because they are against hunting. But, hunting is a source of income and given the low productivity of Mediterranean forests it is important to count it among the issues of SFM. Hunting indicators can be included either as part of economic criteria or as part of recreation. In this case, it was considered that hunting has a lot of a social and cultural activity.

The indicator related to places, from the criterion *historical and cultural heritage,* gets a low value (*Figure 22*). It can be because there are few places in Spain holding a religious or inspirational significance. It can also be that respondents did not understand very well what it refers to or that they have never been in such a kind of place.

Habitat conservation receives quite a high weight (*Figure 26*), especially if compared with the other indicators of its criterion. It can be seen that it is a very important topic in order to maintain biodiversity. However, the description of this indicator is vague; a respondent said that it is a good indicator, but expensive, difficult and subjective to measure. This is one of the indicators that will require further research after this thesis in order to make it more specific and quantitative.

Concerning *hydrological regulation*, the highest weights go to the indicators *forest area affected by different types of erosion*, *forest area affected by compaction* and *flood control infrastructures inventory* (*Figure 27*). *Nutrient inventory, restrictions to the application of fertilisers and pesticides*, *forest area managed to generate water surpluses for aquifer filling* and *forest area suffering from soil infiltration problems* get the lowest weights. Taking in consideration these weights and the comments from respondents some changes were made to these indicators.

An expert suggested that *nutrient inventory* and *fertiliser restrictions* should be in a different criterion because they are not really topics of hydrological regulation. The indicator *nutrient inventory* was deleted because it was considered that it is not applicable to ask a forest owner to carry out soil chemical analysis regularly. As suggested by the same expert, the indicator related to fertilisers was moved to criterion 1 because it fits better since *persistence and stability* also includes the state of the soil. Finally, an expert said that soils suffering from infiltration problems are natural, so that this indicator was deleted. On the contrary, *aquifer filling* was kept because, even though it gets a low weight, it is part of the hydrological regulation (Generalitat Valenciana, 2011) and it was considered to be relevant as an objective of SFM.

For the criterion *forest fires*, the indicator *causes of forest fires* gets a very high weight (*Figure 29*). In Spain the origin of 15% of forest fires remains unknown (MARM, 2008b) and this explains why experts think of it as something important. But, like *habitats conservation*, it requires further research to make it more specific and say more precisely what is it intended to be described. Related also to *forest fires*, *bush density* receives a very low weight. It is surprising given that many fires spread faster because there is a dense bush layer.

With reference to *carbon storage*, big quantities of organic carbon are kept in the soil, much more than in vegetation and for longer periods of time (Generalitat Valenciana, 2011). Nevertheless, respondents provided a low weight to the indicators related to storage in the soil (*forest area showing dry and cracked soils*, *forest area where soil structure has been broken or altered* and *in areas managed to comply with this criterion silvicultural treatment are minimised*) (*Figure 30*). This can be because other indicators may have been proposed in the questionnaire (but no new indicators were suggested by the experts). It can also be that experts see that forestry acts mainly on vegetation and a proper management does not have a big impact on soil structure and content. Because of this low weight and the reasons indicated in the results section, these indicators were deleted.

Chapter 6-General discussion of the thesis results

This thesis presents the following results:

- A set of requirements of SFM for Mediterranean conditions.
- An analysis of Spanish forestry which includes: the introduction of the requirements, the difficulties to achieve SFM and proposals for improvement.
- A framework of criteria to assess participatory processes and their outcomes.
- Several criteria and aspects of SFM including stakeholders' preferences for a FMU of Comunidad Valenciana.
- Indicators of SFM prioritised by experts.

Requirements of SFM

When comparing the relevance of the requirements of SFM with their current introduction (Figure 1) it can be seen that the biggest effort in Spain should be in increasing the number of forests with a management plan and in improving the contribution of forest management to rural development and quality of life. Forest management in Spain is not happening widely due to low productivity of forests, lack of economic compensation to forest owners because of the ecosystem services provided and the small size of private properties (Figure 2). The low introduction of the other two requirements (*rural development* and *life quality improvement*) is mainly because of the lack of interaction between forestry planning and land management.

The experts who answered the questionnaire in Chapter 2 suggested that these difficulties could be overcome if forest management was focused on the diversity of products and the services that Mediterranean ecosystems have to offer. It would be then necessary that compensation mechanisms exist for the provision of those services. For these mechanisms to work, society must become more aware and feel more responsible for the condition of forests; in this sense, participatory processes can help (Generalitat Valenciana, 2011).

Criteria to assess participation

For a participatory process to be successful the promoters have to lead the process efficiently, participants have to receive suitable information on the process and on the topics to make decisions and participants have to be encouraged to actively engage in the process. Considering how the analysis of the papers in Chapter 3 was carried out, there are some criteria of a participatory process that still seem relevant, even though they do not show significant differences between the two groups of case studies (LL and UR) when comparing their criteria score profiles (see *Tables 8* and *9*). These criteria are: *representation* and *transparency*. Both get high scores in the two groups, so that they are considered important in order to achieve realistic and adequate solutions.

The development of the framework of criteria to evaluate participatory processes in Chapter 3 highlighted the relevance of assessing both the process and the outcomes. Traditionally, the evaluation of participation focused on the development of the process. However, as important as the process are the results, because participation is useless if no results are achieved or these are not satisfactory (Rowe and Frewer, 2000; Lawrence, 2006; Blackstock *et al*, 2007). Besides, the literature revealed that when analysing the outcomes it is necessary to think about the decisions intended to be made or the tools intended to be developed. But, it is also necessary to think about the changes in participants' perceptions and knowledge towards the issues of the process (Jakku and Thorburn, 2010). All these aspects were reflected in the framework (*Tables 4*, *5*, *6* and *7*).

Criteria of SFM

15 criteria of SFM under Mediterranean conditions were identified (*Table 18* and *Annex 3*). An effort was made for the criteria to transform ecosystem services into management procedures and goals. Thus, the criteria intend to maintain the provision of ecosystem services of Mediterranean forests. It is explained in Chapter 4, in the material and methods section, the association made in this thesis between the three types of ecosystem services and the three pillars of sustainable development. Therefore, it could be said that adapting the criteria to an ecosystem services classification results in criteria that cover these three pillars.

There are 3 economic criteria identified, 7 social and 5 ecological. It was the aim of this research to emphasise the social aspects associated to forestry since most existing C&I standards worldwide include social and cultural aspects in one single criterion. It does not mean that the economic part is not important, but this thesis started from the premise that traditional forest management focuses on the production of wood, and it was its aim to look at other issues.

In the participatory process carried out in *Ayora*, stakeholders expressed their preferences towards the criteria and no special differences were found among their weights after aggregating the answers from all the participants (the main ones have been commented in the results section of Chapter 4). None of the criteria gets such a low weight that it would be recommended to eliminate it. These similarities suggest that the criteria proposed are realistic.

The criteria assessed by stakeholders (Chapter 4) can be compared with the requirements determined in Chapter 2. Firstly, it has to be said that the requirements were meant for a general situation of SFM, whereas the criteria are specific for the FMU level. Secondly, the criteria intend to maintain and improve the provision of ecosystem services; therefore, they find a balance between the economic, social and ecological topics related to SFM. The requirements are more generic than the criteria in their definition and content. *Management planning* was valued as the most relevant requirement for SFM, but the criteria consider it as something inherently implicit in forest management and no criterion refers to it. The requirement *landscape management* has been split into its cultural, visual and ecological components in different criteria. *Rural development* and *life quality improvement* have not been considered to apply at FMU level, because for their accomplishment it is necessary the interaction among different sectors involved in land management (forestry, agriculture, industry); therefore, they were not included in the criteria. The other requirements match well with the criteria, either as an explicit criterion or as part of any of them.

Aspects and indicators of SFM

The aspects of each criterion valued during the participatory process (Chapter 4) and the results of the AHP questionnaire with experts to prioritise the indicators (Chapter 5) are comparable. It has to be said that the aspects are more general, the indicators are more technical and the respondents of both questionnaires had different knowledge and expertise. Besides, the questions were different: stakeholders were asked to order the aspects depending on their management preferences and experts were asked to state the relative importance of the indicators depending on their relevance for assessing the performance of SFM. In spite of these differences between the processes to carry out both questionnaires, something can be said. In the next paragraphs, some of the criteria are commented.

In the case of the criterion *profitability of forest resources*, stakeholders considered that *in-kind incomes* was the most important aspect and *money incomes* the least important one (*Figure 12*). But, for the indicators, the one related to *in-kind incomes* (*current value of resources present, or not harvested, in the forest*) gets a medium weight compared to the other indicators; whereas the sum of the weight of the indicators referring to *money incomes* (*incomes resulting from selling the forest resources harvested*; *expenses resulting from management operations*; *incomes due to subsidies and other sources different from forest resources produced*) account together for the biggest weight (*Figure 17*). A possible explanation for this is that stakeholders perceive that economic profitability will turn into a degraded ecology of the forest. The experts, apart from thinking that forest management needs revenues to keep on going, may consider that the most reliable and easy measure of profitability is the difference between incomes and costs.

A similar situation appears in the criterion *employment and working conditions*. Its aspects *job posts* and *training* were weighted as the preferred ones (*Figure 12*), but they get the lowest weights as indicators (*number of employees in the forest*; *workers' training is suitable for their posts*) (*Figure 19*). In the case of the aspect *training*, the result is likely to be so low for its indicator because it is difficult to measure. For the indicator *job posts*, experts seem to consider that forestry at FMU level can hold a maximum number of workers and it is not feasible to hire more people.

Regarding the criterion *visual character*, stakeholders gave a medium weight to the aspect *watching areas* (*Annex 5*). On the contrary, the indicator related to this aspect (*main watching areas inventory: number and state of conservation*) gets a low weight (*Figure 21*). Experts happen to be more concerned with managing the visual characteristics of the forest while stakeholders want to enjoy the views of the landscape.

Many of the aspects included in the criterion *participatory processes* (*Table 19*) were inspired from the criteria of the framework developed in Chapter 3 (*Tables 4* and *6*). The aspect *representation* corresponds to the criterion with the same name; *leadership* to *structured group interaction*; *information* to *quality and selection of information and resources*; *objectives* to *clear mandate and goals*; with *transparency* occurs the same as with *representation*; *acceptance* is related to the outcome criterion *acceptance of process and outputs*; *impacts* to *recognised impacts*; and *social relationships* to *relationships and social capital building*. Therefore, the participatory process of *Ayora* served to test some of the criteria of the framework proposed in Paper 2.

Concerning the indicators of the criterion *participatory processes*, the one that relates to the aspect *representation* (*number of stakeholder groups and number of participants of each group in every participatory process*) gets a low weight (*Figure 23*). Maybe the indicator could have been better defined and experts understood it in terms of quantity and not representation of the different groups involved. On the other hand, the indicator referring to the aspect *impacts* (*participants perceive that the final decision-making has considered their contributions during the process*) receives a high weight compared to the other indicators of this criterion. Changes were made later to the indicators taking into account the comments from the experts, mainly because the information contained within some of the indicators was very similar. Theses changes are explained in detail in the results section of Chapter 5.

Concerning *biodiversity and habitats*, all the aspects get a similar weight (*Annex 5*), but the indicator *forest habitats inventory* gets a very high weight (*Figure 26*). Good habitat conservation is very important for a good state of the other indicators proposed in this criterion.

Participants gave a similar weight to all aspects included in the criterion *hydrological regulation* (*Annex 5*). Experts consider that the indicators *forest area affected by different types of erosion* and *forest area affected by compaction* together are the most important of this criterion (*Figure 27*). The indicators referring to the aspect *floods* (*human infrastructures allow free water flow in hillsides and natural water channels* and *flood control infrastructures inventory*) get a medium weight. Finally, *Aquifer filling* indicators (*forest area managed to generate water surpluses for aquifer filling* and *forest area suffering from soil infiltration problems*), *soil productivity* indicators (*nutrient inventory*) and *soil pollution* indicators (*restrictions to the application of fertilisers and pesticides*) receive a low weight.

In the case of the aspect *aquifer filling*, the low weight that its indicators get can be because experts do not see it as something that applies at the FMU level, or due to the fact that the type of silviculture needed to improve aquifer filling goes against the silviculture for other aspects like *flood and erosion prevention* or criteria like *profitability* (aquifer filling requires lower tree densities than the other mentioned aspects and criteria – Generalitat Valenciana, 2011). As indicated in *Annex*

3, the multiple objectives of SFM sometimes would require zoning the FMU and establishing priorities in zones with competing objectives. In relation to the low weight of the indicators of the aspects *soil productivity* and *soil pollution*, experts may see them as being out of the scope of *hydrological regulation* (one of the respondents suggested to define a new criterion for them) and that they might apply more in agriculture than in forest management. Changes have been made to the indicators of this criterion and the reasons are explained in Chapter 5.

Finally, with regard to *carbon storage*, in the participatory process of *Ayora* participants provided the same weight to the aspects related to storage in the vegetation and storage in the soil (*Annex 5*). However, experts gave to the indicators related to carbon storage in the soil (*forest area showing dry and cracked soils*; *forest area where soil structure has been broken or altered*; and *in areas managed to comply with this criterion silvicultural treatments are minimised*) together a weight of 21% (*Figure 30*). Carbon is stored in the soil in bigger quantities than in vegetation and during more time. But silviculture acts on vegetation and as long as the other criteria proposed in this thesis are respected (particularly *hydrological regulation*), the soil might not be affected and the organic carbon might be kept. So that experts do not seem to see it as necessary that forest management considers carbon storage in the soil explicitly.

Chapter summay

The information contained within this chapter is very detailed. Therefore, it is considered that a summary would be suitable. Mediterranean forests are fragile and not very productive. Besides, in Spain there is the problem of small private properties and lack of coordination with land management. In order to achieve higher management rates, it is important to pay for the ecosystem services provided by these forests and to raise social awareness. Participatory processes in forestry decisions play a key role in raising social awareness. The success of a participatory process is both in the process and the results. The process has to be representative and participants have to be well informed and encouraged to participate.

15 criteria of SFM were identified. They refer to an ecosystem services classification, so that they cover the three pillars of sustainable development. The indicators identified refer to specific aspects of the criteria. However, there are differences between the results of the participatory process about the aspects and the AHP questionnaire to experts about the indicators. Participants select as their first choice what they would like the forest to be like, whereas experts do not only think in terms of wish, but also of realism and usefulness. In view of this, the question of who might be consulted and considered in order to make forestry decisions comes up.

Chapter 7-Thesis conclusions

The work developed aimed at searching for the issues that SFM under Mediterranean conditions may consider. It is difficult to define universal guidelines; the principles of SFM are not exactly the same for the different types of forests existing worldwide. C&I help to extend the understanding in relation to this concept and adapt to the different situations. A set of C&I is proposed in this thesis. The scope was set for the FMU level. Literature reviews, questionnaires and a participatory process were carried out.

The general requirements of sustainable forestry are the protection of natural resources: soil, water and biodiversity. It should also improve the quality of life of the local population and contribute to the economic and social development of the nearby area (what is commonly known as rural development). In the case of Mediterranean forests, forest fire prevention measures and extinction aid infrastructures are important issues. Also, the conservation of the visual and cultural features of the landscape becomes a relevant topic in places where there is a long history of human intervention like the Mediterranean region.

In Spain it might be tackled the problem of how to activate forest management. The main reasons for not managing forests are the low productivity and the rural exodus to the cities. The lack of coordination between forestry planning and land management increases this problem.

Ecosystem services are very relevant and socially recognised in any forest, even more in Mediterranean ones given their low productivity, but also because these are fragile ecosystems and because they hold acknowledged cultural values. Therefore, in this thesis the criteria of SFM identified were adapted to an ecosystem services framework.

Provisioning services were associated to the economic aspects of forest management, regulating services to the ecological aspects and cultural ones to the social aspects. Therefore, the criteria cover the three pillars of sustainability. The proposed set is composed of 15 criteria: 3 economic, 7 social and 5 ecological. The economic criteria refer to maintaining all the resources of the forest in a proper state, so that they are healthy and keep being a source of incomes. There is also a good representation of the ecological issues. An important focus was made on identifying social criteria, which was one of the objectives of the thesis because they were considered underrepresented in other existing C&I standards.

SFM in Spain at the FMU level might look at maintaining and improving the provision of ecosystem services and also look at getting incomes from providing them. Traditional management for wood production might be kept, but it should be studied the possibility of producing and selling other goods (aromatic plants, berries). Forest owners alone, or associated if their properties are small, may keep the visual and cultural character of the landscape and provide facilities for recreation and education. Management should preserve habitats and the structure of the forest cover in order to conserve biodiversity and also to reduce runoff speed and quantity; it should also prevent forest fires and mass flows and manage the forest to increase its function as a carbon sink.

In order to achieve a forest management based on the provision of ecosystem services, actions are needed from forest owners but also from society and the authorities because these services benefit the population of urban and rural areas. To increase incomes associated to other products apart from traditional ones (wood, cork, resins), their demand has to be studied and marketing strategies are necessary. Incomes associated to cultural services may come from direct payments from users or PES mechanisms; therefore, social awareness on forestry and the environment might be raised. Finally, subsidies are necessary to compensate for the provision of regulating services.

Participation goes hand in hand with SFM because main forestry decisions may include the perspectives of stakeholders and affected people, so that the results are more realistic and accepted by the population, and because it helps people to feel responsible for the state of forests. Participatory processes were present throughout the entire thesis and participants interacted with MCA techniques. Participatory processes and MCA techniques help to verify and make changes to a preselected list of elements. The requirements, criteria and aspects proposed were verified and the indicators were reduced from 99 to 90.

The success of a participatory process depends upon the good leading of the promoters of the process, who have to keep discussions on track and assure balanced input from participants. It is also important to inform appropriately on the objectives, characteristics and deciding topics of the process. Representation of stakeholders and transparency to make decisions are very relevant criteria to consider. Finally, it is important to encourage participants to imagine and create possible new situations and make them want to influence future scenarios.

Both experts and stakeholders participated in the development of the thesis, and some differences can be noticed. Stakeholders visualise the situation they want and they state their preferences accordingly. On the contrary, experts search for a balance between preference and feasibility. It is therefore recommended to consider stakeholders' preferences; but experts may act later as a filter that determines what is realistic and how could it be done.

The C&I that result from this thesis constitute a proposal that can be used as a guide of what to look at for managing Mediterranean forests sustainably. However, the methodologies carried out have some limitations and the proposal still needs changes and further research to be considered a complete C&I set applicable in Spain under Mediterranean conditions at the FMU level.

The sampling method applied both in the questionnaires and the participatory process was purposive sampling, a kind of nonprobability sampling. Nonprobability sampling means that respondents are not selected randomly, so that samples are not unbiased.

Another limitation concerns the AHP questionnaire. Consistency of respondents was assumed for an abbreviated version of the method so that the questions could be answered more quickly. However, the proper procedure of the method would have obliged experts to rethink their answers and results might be different if this had been the case.

Concerning the indicators, some of them could be clearer on what specific characteristics have to be measured or described. For example, *habitats inventory* or *causes of forests fires* need to be better defined in order to determine the variables or aspects to look at. Besides, there are yes-no indicators which would be better transformed into more quantitative or descriptive ones. In the case of the quantitative indicators, measure units should be specified for their variables. For the descriptive ones, a qualitative evaluation scale would be advisable (poor-medium-good, as an example).

Further research should consider the performance of the indicators in several FMUs representative of different soil and climate conditions and different main tree species, in order to test their applicability and ease of use, and so as to develop a generic set applicable in Spanish Mediterranean forests. It would be recommended to do that in each of the selected FMUs for different management scenarios with the objective of analysing the sensitivity of the indicators to changes.

Reference values might be defined for a complete indicator set. There are three types of reference values: an object or ideal value to achieve; maximum or minimum acceptable values; and threshold values from which the system stops being sustainable. These values require modeling the performance of quantitative indicators against different environmental variables and management practices.

A final note to say that, in spite of achieving a consistent C&I set, decisions concerning SFM have to be flexible and adapt to the conditions of each forest at a certain time. Forest management may not work as an algorithm that applies the same for all possible different situations.

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ANNEXES

Annex 1. Questionnaire sent to experts

General data

Answer the following general questions before proceeding with the questionnaire

Put an X where suitable

	Man	Woman
Sex		

	<30	30/39	40/49	>50
Age				

University studies

Please, briefly explain your job (entity, areas of work and so on)

1 Components of sustainable forest management

How much do you think that the following aspects define the concept of sustainable forest management?

Order them according to their relevance for sustainable forest management. Put **1 to the most relevant and so on**

Remark: the aspects listed are developed after. Explanations of each of the aspects listed in each of the questions are given next to the question, it is not necessary to read them for completing the questionnaire.

1.1	Contribution to rural development	
1.2	Improvement of quality of life of local population	
1.3	Landscape management	
1.4	Fauna, flora and habitat protection	
1.5	Soil protection from erosion and degradation	
1.6	Conservation of the quality and quantity of the water resources	
1.7	Infrastructure for forest fires prevention	
1.8	Pests treatments: non chemicals use promotion and thorough monitoring of biological control agents use	
1.9	Forest management must be planned, what takes the form of technical documents for management	
1.10	Improvement of the knowledge by means of data storage systems to make forest monitoring, research and management easier	

Cite other aspects that sustainable forest management should consider and indicate, referring to the classification done, between which positions it is located (7-8, 4-5 and so on)

1.11		
1.12		

Comments

Development of the components:

1.1 Forestry should be considered among all the sectors of the local economy (like agriculture or tourism), so that all together contribute to its development. A part from the interactions with other sectors, it has to be considered the diversity of products besides wood: firewood, cork, berries, fungus… and optimise their use and exploitation.

1.2 Sustainable forest management tries to improve life conditions of local poplation. This occurs by maintaining the forest in such conditions that allow the social use (maintenance and improvement of recreational areas), the creation of job opportunities, working conditions (health and safety issues), mechanisms for participatory processes and adequate training and supervisions of workers.

1.3 Sustainable forest management must integrate the knowledge related to landscape and its resources. A proper landscape management results in a positive interaction with other natural resources. For example, landscape fragmentation and its spatial structure are in relation with the abundance and viability of many flora and fauna species.

1.4 Sustainability includes the creation of procedures to protect rare and endangered species and their habitats. It has to be considered the ecosystem conservation with an eye on environmental quality values, and those fragile or unique as well.

1.5 and **1.6** Sustainabe forest management has to preserve natural resources. Special attention will be paid to protect soil from erosion and degradation, and to the conservation of the quantity and quality of water resources, either surface or subsoil water resources.

1.7 There has to be a suitable forest fire prevention and extinction infrastructure (firebreaks, vehicle paths, etc.).

1.8 Sustainable forest management promotes the adoption of non-chemichal methods for pest treatments and a strict control and monitoring when biological control happens is carried out.

1.9 Sustainable forest management is developed in a planned way. This occurs by means of a forestry management plan, which details the management objectives, the annual harvest rate, and it describes and justifies the harvesting methods.

1.10 Knowledge improvement is done in data storage systems and with catography. Both have to be public and transparent. Such systems should facilitate and improve forest management and research. Data collection has to refer at least to the following aspects: management efficiency, growth and regeneration rates, flora and fauna and social and environmental impacts of forestry.

2 Difficulties for sustainable forest management

How much do you think that the following aspects make difficult the development of sustainable forest management?

0→Doesn't make it difficult
1→Very little
2→Little
3→Medium
4→Quite a lot
5→Very much
NA → No answer

2.1	Lack of guidelines of sustainable forest management	
2.2	Lack of interaction between forest planning instruments and land planning instruments	
2.3	Small size of forest private property in general	
2.4	Low productivity of Mediterranean forest	
2.5	Risk of different hazards with a human or natural origin (forest fires, heavy rain)	
2.6	Increase of management costs due to implementation of sustainability criteria	
2.7	Lack of economic incentives for the positive externalities	

Add other aspects that make difficult the development of sustainable forest management

2.8		
2.9		

Comments

Development of the difficulties:

2.1 Forestry laws and planning regulations express that it is necessary to apply sustainable forest management. However, they do not specify how it has to be developed: neither what aspects to consider nor what practices are recommended.

2.2 The content of the forestry planning regulations is not coordinated with the content of the land management instruments of the same geographical area. This implies that, at a legal level, forestry does not interact with other sectors of the local economy, and it is necessary for rural development not to consider forest management as an isolated issue.

2.3 Forest private property in Spain is usually very small (less than one hectare). This makes very difficult the application of sustainable forest management due to the higher costs that it implies. For the owner of a small property the revenues should not be very high, therefore, it is not likely that he/she increases management costs because of the inclusion of sustainability criteria.

2.4 The productivity of Mediterranean forests is generally low, this means that they are not very profitable and thus many owners abandon the management. This fact makes difficult the establishment of a more exigent management with higher costs.

2.5 Mediterranean forests are threatened by natural or human hazards which, when they become catastrophic, may result in a change in the direction of the management. These hazards are forest fires and heavy rains, which can turn into higher erosion rates and floods.

2.6 A reduction of anual harvests might occur if a more sustainable forestry is carried out due to the incorporation of other considerations like biodiversity, landscape or soil protection. On the other hand, forest management that includes sustainability criteria is more expensive, not only because of profitability reduction (due to harvest reduction), but also because other aspects beyond productive ones are taken into account: landscape conservation and improvement, participatory processes and so on. All these issues are people, time and money consuming.

2.7 Forests generate benefits for society which are not paid back to forest owner: scenic views, recreation or biodiversity. Those benefits are known as “externalities”. The lack of economic compensation for their production results in a lack of interest of forest owners to manage their lands.

3 Aspects that make easier sustainable forest management

How much do you think that the following aspects make easier the development of sustainable forest management?

0→Doesn't make it easier
1→Very little
2→Little
3→Medium
4→Quite a lot
5→Very much
NA → No answer

3.1	The basic criteria of forest management: maintenance of the forest cover, profitability and best use of different products and functions	
3.2	The existing guidelines towards the protection of the forest in front of forest fires and pests that establish forest planning instruments	
3.3	The existing guidelines towards the conservation of landscape and biodiversity that establish forest planning instruments	
3.4	Promotion of SFM from Europe and Spanish Government: European Forest Strategy, Spanish Forest Plan and so on	
3.5	The rules on the protection of natural resources and landscape: *Habitats Directive* (Europe), *law 42/2003 on natural resources and biodiversity* (Spain), *law 4/2004 on land planning and landscape protection* (Valencia Region), and so on	
3.6	European directives to promote rural development: regulations *1257/1999 (EAGGF)* and *1260/1999 (structural funds)*	
3.7	Strategic Environmental Assessment (SEA) process to approve public plans and programmes (forest ones included)	

Add other aspects that make easier the development of sustainable forest management

3.8		
3.9		

Comments

Development of these aspects:

3.1 Forest management regulations include some basic criteria that are sustainable in themselves. These criteria or conditions are: maintenance of the forest cover, profitability and best use of different products and functions. The first of them is a sustainability criterion because it says that harvesting should not degrade the ecosystem. The second one implies sustainability considerations because it establishes that the forest has to generate economic benefits to the owners. And the last one refers to sustainability since it states that the different uses and products of the forest (multifunctionality) should be optimised.

3.2 The Spanish *Forest Management Guidelines* (an instrument that determines the content and structure of forestry management plans) establish that, when planning and developing the activities to carry out in the forest, measures have to be taken to protect the forest from pests and fires.

3.3 The *Forest Management Guidelines* state that landscape conservation plans and flora and fauna conservation plans can go with forestry management plans. These guidelines say that such plans will be carried out when the forest is in an area with outstanding landscapes or with protected fauna and flora.

3.4 Sustainable forest management is promoted from the European Commission, through the *European Forest Strategy*, and from the Spanish Central Government, through the *Spanish Forest Plan* and the *Spanish Forest Strategy*. All this indicates that, even though there are few guidelines stating how to carry out sustainable forest management, as it has been mentioned in the difficulties question, there already exist regulations that promote and create a framework for the development of sustainable forest management.

3.5 The regulations are mentioned next. At European level: European Landscape Convention (2000), Habitats Directive and Birds Directive. At Spanish level: Law 42/2003 on natural heritage and biodiversity and Royal Decree 1997/1995 on natural environments. At regional level of Valencia: Law 4/2004 on land planning and landscape protection. All these regulations applied to forest management would cover all the gaps related to natural resources conservation and protection, landscape or biodiversity.

3.6 European Directives that promote rural development: *regulation 1257/1999 of subsidies for rural development in charge of EAGGF*, and *regulation 1260/1999 of structural funds.* Both establish a framework to complete varied activities in rual areas.

3.7 The necessary incorporation of Strategic Environmental Assessment (SEA) processes in public plans and programs (even forestry ones) is a step towards the establishment of sustainable forest management because it requires including sustainability criteria in those plans and programs for them to be approved. In Spain, this is promoted by means of *Law 9/2006 on the assessment of the effects of certain plans and programs on the environment*.

4 Introduction of the components in forest planning

How much do you think that the components of SFM included in the first question are currently considered in forest planning?

0→Not considered
1→Very little
2→Little
3→Medium
4→Quite a lot
5→Very much
NA → No answer

4.1	Contribution to rural development	
4.2	Improvement of quality of life of local population	
4.3	Landscape management	
4.4	Fauna, flora and habitat protection	
4.5	Soil protection from erosion and degradation	
4.6	Conservation of the quality and quantity of the water resources	
4.7	Infrastructure for forest fires prevention	
4.8	Pests treatments: non chemicals use promotion and thorough monitoring of biological control agents use	
4.9	Forest management must be planned, what takes the form of technical documents for management	
4.10	Improvement of the knowledge by means of data storage systems to make forest monitoring, research and management easier	

Give also a value to the current consideration of the aspects added in the first question

4.11		
4.12		

Comments

5 Proposals for sustainable forest management

How much do you think that the following proposals contribute to the development of sustainable forest management?

0→Doesn't contribute
1→Very little
2→Little
3→Medium
4→Quite a lot
5→Very much
NA → No answer

5.1	Establish coordination between forest planning instruments and land planning instruments	
5.2	Create information systems to improve monitoring and assessment of forests	
5.3	Make guidelines of SFM which should be flexible and able to be developed in the different conditions of each region	
5.4	Improve the practical and theoretical formation in SFM for forest workers, professionals and students	
5.5	Reinforce the paper of central and local governments in forest management issues through legislation or compensating for the externalities	
5.6	Apply the process of Environmental Impact Assessment (EIA) to assure sustainability of forest projects	

Do you think that there are other means to improve SFM? Indicate them

5.7		
5.8		

Comments

Development of the proposals:

5.1 In order to achieve sustainable forest management, forest management regulations have to consider the interactions between forest sector and other sectors of local economy. For that purpose, coordination with other land planning regulations is required. A cornerstone for this coordination is PORF (Spanish acronym for *forest resources management plan*, which affects at county leve). In the area affected by a PORF, this plan establishes zones which are assigned different preferential uses depending on their natural and socio-economic conditions.

5.2 Elaborate public information systems that include thematic cartographies and data on the state of forests of a region. Those systems may facilitate monitoring and assessment of the forests. Apart from their applicability in research, they have to allow the standardization of working procedures.

5.3 The development of sustainable forest management guidelines. Such guidelines should consist of forest practices in line with sustainability criteria. They have to be applicable in different forest management levels (regional, county and forest management unit), and they should be easily adapted temporal and spatial variations in forest covers.

5.4 Improve workers' training in forest practices that are environmentally friendly and workers, students and forestry professionals' education in the relevance of sustainable forest management. Increase society's concerns on the relevance of forests and their conservation.

5.5 Reinforce the role of central and local governments in forest management. This may happen by means of: regulations, policies, plans and programs; economic compensation mechanisms for the externalities and for the higher costs derived from applying sustainability criteria.

5.6 Compulsory application of SEA to approve forest plans and programs and of Environmental Impact Assessment (EIA) to approve forestry management plans (which is not compulsory right now). These procedures will assure that forest management better complies with sustainability criteria.

Annex 2. Case studies evaluation according to the developed framework

Case study 1

PROCESS

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	"While researchers aim to keep the conversation directed toward a general area of interest they encourage respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents. Each team had 2 to 3 members and each survey was conducted by 2 to 4 such multidisciplinary teams. Informal conversations within a Sondeo were typically conducted over a 2- to 3- week period. Appointments were scheduled at the convenience of the respondents. Initial contacts were predominantly made by telephone".
Representation	Low	"For surveys of producers, we enlisted the help of county extension agents to provide contact information for a range of representative producers in their areas". "The SECC aims to develop and implement a decision support system that can inform farmers, ranchers, foresters, water resource managers, industry, and policy makers about climate risks". "A series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida were conducted".
Opportunity to influence outcomes and/or process design	High	"Surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for

		AgClimate". Following the 2004 survey, AgClimate was revised according to the survey results".
Quality and selection of information and resources in general	Uncertain	-
Challenging status quo and fostering creative thinking	High	"Researchers encourage respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents".
Clear mandates and goals	Uncertain	-
Transparency	Uncertain	"Team members met regularly to report and discuss conversational interviews conducted the previous day. General conclusions from these group meetings were recorded and presented as working documents or staff papers. As each team presented its findings, they were discussed to highlight similarities and differences with the results of the other teams. This process of reporting and discussion served as the opportunity to identify trends, gaps in information, and new questions to be pursued".
Independence and neutrality of the process	Uncertain	-
Conflict resolution	Uncertain	"Appointments were scheduled at the convenience of the respondents. Individual conversations lasted from 30 min to 2.5 h, and took place in offices, homes, and fields, wherever was most convenient for the respondent". "There was a dichotomy between what farmers and extension agents would want in a web-based DSS. Farmers want specific and concise information, whereas extension agents would also like access to additional detailed information, perhaps through link to other sites".
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				"This paper will analyze a series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida that were conducted from 1999 through 2004. The surveys focused on the following series of topics (see text and *Table 2*)". "With the understanding that this tool is still under construction. Initial surveys assessed the potential value of climate information to agricultural producers in the southeast USA. Subsequent surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate. Following the 2004 survey, AgClimate was revised according to the survey results and officially announced in the fall of 2004".

Prototype phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	“While researchers aim to keep the conversation directed toward a general area of interest they encourage respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents. Each team had 2 to 3 members and each survey was conducted by 2 to 4 such multidisciplinary teams. Informal conversations within a Sondeo were typically conducted over a 2- to 3- week period. Appointments were scheduled at the convenience of the respondents. Initial contacts were predominantly made by telephone”.
Representation	Low	“For surveys of producers, we enlisted the help of county extension agents to provide contact information for a range of representative producers in their areas”. “The SECC aims to develop and implement a decision support system that can inform farmers, ranchers, foresters, water resource managers, industry, and policy makers about climate risks”. “A series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida were conducted”.
Opportunity to influence outcomes and/or process design	High	“Surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate”. Following the 2004 survey, AgClimate was revised according to the survey results”.
Quality and selection of information and resources in general	Uncertain	-
Challenging status	High	“Researchers encourage

quo and fostering creative thinking		respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents".
Clear mandates and goals	Uncertain	-
Transparency	Uncertain	"Team members met regularly to report and discuss conversational interviews conducted the previous day. General conclusions from these group meetings were recorded and presented as working documents or staff papers. As each team presented its findings, they were discussed to highlight similarities and differences with the results of the other teams. This process of reporting and discussion served as the opportunity to identify trends, gaps in information, and new questions to be pursued".
Independence and neutrality of the process	Uncertain	-
Conflict resolution	Uncertain	"Appointments were scheduled at the convenience of the respondents. Individual conversations lasted from 30 min to 2.5 h, and took place in offices, homes, and fields, wherever was most convenient for the respondent". "There was a dichotomy between what farmers and extension agents would want in a web-based DSS. Farmers want specific and concise information, whereas extension agents would also like access to additional detailed information, perhaps through link to other sites".
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				"This paper will analyze a series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida that were conducted from

					1999 through 2004. The surveys focused on the following series of topics (see text and *Table 2*)". "With the understanding that this tool is still under construction. Initial surveys assessed the potential value of climate information to agricultural producers in the southeast USA. Subsequent surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate. Following the 2004 survey, AgClimate was revised according to the survey results and officially announced in the fall of 2004".

Usability Phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	"While researchers aim to keep the conversation directed toward a general area of interest they encourage respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents. Each team had 2 to 3 members and each survey was conducted by 2 to 4 such multidisciplinary teams. Informal conversations within a Sondeo were typically conducted over a 2- to 3- week period. Appointments were scheduled at the convenience of the respondents. Initial contacts were predominantly made by telephone".
Representation	Low	"For surveys of producers, we enlisted the help of county extension agents to provide contact information for a range of representative producers in their areas". "The SECC aims to develop and implement a decision support system that can inform farmers, ranchers, foresters, water resource managers, industry, and policy makers about climate risks". "A series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida were conducted".
Opportunity to influence outcomes and/or process design	High	"Surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate". Following the 2004 survey, AgClimate was revised according to the survey results". "We validated forecast models and output displays, crop model outputs and displays, and management recommendations through direct consultation with farmers and extension agents". "Furthermore, we continuously exposed our DSS to criticism and feedback to insure the appropriateness of tools and

		qualitative information to a diverse community of farmers and extension agents".
Quality and selection of information and resources in general	Moderate	"The most common criticism of the yield tool is that there were no clear instructions on how to use it. Once survey members explained how to use the tool, most extension agents were able to grasp the utility of the tool and how they and farmers could effectively use it".
Challenging status quo and fostering creative thinking	High	"Researchers encourage respondents to discuss both the specific topic of interest and ancillary issues of concern to the respondents".
Clear mandates and goals	Uncertain	-
Transparency	Uncertain	"Team members met regularly to report and discuss conversational interviews conducted the previous day. General conclusions from these group meetings were recorded and presented as working documents or staff papers. As each team presented its findings, they were discussed to highlight similarities and differences with the results of the other teams. This process of reporting and discussion served as the opportunity to identify trends, gaps in information, and new questions to be pursued".
Independence and neutrality of the process	Uncertain	-
Conflict resolution	Uncertain	"Appointments were scheduled at the convenience of the respondents. Individual conversations lasted from 30 min to 2.5 h, and took place in offices, homes, and fields, wherever was most convenient for the respondent". "There was a dichotomy between what farmers and extension agents would want in a web-based DSS. Farmers want specific and concise information, whereas extension agents would also like access to additional detailed information, perhaps through link to other sites".
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				"This paper will analyze a series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida that were conducted from 1999 through 2004. The surveys focused on the following series of topics (see text and *Table 2*)". "With the understanding that this tool is still under construction. Initial surveys assessed the potential value of climate information to agricultural producers in the southeast USA. Subsequent surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate. Following the 2004 survey, AgClimate was revised according to the survey results and officially announced in the fall of 2004".

Testing phase

This phase didn't happen. Next, evidence on this, and on including the other three phases, is shown:

- "The Southeast Climate Consortium (SECC), a multi-disciplinary, multi-institution research consortium, has as its long-term goal to design, develop, and implement a prototype comprehensive information and decision support system that can inform farmers, ranchers, foresters, water resource managers, industry, and policy makers about climate risks and help these decision makers identify management practices that can reduce risks and increase benefits by using this climate information (http://secc.coaps.fsu.edu). In the fall of 2004, the SECC released AgClimate (SECC 2004), a prototype decision support system that provides the first step in meeting this goal".
- "This paper will analyze a series of five surveys of agricultural extension agents, agricultural producers, and ranchers in Florida that were conducted from 1999 through 2004. Details of the survey foci are given in ***Table 2"***.
- "Surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate". Following the 2004 survey, AgClimate was revised according to the survey results".
- "Development of the AgClimate began in 2003 and a prototype DSS was available in mid-2004, which provided climate information, forecasts, and tools to support decisions based on seasonal climate forecasts. The 2004 survey focused on AgClimate and its tools".
- "With the understanding that this tool is still under construction. Initial surveys assessed the potential value of climate information to agricultural producers in the southeast USA. Subsequent surveys addressed needs for specific climate information, means of disseminating and presenting that information, and trustworthiness of climate information, all of which led to the development of prototype tools for AgClimate. Following the 2004 survey, AgClimate was revised according to the survey results and officially announced in the fall of 2004".
- "While the SECC still considers AgClimate as a prototype DSS with continuing need for user inputs to guide improvements, following the 2004 survey to assess AgClimate efforts to solicit these inputs shifted from Sondeo survey methods to farmer advisory panels, questionnaires from workshops, on-line feedback, and other means. Based on these user inputs, the SECC continues to add new tools, new information, and to modify presentation formats in AgClimate".

OUTPUTS

Output	Evidence
A prototype DSS, still in formation.	"In the fall of 2004, the SECC released AgClimate (SECC 2004), a prototype decision support system that provides the first step in meeting this goal". "While the SECC still considers AgClimate as a prototype DSS with continuing need for user inputs to guide improvements, following the 2004 survey to assess AgClimate efforts to solicit these inputs shifted from Sondeo survey methods to farmer advisory panels…" "Although only about half of producers interviewed said they preferred receiving information through the Internet, because

	we felt that this fraction was likely to increase, the SECC planned to disseminate this DSS through a web site, AgClimate (http://AgClimate.org)". "How researchers have responded to comments and suggestions are summarized in *Table 7*".

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	"Individual conversations lasted from 30 min to 2.5 h, and took place in offices, homes, and fields, wherever was most convenient for the respondent".
Acceptance of process and/or outcomes	Moderate	"The 2004 survey focused on AgClimate and its tools. In general, extension agents found the prototype to be informative and user-friendly. Farmers and extension agents mentioned that information presented on the website needs to be more explicit, to use less academic language, and to provide better instructions for users. If not, farmers might conclude that it is "just another website" despite containing potentially useful information. Generally speaking, extension agents found the yield risk assessment tool to have great potential both for use by extension agents as well as for farmers".
Recognised impacts	High	"Participation of farmers and extension agents throughout the entire process of developing AgClimate has been essential (*Fig. 2*). How researchers have responded to comments and suggestions are summarized in *Table 7*.
Social learning	Uncertain	-

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	Uncertain	"Our methods and results also agree with Stern and Easterling (1999) in that the AgClimate DSS is intended not only to inform but to benefit the users; the DSS is based on scientific techniques that few of the recipients understand; the DSS provides

		forecasts several months in the future and these forecasts are probabilistic; the probabilities given contain inherent uncertainties; the forecasts have a limited track record and thus their credibility is difficult to determine; and the predictions are in great measure relevant to the users' decisions because they are interpreted or translated into appropriate formats supplied by the users themselves". **"Our objective of achieving farmers' goals of better risk management is currently under evaluation".** "Most importantly, we continue to maintain the dialogues over the long term, though this paper covers only 1999–2005; the work continues in order to successfully link knowledge with action".
Uptake of the tool/s	Uncertain	"Although our study did not collect data to test this hypothesis, it is likely that benefits such as higher adoption rates, more varied adaptation strategies, and user trust in the provider institution is being enhanced by the collaborative research and development process".
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	"The forecasts have a limited track record and thus their credibility is difficult to determine; and the predictions are in great measure relevant to the users' decisions because they are interpreted or translated into appropriate formats supplied by the users themselves". "Although our study did not collect data to test this hypothesis, it is likely that benefits such as higher adoption rates, more varied adaptation strategies, and user trust in the provider institution is being enhanced by the collaborative research and development process".

CASE STUDY 2:

PROCESS

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"The scientists worked closely with these two groups over 4 years to develop WaterSense". "WaterSense enabled the farmers, extension staff and scientists to collaborate, even though they held diverse perceptions of its function and some of the issues it addressed".
Representation	High	"The stakeholders in each group consisted of farmers and extension officers". "Farmers, extension officers, sugarcane mill operators and other industry representatives in four sugar cane regions in Eastern Australia collaborated with five agricultural scientists, two social scientists and a software developer to construct technologies".
Opportunity to influence outcomes and/or process design	High	"In the preliminary interviews in Bundaberg, both the farmers and the extension staff expressed concerns about the level of detail in which the early versions of WaterSense defined the basic parameters (relating to water holding capacity) of soil types". "*I think the best thing was it was addressing a specific need and we had the flexibility that we could change things slightly as we were going along, as we were starting to learn more and more about what the research was telling us but also more about what the issues were for the growers as well and trying to fine tune them what we were doing at the research level*" (Bundaberg extension officer).
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering	High	"The interaction with the case study group allowed the scientists and the group members to explore their

creative thinking		interests and perspectives in relation to irrigation." "*I think the best thing was it was addressing a specific need and we had the flexibility that we could change things slightly as we were going along, as we were starting to learn more and more about what the research was telling us but also more about what the issues were for the growers as well and trying to fine tune them what we were doing at the research level*" (Bundaberg extension officer).
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	High	"One of the scientists described the way in which he and the other scientists worked with the farmers and extension staff to negotiate these different views on soil naming, noting that *there are so many different names for different soils... [And the farmers] always had specific requirements on the correct [local] terminology to use. Also on what variables they actually wanted to see*". "*They were consulting with us ourselves*".
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"… This involved acknowledging and respecting the different perspectives held by these parties (farmers, extension officers and scientists) and then taking up the opportunity to work together towards a shared understanding (i.e. arriving at more congruent technological frames)".

Inform	**Consult**	**Involve**	**Partnership**	**Empower**	**Evidence**
					"…*It was a participatory process. It was fairly dynamic. It allowed us to move at the same time*. For one of the scientists, the direct feedback from the farmers *allowed the*

Uncertain	*grower to be involved in every step of the way… to actually be part of the design of it* [rather than] *being shown the package* [at the end and told]… *to take it and leave it*". *I feel like we were listened to*. He went on to add that this was in contrast to past experiences, where *some ideas are put up and growers may not have had much input into what they wanted, what they expected out of it. I feel we got a fair bit of input into what we expected of [WaterSense]*. The farmers' genuine involvement in the development of WaterSense was important for developing a sense of shared ownership of the technology. "…*they were committed, they took ownership, and they felt that we valued their input. And I believe also that for me, that these people were all…really contributing, and helping to progress the technology* (Irrigation project team member)".

OUTPUTS

Output	Evidence
WaterSense, an irrigation management DSS	"While the cycles of negotiation around WaterSense clearly improved it as a piece of software, they also resulted in co-learning amongst all involved in the DSS development process".
Other outputs in Paper: "Methods for wider industry adoption"	

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	High	"The farmers from the Mackay group also observed that the collaborative approach used in the project helped establish their trust and confidence in the scientists and in WaterSense. As one farmer admits, ''*When we started out I was little bit sceptical of [the scientists]... The relationship has just grown through the whole project and we've got respect for each other, that's for sure*". "Our case studies of the irrigation scheduling DSS WaterSense showed that, by acting as a boundary object, WaterSense was able to help bridge gaps between these parties (farmers, scientists and extension officers) through an iterative and participatory cycle of discussion and feedback".
Acceptance of process and/or outcomes	High	"In Mackay, one farmer summarised his initial expectations of WaterSense as *a useful tool [for] people like myself and most… growers [in this area who] have a limited water supply, [to] make the best use of it at the best time*". "For instance, one of the extension staff noted that DSSs like WaterSense may be a *very useful thing for an extension officer or an adviser or someone working in the subject area*, but might be less suited to a farmer. Similarly, another extension officer noted that from the beginning of the project, he was *aware that we were going to have to make [WaterSense] farmer-friendly and we were going to have to iron out some bugs and fill*

		that gap between science and the people". "The scientists also acknowledged that the simulation modelling, which WaterSense was based upon, represented a different way of understanding farming, since *the growers operate intuitively… they don't think in terms of models*".
Recognised impacts	High	"The categorisation of soil types remained an issue in the main round of interviews at the end of the DSS development process, with difference between the names used by the farmers and scientists for soils". "Another of the scientists made a similar observation, remarking that *I remember one bloke in Bundaberg getting up on the whiteboard and he said, look, I understand what you've done, [but] that's not what we want. If you do it like this – and he drew a picture on the board. If you do it like that, we will use it. And we did it like that*". "*I like the idea that they [accepted] our data too… Scientists tend to want to look at irrigation on a wide scale thing and... they looked at it as us in Mackay and they took all our research*" (Farmer, Mackay).
Social learning	High	"The scientists also viewed WaterSense as a possible catalyst for increased use of other technologies, for instance: *given that we're talking about a new type of tool. . .this will open up people's ideas about what other types of technology related to their own farm management or business management [they could] be using*". "*I'm pretty sure that they'd all say that they've learned and... they've gained from the whole experience*". "A farmer from Bundaberg remarked that through his involvement he had *a massive increase* in his knowledge of irrigation: ''. . .*this last 3 years involved with the group. . .my knowledge in water use and in particular in the cane industry, has improved massively*".

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	High	“The farmers’ and extension officers’ more contextualised understanding of their local soil types influenced how they viewed this key feature of WaterSense. This illustrates the way in which the abstract scientific knowledge that DSSs like WaterSense are based on has to be adapted to suit local needs, by incorporating local knowledge”. “While the cycles of negotiation around WaterSense clearly improved it as a piece of software, they also resulted in co-learning amongst all involved in the DSS development process”.
Uptake of the tool/s	Uncertain	“Most of the participants in our case studies noted that they wanted to continue using WaterSense to help guide their irrigation scheduling decisions”. “However, there were some farmers, especially in Mackay, who felt there was no need to change their current practice. For one Mackay farmer, WaterSense *pretty well coincided with what I intended to do anyway*”. “Another farmer commented that *even though [he] didn’t know how to use [WaterSense] physically, the information and education [he] got from it is something that will stand [him] in good stead whether... or not [he uses WaterSense]*”. “*With only a small amount of [irrigation] water, the good that [Water-Sense] actually does, is not worth a lot to me in real dollar terms. I’m inclined to not worry too much about it. I just do the best I can and that’s that*”. “This result is consistent with Outcome 3 in the framework, where those involved find their understanding of the problem has improved but perceived no relative advantage associated with the change or further use of the DSS”.
Legacy	Uncertain	“One of the extension officers remarked that there were some issues. . .in relation to soils *that meant that the development of WaterSense will probably be ongoing*”.
Impact on	Uncertain	

policy making		
Impact on users' practice	High	"In Bundaberg, the farmers framed WaterSense as a tool that could allow them to explore their options and possible scenarios for scheduling their irrigation". "Another Mackay farmer admitted that *we always had a big issue of where we needed to irrigate first and what our priorities were on our farm. . . .We tried to put as much on as quick as we could and that's how we irrigated*. For this farmer, the value of WaterSense was that it had the potential to provide guidance on when to schedule his irrigation". "Most of the participants in our case study noted that they wanted to continue WaterSense to help guide their irrigation scheduling decisions. As one Bundaberg farmer explained, without WaterSense *you have to drive around every [farm] block at a certain time of day, morning and afternoon, and say mid morning and mid afternoon, to observe those crops and see what they're doing, whereas [with] WaterSense, you just pull a screen up*".

CASE STUDY 3

PROCESS

"In an early stage the end users have been included in the design process. As a first activity, several workshops were organized having potential end users as participants. Among the participants were river-engineers, DSS developers, policymakers and GIS-specialists. These people were interviewed with the aim to make an inventory of the user-requirements of the DSS" **(SCOPE)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	"Within the DSS-Large Rivers project, the development of the DSS was hindered by inappropriate communication with the end user organisations during delays. Although pretty obvious, it is recognised that these kinds of projects, i.e. with many people from different organisations working together on the same product,

		require strict regulations concerning both timeframe and technical contents of software components and necessary data”.
Representation	High	“Several workshops were organized having potential end users as participants. Among the participants were river-engineers, DSS developers, policymakers and GIS-specialists”. “At the period of the interviews, it was not yet clear for whom the system should be developed, e.g. policy makers, project managers, or scientific and technical experts. Therefore, all categories were interviewed”.
Opportunity to influence outcomes and/or process design	High	“In an early stage the end users have been included in the design process. As a first activity, several workshops were organized having potential end users as participants. These people were interviewed with the aim to make an inventory of the user-requirements of the DSS”. “While answering those questions, and providing information relevant to the system requirements, the interviewed persons showed, in general, a quite sceptic attitude towards DSS-s in general. Many people have indicated that they want the system to produce uncertainty ranges. Within the development of the DSS-Large Rivers no priority has been given to functionality to provide additional insight in uncertainty ranges”. “While the intended users were not known beforehand, the organisations asking for a new DSS also grew from one initiator to three commissioners. However, all organisations were having different demands… Putting these two opportunities together, the base for joint development of a full-fledged DSS was made”.
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering	Moderate	“In an early stage the end users have been included in the design process. As a first activity, several

creative thinking		workshops were organized having potential end users as participants. These people were interviewed with the aim to make an inventory of the user-requirements of the DSS. The following questions were posed”: - What are, according to you, the key-tasks of a DSS - What are (on the short term) the minimal requirements of a DSS, such that your organisation will use it. And what are the requirements on the long term - What is NOT necessary to incorporate in a DSS - What are the requirements within your organization to operate and maintain a DSS. “While answering those questions, and providing information relevant to the system requirements, the interviewed persons showed, in general, a quite sceptic attitude towards DSS-s in general. Many people have indicated that they want the system to produce uncertainty ranges. Within the development of the DSS-Large Rivers no priority has been given to functionality to provide additional insight in uncertainty ranges”.
Clear mandates and goals	Uncertain	
Transparency	Uncertain	“While answering those questions, and providing information relevant to the system requirements, the interviewed persons showed, in general, a quite sceptic attitude towards DSS-s in general. Many people have indicated that they want the system to produce uncertainty ranges. Within the development of the DSS-Large Rivers no priority has been given to functionality to provide additional insight in uncertainty ranges”. “While the intended users were not known beforehand, the organisations asking for a new DSS also grew from one initiator to three

		commissioners. However, all organisations were having different demands… Putting these two opportunities together, the base for joint development of a full-fledged DSS was made”.
Independence and neutrality of the process	High	“While answering those questions, and providing information relevant to the system requirements, the interviewed persons showed, in general, a quite sceptic attitude towards DSS-s in general. Many people have indicated that they want the system to produce uncertainty ranges. Within the development of the DSS-Large Rivers no priority has been given to functionality to provide additional insight in uncertainty ranges”. “While the intended users were not known beforehand, the organisations asking for a new DSS also grew from one initiator to three commissioners. However, all organisations were having different demands… Putting these two opportunities together, the base for joint development of a full-fledged DSS was made”.
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partnership**	**Empower**	**Evidence**
	X				“In an early stage the end users have been included in the design process. As a first activity, several workshops were organized having potential end users as participants. Among the participants were river-engineers, DSS developers, policymakers and GIS-specialists. These people were interviewed with the aim to make an

					inventory of the user-requirements of the DSS. The following questions were posed…” “While answering those questions, and providing information relevant to the system requirements, the interviewed persons showed, in general, a quite sceptic attitude towards DSS-s in general. Many people have indicated that they want the system to produce uncertainty ranges. Within the development of the DSS-Large Rivers no priority has been given to functionality to provide additional insight in uncertainty ranges”. “While the intended users were not known beforehand, the organisations asking for a new DSS also grew from one initiator to three commissioners. However, all organisations were having different demands… Putting these two opportunities together, the base for joint development of a full-fledged DSS was made”.

OUTPUTS

Output	Evidence
A DSS for river landscape planning	"DSS-Large Rivers is targeted at flood management by way of river landscape planning".

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Moderate	"This implementation of known working procedures has been facilitated by the relatively simple menu-structure (explore, design, calculate, analyse), and is highly appreciated by the people on the work floor. In addition, end users have shown appreciation for the DIS, as it improves communication about river projects". "The way the basic data and calculation results have been made accessible has, with some minor changes, been appreciated". "In general however, the users, i.e. technicians, are satisfied (although they always want more features than available)".
Recognised impacts	Moderate	"The intended diversity of the system is also recognised, although not all aspects mentioned during the interviews are implemented yet". "In the first interviews, it was denoted that a cost module may come in handy, to get a first insight in the costs of individual measures, projects and cases. In a later stage, this idea was already extended in the sense that also insight in the uncertainty of those estimates would be convenient. Therefore, a Monte-Carlo analysis was requested, either by linking the outcome to an existing tool or by developing a new one. As a result of this discussion, part of the development effort was focused on a

		linkage to an external Monte-Carlo tool, while other parts, e.g. to obtain relevant information from GIS-data, have been neglected". "Meanwhile however, the end-users continued in developing expectations about the DSS, some of which they obviously could not recognize in the subsequent releases".
Social learning	Uncertain	

Factual outcomes

Criteria	**Eval.**	**Evidence**
Objectives met	Low	"During the first months, some small inconveniences and requests were fulfilled, while some algorithms to translate measures into modifications of the hydraulic model also required some fine-tuning to capture unforeseen critical cross-sections. In general however, the users, i.e. technicians, are satisfied (although they always want more features than available)". "First of all, the intended Rapid Application Development has not functioned properly. In the beginning, much information was collected from the end-users, and incorporated in the design documents and also implemented. However, a proper RAD approach requires frequent feedback with the end users during the entire process". "However, the benefits of this open formulation did not fulfil the expected purpose, as repeatedly discussions arose on the details of functionality and interaction procedures. Besides, the technical design was not sufficient specific to describe the details of the functionality, the communication mechanisms and GUI-support".
Uptake of the tool/s	High	"After a turbulent period to get the system running properly, and producing sound output, a stage of maintenance and support has been reached, while various organisations (both consultants as well as governmental organisations) apply the system for their studies concerning the Meuse and Rhine. Findings on the application of the DSS-Large Rivers will be presented in Schielen and Gijsbers (2002)".

Legacy	Uncertain	
Impact on policy making	High	"After a turbulent period to get the system running properly, and producing sound output, a stage of maintenance and support has been reached, while various organisations (both consultants as well as governmental organisations) apply the system for their studies concerning the Meuse and Rhine".
Impact on users' practice	Uncertain	

CASE STUDY 4

PROCESS

"The research involved two participatory stakeholder workshops held in Chennai in March 1998 and February 1999 respectively, and development of a decision support system and environmental model in the form of a loosely coupled GIS and water quality simulation model. The first workshop focused on problem identification and developed the conceptual model on which the DSS was based **(SCOPE)**. In the second workshop, participants used the DSS to develop management scenarios and undertake exploratory scenario analysis to investigate the impacts of alternative management interventions" **(TESTING)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"Letters of invitation were sent to representatives of key government departments, management boards, NGOs, research institutes and academics". "The research involved two participatory stakeholder workshops held in Chennai in March 1998 and February 1999, and development of a decision support system in the form of a loosely coupled GIS and water quality simulation model. The first workshop focused on problem identification and developed the conceptual model on which the DSS was based". "Expression of the problem situation involved exercises for identification, definition and measurement of pertinent actors, elements, interactions and relationships. A key technique used

		here was the collaborative development of a 'rich picture' of the problem situation". "In this work, stakeholders discussed and debated such activities in facilitated discussion"
Representation	High	"Workshop participants were selected based on their professional roles, expertise, and interest in environmental management of Chennai waterways. Potential participants were identified based on personal knowledge and contact networks developed through previous workshops held at the University of Madras. Letters of invitation outlining the objectives and methodology of the research program were sent to representatives of key government departments, management boards, NGOs, research institutes and academics. Follow-up interviews with the invitees were used to identify additional participants who may have been missed in the initial mailing. Advertisements placed in English and Tamil newspapers invited participation by the general public. Table 1 summarizes the categories of participants represented in workshops and identifies the key agencies represented".
Opportunity to influence outcomes and/or process design	High	"The first workshop in March 1998 brought together stakeholders in the situation (government managers and scientists, academics, NGOs and other public representatives) to define and scope the problem situation, generate objectives for rehabilitation and management of the system, and discuss potential interventions to achieve these objectives".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	High	"Expression of the problem situation involved exercises for identification, definition and measurement of pertinent actors, elements, interactions and

		relationships. A key technique used here was the collaborative development of a 'rich picture' of the problem situation. This diagrammatic technique (adapted from SSM) provided a forum for participants to express the complexity and scale of the problem (Fig.3 is part of this rich picture). Rich pictures such as this are intended to express messy, ill-structured problematic situations, and intentionally avoid attempts to organize them as a system. It is themes that are drawn out of the rich picture that provide the basis for conceptual modeling".
Clear mandates and goals	High	"Letters of invitation outlining the objectives and methodology of the research program were sent to representatives of key government departments, management boards, NGOs, research institutes and academics".
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"The collaborative process of system identification, conceptualization of important subsystems (themes) and exploration of these in the context of rehabilitation of the Cooum River and environs contributed to the development of a common understanding and conceptual model of a 'Cooum system' that was to be the focus of management efforts".

Inform	Consult	Involve	Partnership	Empower	Evidence
			X		"The research involved two participatory stakeholder workshops held in Chennai in March 1998 and February 1999 respectively, and development of a decision support system and environmental

					model in the form of a loosely coupled GIS and water quality simulation model. The first workshop focused on problem identification and developed the conceptual model on which the DSS was based”. “In this work, stakeholders discussed and debated such activities in facilitated discussion. Particular attention was paid to the roles of different actors, impacts of actor behaviour, and inputs and outputs of sub-systems comprising the conceptual model in the context of the problem situation expressed in the rich picture”. “Basic conceptualizations of subsystems such as this were expanded in further discussion, debate, paper presentations and working sessions. Workshop participants discussed subsystems in terms of their spatial and temporal scope, relationship to the larger Cooum system, the development of management objectives and associated

					indicators, and potential interventions in the system. The collaborative process of system identification, conceptualization of important subsystems (themes) and exploration of these in the context of rehabilitation of the Cooum River and environs contributed to the development of a common understanding and conceptual model of a 'Cooum system' that was to be the focus of management efforts".

Testing phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"Letters of invitation were sent to representatives of key government departments, management boards, NGOs, research institutes and academics". "The research involved two participatory stakeholder workshops held in Chennai in March 1998 and February 1999, and development of a decision support system in the form of a loosely coupled GIS and water quality simulation model. In the second workshop, participants used the DSS to develop management scenarios and undertake exploratory scenario analysis to investigate the impacts of alternative management interventions".
Representation	High	"Workshop participants were selected based on their professional roles, expertise, and interest in environmental management of Chennai

		waterways. Potential participants were identified based on personal knowledge and contact networks developed through previous workshops held at the University of Madras. Letters of invitation outlining the objectives and methodology of the research program were sent to representatives of key government departments, management boards, NGOs, research institutes and academics. Follow-up interviews with the invitees were used to identify additional participants who may have been missed in the initial mailing. Advertisements placed in English and Tamil newspapers invited participation by the general public. Table 1 summarizes the categories of participants represented in workshops and identifies the key agencies represented".
Opportunity to influence outcomes and/or process design	High	"Participants made revisions in the conceptual model of the system, and indicated areas for improvement in the Cooum DSS".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	High	"At the second workshop in 1999, participants questioned several assumptions stemming from the conceptual model developed at the first workshop".
Clear mandates and goals	High	"Letters of invitation outlining the objectives and methodology of the research program were sent to representatives of key government departments, management boards, NGOs, research institutes and academics".
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
				X	“The research involved two participatory stakeholder workshops held in Chennai in March 1998 and February 1999, and development of a decision support system in the form of a loosely coupled GIS and water quality simulation model. In the second workshop, participants used the DSS to develop management scenarios and undertake exploratory scenario analysis to investigate the impacts of alternative management interventions”. “In the second workshop, participants worked in small teams with the Cooum DSS to develop baseline scenarios for dry and monsoon season conditions in the Cooum system, and then developed a series of single-intervention management scenarios to explore the response of the system as indicated by water quality in the Cooum River”. “Participation of

					government stakeholders (along with those from NGOs, academia and the public), and their ownership of the process and shared conceptual and computer-based environmental models generated in this work, is a first step toward change".

OUTPUTS

Output	Evidence
GIS-based DSS and environmental model	"This involved participatory development of conceptual models of relevant systems that informed construction of a GIS-based DSS and environmental model".

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	High	"This involved participatory development of conceptual models of relevant systems that informed construction of a GIS-based DSS and environmental model. This paper addresses the link between conceptual models and the DSS. The process of problem identification, system conceptualization, development of the GIS database and DSS, and its use for exploratory scenario analysis was found to stimulate learning about the situation and promoted novel solutions to the problem". "The participatory process of problem definition, system identification and exploratory scenario analysis in this work resulted in development of a shared understanding of the problem situation that was not likely to have arisen in the normal course of management by Indian institutions". "Whether the current institutional setting in Chennai will allow such integrated and interjurisdictional management is questionable. However, participation of government stakeholders (along with those from NGOs, academia and the public), and their ownership of the process and shared conceptual and computer-based environmental models generated in this work, is a first step toward change".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 5

PROCESS

"However, a major obstacle to the assimilation of our system in clinical practice was that it had not been adjusted to users' needs. In the study reported in this paper, we therefore applied qualitative, cognitive, and information systems methods to collect and analyze data on users' needs and workflows. We used that information to design and evaluate a prototype of the front end of the DSS for diabetic foot care. In order to do so, we followed a life-cycle development and evaluation approach to adapt methods drawn from multiple disciplines. In this paper we describe the alignment of our system analysis methods with the specific requirements potential users identified. This alignment process enabled us to create a DSS prototype and evaluate potential users' intentions to adopt it" **(SCOPE)**.

"The life-cycle approach combines two system development methodologies: the Waterfall model and the prototyping model. The combination of the Waterfall with the prototype method formulates a four-stage process in system design: data collection and an analysis stages, as in the Waterfall model, followed by prototype creation and evaluation stages" **(SCOPE, USABILITY)**.

"We inspected the prototype's usability using heuristic evaluation. Our evaluationwas based on Nielsen's ten heuristics [20]: (1) visibility of system status; (2) match between system and the real-world; (3) user control and freedom; (4) consistency and standards; (5) error prevention; (6) recognition rather than recall; (7) flexibility and efficiency of use; (8) aesthetic and minimalist design; (9) helping users to recognize, diagnose, and recover from errors; (10) help and documentation. This step helped us to refine the initial UI design prior to usability testing. We employed usability testing methods to obtain user feedback on the prototype; in particular, to identify the features users preferred or disliked, to clarify the reasons for their views, and to study their overall perceptions of the system and their acceptance of it" **(USABILITY)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	"First, we conducted structured interviews with five family physicians, which is the main group of potential users. Eight questions (see Appendix A) concerned users' workflows (question 1), users' preferences regarding interaction with the system (question 2), and users' goals for the DSS (questions 3–8). Additional questions (see Peleg [17]) addressed users' work practices/tasks". "To further understand users' needs and to cross-validate the collected data, we carried out a field observation of a family physician as he examined a diabetic patient's foot. During this consultation the physician "thought aloud" [18]. We also observed the

		work environments of all five family physicians". "Also, we interviewed a diabetes expert and a vascular surgeon to whom family physicians refer patients with diabetic foot problems".
Representation	Moderate	"First, we conducted structured interviews with five family physicians, which is the main group of potential users". "Also, we interviewed a diabetes expert and a vascular surgeon to whom family physicians refer patients with diabetic foot problems". "A small convenience sample of family physicians participated in the requirements gathering and evaluation. Therefore, our results may not be representative of the entire clinician population".
Opportunity to influence outcomes and/or process design	Low	"First, we conducted structured interviews with five family physicians, which is the main group of potential users. Eight questions (see Appendix A) concerned users' workflows (question 1), users' preferences regarding interaction with the system (question 2), and users' goals for the DSS (questions 3–8). Additional questions (see Peleg [17]) addressed users' work practices/tasks". "To further understand users' needs and to cross-validate the collected data, we carried out a field observation of a family physician as he examined a diabetic patient's foot. During this consultation the physician "thought aloud" [18]. We also observed the work environments of all five family physicians". "Also, we interviewed a diabetes expert and a vascular surgeon to whom family physicians refer patients with diabetic foot problems".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering	Low	"First, we conducted structured interviews with five family physicians, which is the main group

creative thinking		of potential users. Eight questions (see Appendix A) concerned users' workflows (question 1), users' preferences regarding interaction with the system (question 2), and users' goals for the DSS (questions 3–8). Additional questions (see Peleg [17]) addressed users' work practices/tasks". "To further understand users' needs and to cross-validate the collected data, we carried out a field observation of a family physician as he examined a diabetic patient's foot. During this consultation the physician "thought aloud" [18]. We also observed the work environments of all five family physicians". "Also, we interviewed a diabetes expert and a vascular surgeon to whom family physicians refer patients with diabetic foot problems".
Clear mandates and goals	Uncertain	
Transparency	Low	"We analyzed the data collected from structured interviews, observations, and official documents according to the four perspectives noted in Table 1: medical practice data, workflow data, UI data, and decision support goals data. In this paper we focus on the last three perspectives. The five family physicians often responded to the structured-interview questions with more than a simple yes/no answer. We collected the answers participants identified as system requirements and we recorded other requirements that were raised but that were not directly addressed by the interview questions".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
		X			“First, we conducted structured interviews with five family physicians, which is the main group of potential users. Eight questions (see Appendix A) concerned users’ workflows (question 1), users’ preferences regarding interaction with the system (question 2), and users’ goals for the DSS (questions 3–8). Additional questions (see Peleg [17]) addressed users’ work practices/tasks”. “To further understand users’ needs and to cross-validate the collected data, we carried out a field observation of a family physician as he examined a diabetic patient’s foot. During this consultation the physician “thought aloud” [18]. We also observed the work environments of all five family physicians”. “Also, we interviewed a diabetes expert and a vascular surgeon to whom family physicians refer patients with diabetic foot problems”.

					"We used that information to design and evaluate a prototype of the front end of the DSS for diabetic foot care".

Usability Phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE's stand-alone UI, and our analysis of users' needs for a diabetic foot care DSS. We also provided a short demonstration of the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it".
Representation	Moderate	"Eight physicians evaluated the UI: six family practitioners (two of whom participated in the interviews to elicit user requirements, and two others who were diabetes experts), an endocrinologist, with diabetes being his main focus, who was also a member of our research team (Karnieli), and a general internist who was also a medical informatics researcher". "A small convenience sample of family physicians participated in the requirements gathering and evaluation. Therefore, our results may not be representative of the entire clinician population".
Opportunity to influence outcomes and/or process design	High	"We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE's stand-alone UI, and our analysis of users' needs for a diabetic foot care DSS. We also

		provided a short demonstration of the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it". "We conducted the usability study during the second hour. In order to gather individual feedback that was not biased by peer views, participants used the prototype individually (but at the same time and in the same location). We observed the participants while they used the prototype system, and we asked two of them to "think-aloud" [18] (i.e., to verbalize their thoughts while working with the prototype's front end), while recording their thoughts on paper. This methodology allowed us to gain insights into participants' cognitive processes and to identify the proposed design's potential cognitive pitfalls".
Quality and selection of information and resources in general	High	"We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE's stand-alone UI, and our analysis of users' needs for a diabetic foot care DSS. We also provided a short demonstration of the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it". "We conducted the usability study during the second hour. In order to gather individual feedback that was not biased by peer views, participants used the prototype individually".
Challenging status quo and fostering creative thinking	High	"We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE's stand-alone UI, and our analysis of users' needs for a diabetic foot care DSS. We also provided a short demonstration of

		the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it”.
Clear mandates and goals	High	“We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE’s stand-alone UI, and our analysis of users’ needs for a diabetic foot care DSS. We also provided a short demonstration of the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it”.
Transparency	Uncertain	“Users’ comments and actions were mapped in order to screen elements and cognitive processes and rated according to severity from one (cosmetic problem) to five (critical). We also recorded participants’ comments on the system’s characteristics as well as their overall attitudes towards it (marked as positive or negative). During this encounter we also asked the participants to answer two questionnaires: one before they used the prototype and the other after. Adaptation to the specific context of the diabetic foot DSS was done by rephrasing some of the original items and by adding some new constructs (see below) and system-specific items”.
Independence and neutrality of the process	High	“We conducted the usability study during the second hour. In order to gather individual feedback that was not biased by peer views, participants used the prototype individually (but at the same time and in the same location). We observed the participants while they used the prototype system, and we asked two of them to “think-aloud” [18] (i.e., to verbalize their thoughts while working with the prototype’s front end), while recording their thoughts on paper. This methodology allowed us to gain insights into participants’ cognitive processes and to identify

		the proposed design's potential cognitive pitfalls".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partnership**	**Empower**	**Evidence**
		X			"We conducted our prototype evaluation in a highly structured and carefully planned 2h session. During the first hour we verbally informed participants about the goals of the DSS, the guideline encoding process and its execution through GLEE's stand-alone UI, and our analysis of users' needs for a diabetic foot care DSS. We also provided a short demonstration of the prototype. A brief discussion followed, during which participants expressed their views about the need for the system and tried to identify potential problems with it". "We conducted the usability study during the second hour. In order to gather individual feedback that was not biased by peer views, participants used the prototype individually (but at the same time

					and in the same location). We observed the participants while they used the prototype system, and we asked two of them to “think-aloud” [18] (i.e., to verbalize their thoughts while working with the prototype’s front end), while recording their thoughts on paper. This methodology allowed us to gain insights into participants’ cognitive processes and to identify the proposed design’s potential cognitive pitfalls”. “Users’ comments and actions were mapped in order to screen elements and cognitive processes and rated according to severity from one (cosmetic problem) to five (critical). We also recorded participants’ comments on the system’s characteristics as well as their overall attitudes towards it (marked as positive or negative). During this encounter we also asked the participants to answer two questionnaires: one before they

					used the prototype and the other after. Adaptation to the specific context of the diabetic foot DSS was done by rephrasing some of the original items and by adding some new constructs (see below) and system-specific items”.

OUTPUTS

Output	Evidence
A guideline-based DSS prototype	“To develop a guideline-based decision support system (DSS) prototype to help clinicians deal with diabetic patients’ foot problems”.

OUTCOMES

Difficult to evaluate outcomes because of the following evidence:

“Whether this model accurately predicted acceptance of our DSS is unknown, however, because the system has not yet been implemented”.

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	“They liked the minimal-interaction design, the patient-education materials the prototype generated, and the availability of explanations when needed. They thought the UI was clear and easy to use and expressed a high level of intention to use the DSS in the future”.
Recognised impacts	Uncertain	

Social learning	Uncertain	

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	High	"To develop a guideline-based decision support system (DSS) prototype to help clinicians deal with diabetic patients' foot problems". "Based on these results we conclude that using multiple methods and perspectives for assessing users' needs and requirements, as well as for system design and evaluation, is a useful approach for implementing a guideline-based DSS. Like other researchers [13–15], we believe it is necessary to use a life-cycle, user-centered design approach for developing such systems. Further, we believe the process should address user requirements from multiple angles. Within this broad agreement, two aspects are unique to our approach (see text)".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 6

PROCESS

Scope phase

This case study only includes this phase. Evidence on this is shown next:

The steps followed are these:

1. "The need for new options to monitor land degradation and enhance rangeland management was identified through a Sustainable Livelihoods Analysis with pastoralists in the study area. This was done through semi-structured interviews".

2. “Innovative monitoring and management options were then identified through semi-structured interviews”.
3. “These options were then optimised during focus groups with innovators (three in each Study Area) from communities within each study area, before being disseminated to land managers through a manual-style decision support system. As part of this optimization process, innovative options for monitoring and management in the DSS were evaluated and refined in relation to evidence about how land managers are likely to evaluate whether to adopt or reject using the DSS and the options it contained”.

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	
Representation	High	“First, the need for new options to monitor land degradation and enhance rangeland management was identified through a Sustainable Livelihoods Analysis with pastoralists in the study area (Reed and Dougill, 2002; steps 1 and 2 in Fig. 2). This was done through semi-structured interviews and the drawing of capital asset time-lines (to determine trends in capital assets and their resilience to drought) with participants. Innovative monitoring and management options were then identified through semi-structured interviews (n = 67, 40 and 53 in Study Areas 1, 2 and 3 respectively) (Reed et al., 2007, 2008; step 3 in Fig. 2). These options were then optimised during focus groups with innovators (three in each Study Area) from communities within each study area (Reed et al., 2007, 2008; steps 4 and 5 in Fig. 2), before being disseminated to land managers through a manual-style decision support system (step 7 in Fig. 2)”. “The monitoring and management options contained in the DSS were developed in collaboration with local communities who wanted to find more sustainable alternatives to current practice”.
Opportunity to influence outcomes and/or process design	Uncertain	
Quality and	Uncertain	

selection of information and resources in general		
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Moderate	"These options were then optimised during focus groups with innovators (three in each Study Area) from communities within each study area, before being disseminated to land managers through a manual-style decision support system".

Inform	Consult	Involve	Partnership	Empower	Evidence
		X			"The need for new options to monitor land degradation and enhance rangeland management was identified through a Sustainable Livelihoods Analysis with pastoralists". "Innovative monitoring and management options were then identified through semi-structured interviews". "These options were then optimised during focus groups with innovators (three in each Study Area) from

					communities within each study area. As part of this optimization process, innovative options for monitoring and management in the DSS were evaluated and refined in relation to evidence about how land managers are likely to evaluate whether to adopt or reject using the DSS and the options it contained”.

OUTPUTS

Output	Evidence
A manual style DSS	“Separate manuals have been developed for each study area in response to the different indicators and management options deemed relevant for each area by local communities”.

OUTCOMES

There is no evidence on outcomes. The case study only reports until the prototype has been developed and delivered, and does not provide more evidence on the results of testing the DSS. Evidence on this is shown next:

“They have been translated into local languages and distributed to local pastoralists and extension services in Study Areas 1 and 2. In Study Area 3, trials are being conducted as part of the EU-funded DESIRE project to further enhance management options prior to publication”.

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	Uncertain	
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 7

PROCESS

Scope phase

The case study only includes this stage because of the following:

"Case studies from central and northern Namibia were used to combine qualitative and quantitative data to develop this Decision Support System. The DSS currently consists of two databases and an expert system, which evaluates the results of land users' management practices, and provides easily accessible information and advice for participants in the system, based on the incorporated data".

"The Namibia Agricultural Union (NAU) has identified the need to capture all the information on the types of technologies that have already been applied by farmers and land users in Namibia into a single database, including the results and outcomes regarding the effectiveness of certain technologies after implementation. Since the Potchefstroom University for Christian Higher Education (PU for CHE) has already developed similar databases e.g. Grass Expert, consisting of technologies to reclaim degraded and denuded rangelands, it was decided to develop the database on bush control technologies (Bush Expert), using the same approach as that of Grass Expert".

"The case studies in the Bush Expert database consist of results and information of existing technologies and best practices obtained by means of a qualitative questionnaire completed by the land user, in collaboration with the researcher, technician or agricultural extension worker. The questionnaire compiled was tested by a number of farmers, scientists, extension workers and experts".

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	"The case studies in the Bush Expert database consist of results and information of existing technologies and best practices obtained by means of a qualitative questionnaire completed by the land user, in collaboration with the researcher, technician or agricultural extension worker".
Representation	High	"Qualitative questionnaire completed by the land user, in collaboration with the researcher, technician or agricultural extension worker". "The questionnaire compiled was tested by a number of farmers, scientists, extension workers and experts".
Opportunity to influence outcomes and/or process design	Low	"The case studies in the Bush Expert database consist of results and information of existing technologies and best practices obtained by means of a qualitative questionnaire completed by the land user, in collaboration with the researcher, technician or agricultural extension worker". "The questionnaire compiled was tested by a number of farmers, scientists, extension workers and experts".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	

Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
X					“The Namibia Agricultural Union (NAU) has identified the need to capture all the information on the types of technologies that have already been applied by farmers and land users in Namibia into a single database. Since the Potchefstroom University for Christian Higher Education (PU for CHE) has already developed similar databases e.g. Grass Expert, consisting of technologies to reclaim degraded and denuded rangelands, it was decided to develop the database on bush control technologies (Bush Expert), using the same approach as that of Grass Expert”. “The case studies in the Bush Expert database consist of results and

					information of existing technologies and best practices obtained by means of a qualitative questionnaire completed by the land user, in collaboration with the researcher, technician or agricultural extension worker”. “The questionnaire that was compiled, was tested by a number of farmers, scientists, extension workers and experts, through in depth discussions at various workshops”.

OUTPUTS

Output	Evidence
A computerised DSS consisting of two databases and an expert system.	“The expert system shell, developed for the specific needs of bush control and restoration of degraded land, is based on the Microsoft Windows Access database, which is easily accessible and updateable, should it be necessary to add additional data, edit existing data or construct extra databases within the EcoRestore DSS. The DSS is based on artificial intelligence methodologies by which a number of case studies, that have been stored in the databases, can be searched by means of an expert system approach to advise the most appropriate solution (action) to similar bush encroachment, bush thickening or degradation problems. These databases will serve as a computerised DSS and user-friendly consulting tool for future combating of degradation and desertification applications”.

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Moderate	"The DSS does not only offer a consulting tool for extension workers and technicians, but also creates networking and participation between other land users, researchers and conservationists".
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Low	"Better awareness will be created amongst land users and in farming communities, with regard to the reporting of data and gathering of information of applied technologies or practices. The importance of monitoring these practices will also be enhanced".

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The objectives that have been set for this project include the following: 1. Gather as much quantitative data of existing rangeland restoration and control of bush encroachment technologies as possible, in order to develop the Bush Expert and Grass Expert databases. 2. Evaluate the different rangeland restoration and bush control technologies used by farmers, rangeland managers, scientists and extension workers. 3. Identify the most applicable 'best bet' bush control and restoration technologies for a certain problem under specific environmental conditions. 4. Evaluate the economic viability of the bush control and restoration technologies. 5. Construct a user-friendly DSS which rangeland managers, farmers, scientists and extension workers could

		use as a consulting tool. 6. Create a web page to make the data available to as many users as possible. 7. Link the EcoRestore web page to other web pages and databases, especially those of other Agricultural and Conservation institutions. 8. Create networks and participation between farmers or rangeland managers and scientists and extension workers". "The expert system shell, developed for the specific needs of bush control and restoration of degraded land, is based on the Microsoft Windows Access database, which is easily accessible and updateable, should it be necessary to add additional data, edit existing data or construct extra databases within the EcoRestore DSS. The DSS is based on artificial intelligence methodologies by which a number of case studies, that have been stored in the databases, can be searched by means of an expert system approach to advise the most appropriate solution (action) to similar bush encroachment, bush thickening or degradation problems". "These databases will serve as a computerised DSS and user-friendly consulting tool for future combating of degradation and desertification applications. The process of updating the DSS is ongoing and allows the substance and context of the required information flows to be updated, as more knowledge becomes available".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 8

PROCESS

Scope phase

Only this phase is included because of the following:

"Three workshops were held with different stakeholder groups. The first workshop was attended by representatives of all government organisations involved with agriculture in the basin while the remaining two were attended by different farmers from the head and tail of the basin respectively (see Table 2). Each workshop was designed to meet the practical objectives of the wider investigation as well as to answer the research questions of the DSS study. The practical objectives of the wider study were defined as:
1. identifying the agricultural problems in the Deduru Oya basin,
2. investigating the impact of possible solutions to these problems, and
3. identifying which of these solutions are most effective at solving the problems".

However, government workshop and farmer workshops happened differently and the process is analysed for both separately.

Government workshop

Criteria	Evaluation	Evidence
Structured group interaction	High	"The research questions were answered by an assessment of the ways in which the method helped the participants address the practical objectives. This assessment was carried out by both the research team and the participants". "The participants were formed into four groups. Each was guided by a set of instructions and facilitated independently. Although only the facilitator of group 1 had substantial experience with Bayesian networks, the other facilitators had received some training in their development and use. Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system".
Representation	High	"This workshop was held on 24 September 1999 at Wariyapola Training Centre and lasted for 6 h. Thirty participants attended, representing the following government

		organisations: - The Irrigation Department - The Department of Agrarian Services - The Department of Agriculture and Agricultural Development Authority - The Department of Forestry - The National Water Supply and Drainage Board - The Department of Public Administration - Representatives from Pradeshiya Sabawas (local councils) The participants were formed into four groups (see Table 2)".
Opportunity to influence outcomes and/or process design	Low	"The participants were formed into four groups (*see Table 2*). Each was guided by a set of instructions and facilitated independently. Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system. Moreover, they were asked to structure their discussions in such a way so that a BN capturing their viewpoint could be constructed". "At the end of the workshop, each group was encouraged to present their cause and effect diagram to the other groups to facilitate wider discussion. Following the presentation and the closing of the meeting, the participants were asked to fill out an evaluation questionnaire".
Quality and selection of information and resources in general	High	"The participants were formed into four groups. Each was guided by a set of instructions and facilitated independently. Although only the facilitator of group 1 had substantial experience with Bayesian networks, the other facilitators had received some training in their development and use. They were asked to structure their discussions in such a way so that a BN capturing their viewpoint could be constructed. To this end, the task was divided into seven steps (*see paper*)". "Although software is available to support the construction of Bayesian networks, it is not essential. For example, the cause and effect diagram referred to in step 5 is essentially a BN flow diagram but it was decided prior

		to the workshop that it would be easier to construct these on paper. However, as one of the groups had made good progress during the workshop, the opportunity was taken to test the ease with which they could use the software directly.
Challenging status quo and fostering creative thinking	High	"The participants were formed into four groups (*see Table 2*). Each was guided by a set of instructions and facilitated independently. Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system. Moreover, they were asked to structure their discussions in such a way so that a BN capturing their viewpoint could be constructed". "At the end of the workshop, each group was encouraged to present their cause and effect diagram to the other groups to facilitate wider discussion. Following the presentation and the closing of the meeting, the participants were asked to fill out an evaluation questionnaire".
Clear mandates and goals	High	"The participants were formed into four groups. Each was guided by a set of instructions and facilitated independently. Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system. Moreover, they were asked to structure their discussions in such a way so that a BN capturing their viewpoint could be constructed".
Transparency	Uncertain	
Independence and neutrality of the process	High	"This paper reports a study to develop a DSS to help manage the agricultural system in the Deduru Oya river basin in Sri Lanka, using a tool called a Bayesian network. The main aim of the study was to investigate whether Bayesian networks, together with approaches to help people use them, could provide the generic framework envisaged above. Recognising the importance of participation, the study also looked at the best ways of involving other stakeholders in the

		construction of the DSS so that their understanding of the system could be recognised and, potentially, incorporated into the DSS". "Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system". "At the end of the workshop, each group was encouraged to present their cause and effect diagram to the other groups to facilitate wider discussion".
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system". "At the end of the workshop, each group was encouraged to present their cause and effect diagram to the other groups to facilitate wider discussion".

Inform	Consult	Involve	Partnership	Empower	Evidence
				X	"Three workshops were held with different stakeholder groups. The first workshop was attended by representatives of all government organisations involved with agriculture in the basin while the remaining two were attended by different farmers from the head and tail of the basin respectively (see Table 2). Each workshop was designed to meet the practical objectives of the wider investigation as well as to answer the research questions of the DSS study". "These objectives were presented to the stakeholders at the

					start of the workshops. The main aim of the study, however, was to use Bayesian networks to help stakeholders address these objectives and so answer the principal research questions". "The research questions were answered by an assessment of the ways in which the method helped the participants address the practical objectives. This assessment was carried out, by both the research team and the participants, in terms of the logic and comprehensiveness of the outputs, as well as the ease with which they were produced". "The participants were formed into four groups (see Table 2). Each was guided by a set of instructions and facilitated independently. Groups were asked to identify problems related to agriculture in the basin and to discuss potential solutions together with the ways in which these might be mediated to impact on the problems and the wider agricultural system. Moreover, they were asked to structure their discussions in such a way so that a BN capturing their viewpoint could be constructed". "At the end of the workshop, each group

					was encouraged to present their cause and effect diagram to the other groups to facilitate wider discussion”.

OUTPUTS

Output	Evidence
Bayesian networks (BN) and “cause and effect diagrams” from the workshops, showing problems and solutions in the basin.	“Comparing the farmer BN flow diagrams with the cause and effect diagrams produced by the groups at the government workshop, showed that perceptions of problems and solutions are largely shared”. “Due to the limited time available for the government workshop, only Group 1 was able to finish the whole process (BN). All the other groups, however, reached Step 6 and produced ‘‘cause and effect’’ diagrams expressing the relationships between the problems and the potential solutions”.

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Moderate	“The approach appeared to work well as a means of drawing out information. Not only were many possible solutions identified (Table 3) but the facilitators noted that further possibilities had been ‘‘uncovered’’ through consideration of the cause and effect diagrams”. “Group 1 appeared to find it fairly straightforward to use the BN software to develop and analyse a fully functioning network (‘‘[it was easy] to feed over solutions etc. to the computer’’). Consequently, they decided that the BN outputs could only be used as a guide and that its outputs needed to be verified against their professional experience and understanding. Nevertheless, they all agreed that it was a useful tool in that

		it encouraged them to think about how the agricultural system operates as a whole”. “The representatives of the Irrigation Department requested further training in the use of the tool so they could apply it to other management problems”. “In general, the response to the questionnaires was positive with 14 out of the 16 questionnaires returned suggesting that the approach was useful. However, a number of participants felt that more time was needed with at least one suggesting that this was unacceptable (‘‘this is time consuming’’). From group 1, there was an almost unanimous request for objective data with which to fill in the CPTs”. “Concerning ease of use, 13 out of the 16 questionnaires returned said it had been easy to use and this was supported by a number of comments”. “In our case study, the response of the policy makers to the workshop suggests that many did see potential benefits and would be willing to use the approach further”.
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	**Eval.**	**Evidence**
Objectives met	Moderate	“Due to the limited time available for the government workshop, only Group 1 was able to finish the whole process (BN). All the other groups, however, reached Step 6 and produced ‘‘cause and effect’’ diagrams expressing the relationships between the problems and the potential solutions”. “The presentation of the cause and effect diagrams at the end of the workshop did not generate significant discussion. This was thought to be due to a number of reasons (including the participants’ desire to go home) but provided no indication as to whether the diagrams were useful to the participants as a means of communicating their perspective on the problem. However, following the

		workshop, the research team did find them a useful tool to compare and combine the ideas produced by each group".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 9

PROCESS

Evidence on the stages included is shown next:

"Borenstein's method consists of laboratory testing followed by field test validation. Laboratory testing starts with a face validation and a subsystem verification and validation, followed by a predictive validation and finally a user validation. Applying these stages in order to develop Pigs2win required a time period of two years".

"A face validation **(SCOPE & PROTOTYPE)** aims at obtaining consistency between the developer's and potential user's view of the problem. In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed".

"Subsystem verification and validation **(USABILITY)** consists of testing, verifying and validating the different DSS modules as they are developed and involves both system developers and other stakeholders. A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined, and finally a workshop was organized to conclude the subsystem verification and validation process. During the workshop, stakeholders used Pigs2win to analyze pig farms and gave final comments".

"For the predictive validation **(TESTING)**, farm advisors provided data of three pig farms that received farm advice in the past. The model developers then compared the results Pigs2win generated for these farms with the advice already given in the past".

“For a user validation **(TESTING)**, interested parties who are not involved in the model’s origins and development determine whether or not the model’s results can be used for decision support. For Pigs2win, user validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool”.

“Field test validation **(TESTING)** involves placing the DSS in the field and seeking to identify any performance errors that occur. For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results”.

Scope and prototype phases

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	“In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed”.
Representation	High	“To ensure scientific soundness, three scientists were selected: one agricultural economist and two technical scientists, specialized in the field of animal sciences. Technical scientists were chosen because of their knowledge of technical aspects that influence economic and environmental performances. One of the technical scientists had to be specialised in animal nutrition, because of the significant share of feed costs in the total costs of Flemish pig farms. Also three pig farmers were selected, in order to find a balance between scientifically sound results and their practical value. Two representatives, one from a feed company and another from a veterinary company were also selected, as these companies provide important resources for pig farming. Also representatives of the two major organisations that protect the interests of famers were included. The stakeholder group was completed with four extension officers from the Flemish government. Extension officers

		may contribute to the practical usability of Pigs2win and to the promotion of the DSS”.
Opportunity to influence outcomes and/or process design	Uncertain	“A face validation aims at obtaining consistency between the developer’s and potential user’s view of the problem. In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed”.
Quality and selection of information and resources in general	High	“Graphs and tables were presented, revealing a substantial variation in economic and environmental performances between pig farms and in underlying KPIs that determine these performances (e.g. feed conversion, mortality rate). It was shown that multiple farms still have substantial improvement margins”.
Challenging status quo and fostering creative thinking	Moderate	“A face validation aims at obtaining consistency between the developer’s and potential user’s view of the problem. In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed”.
Clear mandates and goals	Uncertain	“A face validation aims at obtaining consistency between the developer’s and potential user’s view of the problem. In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore,

		possibilities of frontier analysis in relation to traditional KPIs were discussed".
Transparency	High	"First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed".
Independence and neutrality of the process	Uncertain	
Conflict resolution	High	"The whole stakeholder group agreed on the added value of frontier analysis for benchmarking. Nevertheless, multiple stakeholders were reluctant to incorporate the method into Pigs2win, because users cannot be expected to be familiar with the method. Therefore, although the model developers were authorized to build a prototype of Pigs2win that uses frontier analysis for benchmarking, they were also instructed to incorporate the method in such a way that little effort would be required from the users to become familiar with it".
Develop a shared vision and goals	High	"A face validation aims at obtaining consistency between the developer's and potential user's view of the problem. In our case, the face validation took place during the first stakeholder meeting and had two goals. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed". "The whole stakeholder group agreed on the added value of frontier analysis for benchmarking. Nevertheless, multiple stakeholders were reluctant to incorporate the method into Pigs2win, because users cannot be expected to be familiar with the method. Therefore, although the model developers

		were authorized to build a prototype of Pigs2win that uses frontier analysis for benchmarking, they were also instructed to incorporate the method in such a way that little effort would be required from the users to become familiar with it".

Inform	Consult	Involve	Partnership	Empower	Evidence
				X	"A face validation aims at obtaining consistency between the developer's and potential user's view of the problem. First, all stakeholders had to agree on the objective of Pigs2win. Second, stakeholders had to agree on whether or not using frontier analysis to identify farm-specific benchmarks. Therefore, possibilities of frontier analysis in relation to traditional KPIs were discussed as well as difficulties related to the fact that farmers are not familiar with this method". "Ever since the beginning of the participatory process, all stakeholders felt the need to develop something like Pigs2win, which resulted in a common objective".

Usability Phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	"Subsystem verification and validation consists of testing, verifying and validating the different DSS modules as they are developed and involves both system developers and other stakeholders. A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting".
Representation	High	"To ensure scientific soundness, three scientists were selected: one agricultural economist and two technical scientists, specialized in the field of animal sciences. Technical scientists were chosen because of their knowledge of technical aspects that influence economic and environmental performances. One of the technical scientists had to be specialised in animal nutrition, because of the significant share of feed costs in the total costs of Flemish pig farms. Also three pig farmers were selected, in order to find a balance between scientifically sound results and their practical value. Two representatives, one from a feed company and another from a veterinary company were also selected, as these companies provide important resources for pig farming. Also representatives of the two major organisations that protect the interests of famers were included. The stakeholder group was completed with four extension

		officers from the Flemish government. Extension officers may contribute to the practical usability of Pigs2win and to the promotion of the DSS". "Stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group".
Opportunity to influence outcomes and/or process design	High	"A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win".
Quality and selection of information and resources in general	High	"A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. During the third stakeholder meeting, they argued that it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting.
Challenging status quo and fostering creative thinking	Uncertain	"A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group

		with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined, and finally a workshop was organized to conclude the subsystem verification and validation process. During the workshop, stakeholders used Pigs2win to analyze pig farms and gave final comments".
Clear mandates and goals	Uncertain	"A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined, and finally a workshop was organized to conclude the subsystem verification and validation process. During the workshop, stakeholders used Pigs2win to analyze pig farms and gave final comments".

Transparency	High	"Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined".
Independence and neutrality of the process	Uncertain	"Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined".
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win.

		They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined”.

Inform	Consult	Involve	Partnership	Empower	Evidence
				X	“Subsystem verification and validation consists of testing, verifying and validating the different DSS modules as they are developed and involves both system developers and other stakeholders. A prototype of Pigs2win was presented during the second stakeholder meeting and remarks were used for further refinements. Then, Pigs2win was tested by the stakeholders individually. Based on these tests, stakeholders advised to extend the stakeholder group with pig farm advisors, who would probably be the users of Pigs2win. Three advisors were added to the group. During

					the third stakeholder meeting, the advisors proposed to adapt the objective of Pigs2win. They argued that, besides identifying farm-specific benchmarks and improvement paths, it would be interesting to quantify the economic and environmental effects of moving along these improvement paths. As a result, the stakeholder group decided to add a simulation module to Pigs2win, which was presented during the fourth stakeholder meeting. After this meeting, Pigs2win was further refined, and finally a workshop was organized to conclude the subsystem verification and validation process. During the workshop, stakeholders used Pigs2win to analyze pig farms and gave final comments". "Ever since the beginning of the participatory process, all stakeholders felt the need to develop something like

					Pigs2win, which resulted in a common objective”.

Testing phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	“For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past”. “User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool”. “For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results”.
Representation	High	“For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past”. “User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool”. “For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results”.
Opportunity to influence outcomes and/or process design	Uncertain	“For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past”. “User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool”. “For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm

		results".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Moderate	"For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past". "User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool". "For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results".
Clear mandates and goals	Uncertain	
Transparency	High	"For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past. The model developers then compared the results Pigs2win generated for these farms with the advice already given in the past". "User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool". "For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results".
Independence and neutrality of the process	High	"For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past. The model developers then compared the results Pigs2win generated for these farms with the advice already given in the past". "User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool".

		“For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results”.
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
				X	“For the predictive validation, farm advisors provided data of three pig farms that received farm advice in the past. The model developers then compared the results Pigs2win generated for these farms with the advice already given in the past”. “User validation was done by allowing visitors of a pig-farming exhibition to explore and comment on the tool”. “For the field tests of Pigs2win, farm advisors used the tool during group meetings attended by approximately ten farmers. The aim of these meetings is to analyse and improve farm performances by comparing and discussing farm results”.

					"Ever since the beginning of the participatory process, all stakeholders felt the need to develop something like Pigs2win, which resulted in a common objective".

OUTPUTS

Output	Evidence
Pigs2win, an agricultural DSS for pig farms.	"Features of Pigs2win are distinguished and it is shown how they originate from the participatory process and affect critical success factors of DSSs".

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"The stakeholders appreciated the combined use of frontier analysis and traditional KPIs. Accessibility of Pigs2win is assured, as users do not *a priori* require any knowledge of frontier methods". "During the first stakeholder meeting, multiple stakeholders argued that it should be avoided that users have to buy additional software to use Pigs2win. Therefore, the model developers started to build the tool in Microsoft Excel, which is probably the most popular spreadsheet application development environment today [65]. The stakeholders appreciated the use of Excel for building the tool. They argued that the majority of potential users can be expected to be familiar with Excel".

Recognised impacts	High	“During the third stakeholder meeting, the advisors proposed to extend the initial structure with a simulation stage. The other stakeholders also saw the added value of a simulation stage, so it was decided to extend the structure of Pigs2win”. “During the first stakeholder meeting, multiple stakeholders argued that it should be avoided that users have to buy additional software to use Pigs2win. Therefore, the model developers started to build the tool in Microsoft Excel, which is probably the most popular spreadsheet application development environment today [65]. The stakeholders appreciated the use of Excel for building the tool. They argued that the majority of potential users can be expected to be familiar with Excel”.
Social learning	Uncertain	

Factual outcomes

Criteria	**Eval.**	**Evidence**
Objectives met	High	“After Pigs2win was tested by the stakeholders individually, they were asked who they saw as intended users of the tool. The stakeholders mainly considered Pigs2win as an instrument that can improve the cooperation between farmers and farm advisors. It was mentioned that Pigs2win can be used by farmers themselves, but, nevertheless, it would be interesting for them to use the obtained results to exchange ideas with farm advisors about suitable improvement options. Advisors themselves may gain credibility if their recommendations can be supported with findings of a DSS. They may also be the suitable persons to make farmers familiar with the production-theoretical input-output reasoning, instead of merely thinking in partial KPIs. Finally, if advisors use Pigs2win for multiple farms, they will get used to applying the tool, which reduces the possibility that incorrect data are inserted or that results are not correctly interpreted”. “We selected stakeholders based on the objective of Pigs2win and the aim to develop a DSS that is both

		scientifically sound and usable in practice”. “The size and composition of the stakeholder group also enabled the creation of a broad support by the Flemish pig sector, which was also one of our goals”. “Our participatory approach resulted in the DSS Pigs2win. The ultimate aim of Pigs2win is to facilitate the selection of preferable management decisions. The DSS allows for identifying farm-specific suboptimal KPIs and assessing aggregate economic and environmental effects of improving these suboptimal KPIs”.
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users’ practice	Uncertain	

CASE STUDY 10

PROCESS

“The indicator set was developed on the basis of a conceptual approach, derived from the social sciences called conceptual specification or dimensional analysis (see Fig. 3). It can be used to break down the concept into dimensions, categories and aspects (see Kuhndt and von Geibler, 2002). This approach was applied for the development of the indicator set (see Kristof et al., 2006, for further applications see e.g. Kuhndt et al., 2004; von Geibler et al., 2006, or Global Reporting Initiative, 2006). Three methodological steps were taken to obtain the indicator set. First, based on the specification of the value chain “construction and refurbishment with wood”, a literature and stakeholder analysis is conducted; based on this a preliminary indicator set is formulated. Secondly, stakeholders and specialists are consulted to provide feedback, and thirdly, the indicator set is reviewed and finalized” **(SCOPE)**.

“In order to turn this indicator set into an operational tool, an Internet-based custom-made “Sustainability Check” was developed (see Kristof and Schmitt, 2007). The aim of the tool is to support a sustainability assessment of products in the value chain “construction and refurbishment with wood”. Partners of the project tested the tool in actual product developments. Five interviews were conducted to assess the users’ perceptions regarding the feasibility, relevance and benefits of the online tool (Schmitt and Kristof, 2007). The results show high practicability of the tool and completeness of the aspects covered in the indicator set” **(TESTING)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"Guided interviews of 45 min to 2h were held with 16 individuals, and transcripts were checked".
Representation	High	"The different value-chain actors (individual companies and institutions from science, the economy, networks, etc.) are identified. The selection includes a broad range of social groups to cover the most important sustainability issues". "As a result, the draft was modified based on the feedback received from interviews with a number of stakeholders. Interview partners represent different stages in the chain and different social groups. In addition to the interviews, professional advice was obtained through a workshop".
Opportunity to influence outcomes and/or process design	Uncertain	"Guided interviews of 45 min to 2h were held with 16 individuals, and transcripts were checked. The results of the interviews were analyzed both qualitatively and quantitatively to reassess and adjust the draft indicator set. In addition to the interviews, professional advice was obtained through a workshop".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	"Guided interviews of 45 min to 2h were held with 16 individuals, and transcripts were checked. The results of the interviews were analyzed both qualitatively and quantitatively to reassess and adjust the draft indicator set. In addition to the interviews, professional advice was obtained through a workshop".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	"Guided interviews of 45 min to 2 h were held with 16 individuals, and transcripts were checked. The results of the interviews were analyzed both qualitatively and

		quantitatively to reassess and adjust the draft indicator set. In addition to the interviews, professional advice was obtained through a workshop".
Independence and neutrality of the process	Uncertain	"Guided interviews of 45 min to 2 h were held with 16 individuals, and transcripts were checked. The results of the interviews were analyzed both qualitatively and quantitatively to reassess and adjust the draft indicator set. In addition to the interviews, professional advice was obtained through a workshop".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				"The indicator set was developed on the basis of a conceptual approach, derived from the social sciences called conceptual specification or dimensional analysis (see Fig. 3). It can be used to break down the concept into dimensions, categories and aspects (see Kuhndt and von Geibler, 2002). This approach was applied for the development of the indicator set (see Kristof et al., 2006, for further applications see e.g. Kuhndt et al., 2004; von Geibler et al., 2006, or Global Reporting Initiative, 2006). Three methodological steps were taken

					to obtain the indicator set. First, based on the specification of the value chain “construction and refurbishment with wood”, a literature and stakeholder analysis is conducted; based on this a preliminary indicator set is formulated. Secondly, stakeholders and specialists are consulted to provide feedback, and thirdly, the indicator set is reviewed and finalized”. “Guided interviews of 45 min to 2 h were held with 16 individuals, and transcripts were checked. The results of the interviews were analyzed both qualitatively and quantitatively to reassess and adjust the draft indicator set. In addition to the interviews, professional advice was obtained through a workshop”. “However, the process of identifying key aspects and indicators is a subjective decision, with either relevant risks being left out or irrelevant issues being

					included (see Fürtjes, 1982, p. 38; Rennings, 1994, p. 144). Thus, the first draft of the indicator set was reviewed on the basis of a triangulation approach, i.e. the findings were verified through other experimental methods".

Testing phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	
Representation	High	"Partners of the project tested the tool in actual product developments. Five interviews were conducted to assess the users' perceptions regarding the feasibility, relevance and benefits of the online tool (Schmitt and Kristof, 2007)".
Opportunity to influence outcomes and/or process design	Uncertain	
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				“In order to turn this indicator set into an operational tool, an Internet-based custom-made “Sustainability Check” was developed (see Kristof and Schmitt, 2007). The aim of the tool is to support a sustainability assessment of products in the value chain “construction and refurbishment with wood”. Partners of the project tested the tool in actual product developments. Five interviews were conducted to assess the users’ perceptions regarding the feasibility, relevance and benefits of the online tool (Schmitt and Kristof, 2007). The results show high practicability of the tool and completeness of the aspects covered in the indicator set”.

OUTPUTS

Output	Evidence
An indicator set	“The results show high practicability of the tool and completeness of the aspects covered in the indicator set”.
A DSS in on-line and printed versions	“In order to turn this indicator set into an operational tool, an Internet-based custom-made “Sustainability Check” was developed (see Kristof and Schmitt, 2007). The aim of the tool is to support a sustainability assessment of products in the value chain *construction and refurbishment with wood*. In order to address specific user preferences, the “Sustainability Check” is available in both online and printed versions”.

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"Five interviews were conducted to assess the users perceptions regarding the feasibility, relevance and benefits of the online tool (Schmitt and Kristof, 2007). The results show high practicability of the tool and completeness of the aspects covered in the indicator set".
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	High	"In order to turn this indicator set into an operational tool, an Internet-based custom-made "Sustainability Check" was developed (see Kristof and Schmitt, 2007). The aim of the tool is to support a sustainability assessment of products in the value chain "construction and refurbishment with wood". Partners of the project tested the tool in actual product developments. Five interviews were conducted to assess the users' perceptions regarding the feasibility, relevance and benefits of the online tool (Schmitt and Kristof, 2007). The results show high practicability of the tool and completeness of the aspects covered in the indicator set".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 11

PROCESS

"The evolution of the DSS since its inception is described as a time line in Figure 2. Funding for the CRC (and hence the HotCross project) began in July 1993. A prototype was available for testing in mid-1995. Soon after, a computer programmer was hired to oversee the coding of the DSS. Simultaneously, databases were constructed containing performance data for the prediction equations from various literature sources around the world. The genetics database contained information from tropical crossbreeding studies. Temperate studies were added to allow comparisons between the two environments. A second database was also developed that incorporated data from a number of studies on components of environmental stress, including tick, worm, heat, and nutrition stress on productivity".

"Potential industry-based end users became directly involved in development of the DSS about 18 mo after commencement of the project (Figure 2), although potential end users were queried about their needs prior to the start of the CRC. The focus group comprised five individuals (two seedstock and three commercial producers), who were deemed to be progressive producers by extension advisers. The role of the focus group was to help evaluate the software and indicate features they would like it to have as a finished product" **(USABILITY)**.

"An alpha test version of HotCross was released to a limited number of evaluators (mostly producers and scientists) in October 1996. This version predicted only a limited number of growth traits. Evaluators' comments were collated, discussed, and prioritized, and the DSS was redesigned. Most of the changes were of a "look and feel" nature (e.g., placement of buttons and screen colors) **(USABILITY)**. HotCross was released to industry as a beta version in mid-1997 (Newman et al., 1997). This version contained equations for the prediction of carcass yield and quality in addition to growth traits".

Usability Phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	High	"The consultation process for HotCross involved several iterations of interactive meetings with the focus group, performing suggested revisions of the software (look and feel issues, breeds and traits to include), and releasing the revised beta version for further evaluation. Although the focus group was interested in the development of the software and provided a useful market focus, it was important that the development team set milestones for consultation and meeting with the focus group to advance the project. Maintaining continuity of participation was also an issue: after a period of time, focus group members tended to drop out and thus reduce critical mass".

Representation	Moderate	“Potential industry-based end users became directly involved in development of the DSS. The focus group comprised five individuals (two seed stock and three commercial producers), who were deemed to be progressive producers by extension advisers. An alpha test version of HotCross was released to a limited number of evaluators (mostly producers and scientists). The DSS was also demonstrated to individual producers not associated with the focus group whenever possible”.
Opportunity to influence outcomes and/or process design	Moderate	“The consultation process for HotCross involved several iterations of interactive meetings with the focus group, performing suggested revisions of the software (look and feel issues, breeds and traits to include), and releasing the revised beta version for further evaluation. Although the focus group was interested in the development of the software and provided a useful market focus, it was important that the development team set milestones for consultation and meeting with the focus group to advance the project. Maintaining continuity of participation was also an issue: after a period of time, focus group members tended to drop out and thus reduce critical mass”. “An alpha test version of HotCross was released to a limited number of evaluators (mostly producers and scientists) in October 1996. This version predicted only a limited number of growth traits. Evaluators’ comments were collated, discussed, and prioritized, and the DSS was redesigned. Most of the changes were of a “look and feel” nature (e.g., placement of buttons and screen colors)”.
Quality and selection of information and resources in general	Uncertain	“The consultation process for HotCross involved several iterations of interactive meetings with the focus group, performing suggested revisions of the software (look and feel issues, breeds and traits to include), and releasing the revised beta version for further evaluation”.

Challenging status quo and fostering creative thinking	Uncertain	“The consultation process for HotCross involved several iterations of interactive meetings with the focus group, performing suggested revisions of the software (look and feel issues, breeds and traits to include), and releasing the revised beta version for further evaluation. Although the focus group was interested in the development of the software and provided a useful market focus, it was important that the development team set milestones for consultation and meeting with the focus group to advance the project. Maintaining continuity of participation was also an issue: after a period of time, focus group members tended to drop out and thus reduce critical mass”. “An alpha test version of HotCross was released to a limited number of evaluators (mostly producers and scientists) in October 1996. This version predicted only a limited number of growth traits. Evaluators’ comments were collated, discussed, and prioritized, and the DSS was redesigned. Most of the changes were of a “look and feel” nature (e.g., placement of buttons and screen colors)”.
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
			X		“The consultation process for HotCross involved several iterations of interactive meetings with the focus group,

					performing suggested revisions of the software (look and feel issues, breeds and traits to include), and releasing the revised beta version for further evaluation. Although the focus group was interested in the development of the software and provided a useful market focus, it was important that the development team set milestones for consultation and meeting with the focus group to advance the project. Maintaining continuity of participation was also an issue: after a period of time, focus group members tended to drop out and thus reduce critical mass”. “An alpha test version of HotCross was released to a limited number of evaluators (mostly producers and scientists) in October 1996. This version predicted only a limited number of growth traits. Evaluators’ comments were collated, discussed, and

					prioritized, and the DSS was redesigned. Most of the changes were of a "look and feel" nature (e.g., placement of buttons and screen colors)".

OUTPUTS

Output	Evidence
A beta version (improved prototype) of a DSS (*HotCross*)	"A case study of *HotCross*, a DSS under development to evaluate crossbreeding systems in northern Australia, was used to identify issues involved in DSS development and use". "*HotCross* was released to industry as a beta version in mid-1997. HotCross will be completed in mid-2000".

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	Uncertain	"Even though the workshops have been valuable in the evaluation phase for a variety of reasons, it is still difficult to quantify the immediate impacts of the DSS (i.e., to measure its success). For example, a participant might not use the DSS for decision-making per se. Perhaps the

		impact will be observed through knowledge gained in some other way (e.g., use of estimated breeding values to choose a future sire) to make changes to current practices. A survey is planned to elucidate these issues".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 12

PROCESS

"Several methodologies were employed in this study. Contextual design, first described by Holzblatt and Meyer [16] is a structured methodology for investigating the users work environment for the purpose of designing software that addresses the needs of the user. Contextual design incorporates traditional ethnographic approaches such as field observations and interviews. The aim of contextual design is to create five formalised models of the work processes. The flow model describes the coordination of work and flow of information, as well as the artifacts used. The artifact model describes the objects that support work such as existing software, medical records, or other forms. The cultural model describes aspects that define general policies, values, and relationships. Individuals, groups or entire organizations are depicted as overlapping circles connected by appropriately labelled arrows representing the influence of one on the other. Constraints may be due to policy, personal values, organizational culture or other influences. Physical models describe the physical environment. The sequence model describes activities that form work tasks and the triggers that initiate the sequence".

"The human factors engineer (MM) performed the interviews. Data was obtained over a 4-week period using unstructured interviews with medical, nursing and pharmacy staff, and participation in ward rounds. Detailed observation of the activities within the unit was performed during both morning and evening shifts to observe the changes in workflow patterns over a 24-h period. The information from the interviews and field observation was transcribed and graphically represented as models. The models were presented to and validated by project committee. The output of the initial investigations, and in particular the flow and artifact models, provided the key requirements of the DSS" **(SCOPE)**.

"Rather than progressing directly to a software prototype, we elected to use abstract paper prototyping to test the validity of these assumptions and to increase our confidence that the designs would actually achieve these goals. In paper prototyping, the user is shown a sketch of the system, and asked to solve realistic problems or case studies (Fig. 3) with assistance by a facilitator [20]. This process enables the developers to examine how users would interact with the decision support tool, and provides the users with a simulated experience of using the proposed system. It was useful to perform this in parallel, rather than after, the contextual analysis, because the activities were complementary [21]” **(PROTOTYPE)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	“The human factors engineer (MM) performed the interviews. Data was obtained over a 4-week period using unstructured interviews with medical, nursing and pharmacy staff, and participation in ward rounds. Detailed observation of the activities within the unit was performed during both morning and evening shifts to observe the changes in workflow patterns over a 24h period”. “Contextual Inquiry methodology was ideally suited to describe the complex ICU work-environment, but more importantly integrated the users and the content expert/developers throughout the project”.
Representation	High	“Unstructured interviews with medical, nursing and pharmacy staff, and participation in ward rounds”.
Opportunity to influence outcomes and/or process design	Low	“A criticism of Contextual Inquiry is that the process may become “designer-centered” rather than “user-centered” as the designer is central to the process and may influence the development through preconceptualisation”.
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	High	“Detailed observation of the activities within the unit was performed during both morning and evening shifts to observe the changes in workflow patterns over a 24-h period. The information from

		the interviews and field observation was transcribed and graphically represented as models. The models were presented to and validated by project committee. The output of the initial investigations, and in particular the flow and artifact models, provided the key requirements of the DSS". "There is also no formal data-analysis in this method [33]. To limit the potential bias of this approach, the clinicians validated the data and models obtained from the observations".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
		X			"Contextual design, first described by Holzblatt and Meyer [16] is a structured methodology for investigating the users work environment for the purpose of designing software that addresses the needs of the user. Contextual design incorporates traditional ethnographic approaches such as field observations and interviews. The aim of contextual design is to create five formalised models of the work processes".

					“The human factors engineer (MM) performed the interviews. Data was obtained over a 4-week period using unstructured interviews with medical, nursing and pharmacy staff, and participation in ward rounds. Detailed observation of the activities within the unit was performed during both morning and evening shifts to observe the changes in workflow patterns over a 24-h period”.

Prototype phase

Criteria	Evaluation	Evidence
Structured group interaction	High	“In paper prototyping, the user is shown a sketch of the system, and asked to solve realistic problems or case studies (Fig. 3) with assistance by a facilitator [20]”. “As the user physically placed the cards into the scratchpad area, they were asked to think aloud while the domain expert discussed the proposed prescription. Six users of varying levels of seniority were individually consulted. Each session involved the user, a facilitator (MM) who briefly overviewed the paper prototype design and introduced the tasks, and a domain expert (KT) who simulated the logic that would eventually be provided by the target system”.
Representation	Moderate	“Six users of varying levels of seniority were individually consulted”.

Opportunity to influence outcomes and/or process design	High	"In paper prototyping, the user is shown a sketch of the system, and asked to solve realistic problems or case studies (Fig. 3) with assistance by a facilitator [20]". "The paper prototype design entailed dragging antibiotics onto a "scratch pad", which would be critiqued (see Fig. 4). This was easily simulated using small cards to represent each antibiotic. As the user physically placed the cards into the scratchpad area, they were asked to think aloud while the domain expert discussed the proposed prescription".
Quality and selection of information and resources in general	High	"Five case studies of varying complexity were presented to the user (an example is shown in Fig. 3). Each scenario consisted of a clinical history about a patient followed by a list of microbiology results with or without available antibiotic sensitivities. Additional information that might have been provided included a history of antibiotic allergy, current antibiotic therapy, and presence of renal impairment. Each scenario included at least one factor that influenced the choice of antibiotic". "Each session involved the user, a facilitator (MM) who briefly overviewed the paper prototype design and introduced the tasks, and a domain expert (KT) who simulated the logic that would eventually be provided by the target system".
Challenging status quo and fostering creative thinking	Low	"The paper prototype design entailed dragging antibiotics onto a "scratch pad", which would be critiqued (see Fig. 4). This was easily simulated using small cards to represent each antibiotic. As the user physically placed the cards into the scratchpad area, they were asked to think aloud while the domain expert discussed the proposed prescription".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the	Uncertain	

process		
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
		X			"Rather than progressing directly to a software prototype, we elected to use abstract paper prototyping to test the validity of these assumptions and to increase our confidence that the designs would actually achieve these goals. In paper prototyping, the user is shown a sketch of the system, and asked to solve realistic problems or case studies (Fig. 3) with assistance by a facilitator [20]. This process enables the developers to examine how users would interact with the decision support tool, and provides the users with a simulated experience of using the proposed system". "Each session involved the user, a facilitator (MM) who briefly overviewed the paper prototype design and

					introduced the tasks, and a domain expert (KT) who simulated the logic that would eventually be provided by the target system”.

OUTPUTS

Output	Evidence
A DSS for antibiotic prescribing (ADVISE)	“The final product was a real time microbiology browser and decision support tool for antibiotic prescribing”. “ADVISE became fully functional in January 2002 and was introduced to medical staff with an education program consisting of seminars, one-on-one tutorials, and a user manual. An electronic audit log of usage patterns was recorded from the date of commencement”.

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Moderate	“Contextual Inquiry methodology was ideally suited to describe the complex ICU work-environment, but more importantly integrated the users and the content expert/developers throughout the project”. “The ADVISE recommendations were incorporated into the bedside discussions during the ward rounds”.
Acceptance of process and/or outcomes	High	“The tool was rapidly incorporated into the workflow of the clinical staff that found that the microbiology browser and reporting tool substantially reduced the time taken to normally perform this task. The clinicians were satisfied with the level of content of the algorithms and their appearance. They reported increased confidence in prescribing or ceasing antibiotic therapy, and the ADVISE recommendations were incorporated into the bedside discussions during the ward rounds”.
Recognised	Uncertain	

impacts		
Social learning	High	"The tool was rapidly incorporated into the workflow of the clinical staff that found that the microbiology browser and reporting tool substantially reduced the time taken to normally perform this task. They reported increased confidence in prescribing or ceasing antibiotic therapy, and the ADVISE recommendations were incorporated into the bedside discussions during the ward rounds".

Factual outcomes

Criteria	**Eval.**	**Evidence**
Objectives met	High	"The tool was rapidly incorporated into the workflow of the clinical staff that found that the microbiology browser and reporting tool substantially reduced the time taken to normally perform this task. The clinicians were satisfied with the level of content of the algorithms and their appearance. They reported increased confidence in prescribing or ceasing antibiotic therapy, and the ADVISE recommendations were incorporated into the bedside discussions during the ward rounds". "In summary, there were two major findings: a 10.5% reduction in overall antibiotic utilisation and a reduction in the proportion of patients prescribed broad-spectrum antibiotics".
Uptake of the tool/s	High	"The tool was rapidly incorporated into the workflow of the clinical staff that found that the microbiology browser and reporting tool substantially reduced the time taken to normally perform this task".
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	High	"In summary, there were two major findings: a 10.5% reduction in overall antibiotic utilisation and a reduction in the proportion of patients prescribed broad-spectrum antibiotics". "The tool was rapidly incorporated into the workflow of the clinical staff that found that the microbiology browser and reporting tool substantially reduced the time taken to normally perform this task. They reported

		increased confidence in prescribing or ceasing antibiotic therapy, and the ADVISE recommendations were incorporated into the bedside discussions during the ward rounds".

CASE STUDY 13

PROCESS

"The five cases that were considered in the study involved participatory problem structuring to address water distribution bottlenecks; identification of Non-Revenue Water (NRW) reduction strategies; facilitation of decentralized management of customer accounts; monitoring and control of procurements and expenditure; and geospatial investigation of declining water sales" **(SCOPE)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	"During the study, participation in problem identification was achieved through discussions and brainstorming sessions bringing together top and middle managers within the organization". **Case 1:** "Fortnightly meetings were held". **Case 2:** "Two brainstorming workshops were organized".
Representation	High	**Case 1:** "This forum brought together engineers and technical staff of KW". **Case 2:** "These workshops involved the participation of both technical and commercial managers from all departments and Branches of KW". **Case 4:** "The BIM committee consisted of departmental heads responsible for finance, accounts, procurement, development, monitoring and evaluation".
Opportunity to influence outcomes and/or process design	High	"Apart from the AMM, all the above applications were developed in consultation with the prospective end-users at various stages. The consultations were in form of discussions with individual users and periodic presentations of work-in-progress to groups of users,

		from which feedback was obtained and incorporated into the system designs”. **Case 2:** “Following the first workshop, the researcher and his planning team met a number of times to synthesize the identified strategies and draft an Action Plan indicating specific activities, timelines and responsibility allocations”. **Case 4:** “At its first sitting, the committee spent close to a whole day reviewing the entire procurement process for expenditure items of both capital (CAPEX) and operational (OPEX) nature, and identifying in great detail the actors, activity centres, actions and information needs at each point. During this discussion, a number of necessary modifications to existing practices and procedures were identified and agreed upon”.
Quality and selection of information and resources in general	High	“Maps and other geovisualization tools were also used to inform and enhance the processes of collective problem identification and structuring”. **Case 2:** “The data was analyzed and synthesized into a Power-Point presentation that the researcher made to participants at the start of the first workshop, as a way of informing and guiding the discussions that ensued”.
Challenging status quo and fostering creative thinking	High	**Case 1:** “During these meetings a number of issues were identified, actions formulated, and tasks implemented”. **Case 2:** “During this workshop, four smaller discussion groups were formed to map out strategies for various aspects of the water loss management process”.
Clear mandates and goals	Uncertain	
Transparency	Moderate	“Apart from the AMM, all the above applications were developed in consultation with the prospective end-users at various stages”. **Case 2:** “Following the first workshop, the

		researcher and his planning team met a number of times to synthesize the identified strategies and draft an Action Plan indicating specific activities, timelines and responsibility allocations. In further support of the Action Plan implementation, the researcher developed an integrated set of computerized tools, as described in the next section". **Case 4:** "During this discussion, a number of necessary modifications to existing practices and procedures were identified and agreed upon. The result was a comprehensive needs assessment and high-level specification for the proposed computerized budget tracking tool, which formed the blueprint for the tool that was later developed".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partnership	Empower	Evidence
	X				"Apart from the AMM, all the above applications were developed in consultation with the prospective end-users at various stages". **Case 2:** "Following the first workshop, the researcher and his planning team met a number of times to synthesize the identified strategies and draft an Action Plan indicating specific activities, timelines and responsibility allocations. The

					researcher presented this Action Plan to the KW top and middle managers at the second workshop, where it was adopted for implementation. In further support of the Action Plan implementation, the researcher developed an integrated set of computerized tools, as described in the next section”. **Case 4:** “During this discussion, a number of necessary modifications to existing practices and procedures were identified and agreed upon. The result was a comprehensive needs assessment and high-level specification for the proposed computerized budget tracking tool, which formed the blueprint for the tool that was later developed”.

OUTPUTS

Output	Evidence
A number of prototype DSSs	“A number of prototype decision support tools were developed and implemented”. “In this section, three custom data management applications are described. These applications were developed by the researcher using the Microsoft Jet database engine and Visual Basic for Applications (VBA)”.

OUTCOMES

Personal outcomes

Criteria	Eval.	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	**Case 2:** "Following the first workshop, the researcher and his planning team met a number of times to synthesize the identified strategies and draft an Action Plan indicating specific activities, timelines and responsibility allocations. The researcher presented this Action Plan to the KW top and middle managers at the second workshop, where it was adopted for implementation". **Case 4:** "During this discussion, a number of necessary modifications to existing practices and procedures were identified and agreed upon".
Social learning	Moderate	"Paper III reports that the establishment of T-Cube resulted in the promotion of a culture of participatory problem analysis, especially among the middle-management staff of KW. Paper III also reports that T-Cube did not gain wide membership among the top decision makers within the organization, who continued to apply a more intuitive and spontaneous decision- making approach, pressed by the urgency with which the specific problem situation needed to be addressed".

Factual outcomes

Criteria	Eval.	Evidence
Objectives met	High	"A number of prototype decision support tools were developed and implemented". "In terms of deployment, the QOS and AMM modules were installed on

		computers at the nine different Branches, the WS module was installed in the Water Supply and GIS departments, and the BT was installed on a server at the KW head office and made available to various departmental heads and to first-line staff in the finance and procurement departments".
Uptake of the tool/s	Low	"However, despite the potential benefits that these tools offered, it was not easy to get the intended users to adopt and integrate them into their everyday work practices".
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 14

PROCESS

"We developed the DMS explicitly to foster transparency of Hanford cleanup decision information. A usability test of the DMS was also conducted, and is reported elsewhere" **(USABILITY: not reported in this paper)**.

"The main goal of the design phase was to scope a design for the DMS using a participatory strategy. Design activities included developing a conceptual prototype, conducting interviews with key stakeholders, and synthesizing responses".

"We developed a conceptual prototype of the DMS based on knowledge of DOE problems, the information requirements of stakeholders, risk information and uncertainties, specific tasks in the 100 Area, system development theory, methodology, etc. A "briefing package" consisting of 12 one-page documents described the various features of the envisioned DMS. In addition to the briefing package, an informational presentation was developed for one-on-one and group interviews about the DMS" **(PROTOTYPE: not reported in this paper)**.

"Next, to obtain feedback and recommendations early in the design process, we scheduled and conducted interviews with active Hanford stakeholders about the proposed DMS" **(SCOPE: in this case it comes after the prototype, it is the only phase including information on how it happened)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"An interview protocol was developed and used as an agenda for discussions, which lasted for one to two hours each. Although technically "unstructured," the interviews began with the informational presentation, and included a standard set of questions".
Representation	High	"To develop the DMS, we worked with several Hanford stakeholders to identify the most important goals for decision transparency and implement them in the context of an ongoing cleanup in the Hanford 100 Area". "We recruited subjects based on one of two major criteria—all either participated directly in the Hanford Openness Workshops, or they were acting (at the time) as managers on the 100 Area Soil Cleanup for DOE or EPA. We made special efforts to include representatives of local Indian tribes, including the Yakima, Umatilla, and Nez Perce Tribes, because of the unique perspectives that tribes bring to cleanup dialogue. Several expressed interest in the DMS, but none participated in the design phase. Eleven of 17 invited individuals participated in the user information needs analysis. All 11 individuals who participated in the design phase were regular participants in the 100 Area decision-making processes throughout 1999–2002. Individuals hailed from a variety of organizations, including DOE, EPA, WA Ecology, Oregon Office of Energy, Columbia River Keepers, Government Accountability Project, and the Hanford Openness Workshops (facilitator)".
Opportunity to influence outcomes and/or process design	High	"The question set included issues such as the meaning and importance of transparency, comments about the DMS information structures, and overall impressions about the project". "Participants strongly encouraged us to move forward and implement the pilot DMS because they expected that the system would provide desired information in a more integrated and understandable way".
Quality and selection	High	"Although technically "unstructured," the interviews began with the

of information and resources in general		informational presentation, and included a standard set of questions. Draft summaries of the major themes and issues were prepared and distributed to participants for review".
Challenging status quo and fostering creative thinking	High	"Several core themes emerged from the dialogue about transparency and the DMS".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	High	"Nearly every one of the participants interviewed placed transparency as a top issue for Hanford cleanup. One participant noted, "Starting with the basics and a fairly transparent process would reduce greatly the opportunities to have misunderstandings lead to conflicts, which lead to stalemate, which cost money and don't get things done." Participants also highlighted the long periods of time associated with decision processes for nuclear waste cleanup, and emphasized the importance and difficulty of tracking decision information over these long periods".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
		X			"To obtain feedback and recommendations early in the design process, we scheduled and conducted interviews with active Hanford stakeholders about the proposed DMS" "This user information needs assessment led us to work toward a system that would allow users to: know what is being done; where it's being done, and why".

OUTPUTS

Output	Evidence
An internet-based GIS (DMS)	“The result was an Internet-based and Geographic Information System (GIS) product called the Hanford Decision Mapping System (DMS) pilot project”

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	“The participants were generally positive about the DMS and the transparency measurement framework”.
Recognised impacts	High	“Once comments and approval were received, summaries were finalized. These interview summaries served as primary sources for the project. In addition, feedback from informal interactions—e.g., conversation with colleagues, presentations in university classrooms, and lectures at professional society meetings—was summarized and added to the project file as source material”. “This user information needs assessment led us to work toward a system that would allow users to: know what is being done; where it’s being done, and why”.
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	Moderate	“This article describes a collaborative effort (using community-based participatory research approaches) to develop new strategies for organizing and presenting Hanford cleanup decision information. The result was an Internet-based and Geographic Information System (GIS) product called the Hanford Decision

		Mapping System (DMS) pilot project" "Our working definition of "transparency" for this project is information that allows all people who are interested in a decision to understand what is being decided, why, and where. We developed the DMS explicitly to foster transparency of Hanford cleanup decision information". "The information structures included in the DMS were generally expected to be useful for promoting transparency". "The transparency measurement framework is still in its infancy and additional debate, validation, and research on the framework is needed". "Another shortcoming of the DMS is that values information was included only in a limited way. A key challenge to understanding Hanford cleanup is that many different values influence decision processes; such values are not always expressed explicitly".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 15

PROCESS

"We conducted interviews with the project manager of a major core business system at the ABC Bank and also requested for other supplementary documents to verify and triangulate our findings. Eventually, data was collected from a variety of sources including minutes of over 40 internal meetings of the project team, newsletters, design documents, and over 15 hours of in-depth interview with one of the project managers. Both of us participated in the face-to-face interviews, which occurred over a period of about six months, and took a large volume of notes. We also had numerous contacts with the informant via e-mail and online chats for clarification and supplementary information and got detailed answers".

"The Finance Department of ABC Bank started a fullscale business requirements analysis for the entire bank, with the objective of eventually installing comprehensive management accounting information systems.

"In October 2004, the team gathered in Guangzhou, the capital city of Guangdong Province, to start the development. The team spent the first month on refining requirements and regrouping the subsystems" **(SCOPE)**.

JOINT DEVELOPMENT STARTS: "The Guangdong Branch added four more developers, but even with these 20 developers the task was still too heavy to bear. The team decided to outsource, and the first choice came to their mind was XYZ Software Company. Starting from this point, the project switched to a joint development mode. In February 2005, the development of the user interfaces was completed by the four development groups. Each group had completed one subsystem's coding for an incomplete prototype" **(PROTOTYPE)**.

"The adherence to the user-centered design principles proved to be extremely useful. Other than in the coding stage, they were full participants as the source of requirements throughout all other stages of development when they prepared testing cases. They contributed to the entire process of system development, from requirements definition, construction of the system model and architecture, functional point analysis, prototype of user interfaces, preparation of use cases and test cases, to acceptance tests. Exactly one year later after the project kickoff, the project team was ready for user acceptance tests **(TESTING: no more details on this stage)**. Subsequent kickoff, preparation, and training, data conversion, demos, and installation of the production environment went smoothly. Six weeks later, the system went online in the Guangdong branch and worked smoothly".

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	"The team spent the first month on refining requirements and regrouping the subsystems, but was unable to make a decision on the development approach and platform. Subsequently, it was also unable to decide on what documentation tool to use due to fragmentation in the team, diverse opinions pulling in different directions, and lack of coordination and leadership". "Having closely worked with Mr. Niu for over half a year and recognized his strong commitment and managerial talent, Mr. Miao transferred all management responsibilities to Mr. Niu. It was from this point that the project team had a single point of management responsibilities".
Representation	High	"The project team consisted of only a dozen internal employees. They were mostly domain experts summoned from subsidiary branches, with only one IT person in the team". "The AIS project management structure consisted of a project steering committee, under which

		there were a technical team and a business support team. The steering committee members were senior executives of the bank, and they played a nominal and ceremonial role only, without any real responsibilities. The de facto project management responsibilities fell on three people".
Opportunity to influence outcomes and/or process design	High	"The team decided to use the familiar data flow diagrams (DFDs) to model the complex business processes". "As a result, the five subsystems previously defined were restructured into seven, and each of them was given redefined modules and functional specifications".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	High	Two months later, as the understanding of the requirements deepened, the project team fully recognized that the traditional development method, technologies, and architecture could not meet the requirements. Meanwhile, through constant discussion, the domain experts and technical members refined the requirements".
Clear mandates and goals	Uncertain	
Transparency	High	"The project team had developed a more realistic and thorough understanding of the architecture of modern management accounting systems than the feasibility report". "When the team refined the requirements and regrouped the subsystems in Guangzhou, it became clear that the JEEE technology based on the browser/server architecture was a better choice".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"The project team had developed a more realistic and thorough understanding of the architecture of modern management accounting systems than the feasibility report". "When the team refined the requirements and regrouped the subsystems in Guangzhou, it became clear that the JEEE technology based

		on the browser/server architecture was a better choice”.

Inform	Consult	Involve	Partner	Empower	Evidence
			X		“The Finance Department of ABC Bank started a fullscale business requirements analysis for the entire bank, with the objective of eventually installing comprehensive management accounting information systems. In October 2004, the team gathered in Guangzhou, the capital city of Guangdong Province, to start the development. The team spent the first month on refining requirements and regrouping the subsystems”. “The project team consisted of only a dozen internal employees. They were mostly domain experts summoned from subsidiary branches, with only one IT person in the team”. “The AIS project management structure consisted of a project steering committee, under which there were a technical team and a business support team. The steering committee members were senior executives of the bank, and they played a nominal and ceremonial role only, without any real responsibilities. The de facto project management responsibilities fell on

					three people”.

Prototype phase

Criteria	Evaluation	Evidence
Structured group interaction	Moderate	“The project management responsibilities remained in the ABC bank’s team. The external helpers were placed at the middle tier or below, as they provided input to the course of project management when needed. The project managers initially had high hopes for the project manager from XYZ to make a strong contribution to project management. Unfortunately, he was unable to deliver and was not as competent as expected. In response to ABC’s request, XYZ sent another expert in project management to the team”. “However, to Mr. Niu’s surprise, the XYZ developers seemed without a common process and style. Their two leaders were not able to create a homonymous and collaborative group culture, and the group had shown signs of disintegration, which planted the seed for later labor problems”. “The number of developers in the team’s four groups exceeded 70 in the coding stage. This further complicated the development environment. Mr. Niu restructured the team and promoted an elder and well-respected developer, who was from one of the smaller software firms, to be his deputy. After this round of restructure, each group’s responsibilities as well as the group leaders’, became clearly defined”. “To ABC’s internal subject experts, who were outside of the SDC, Mr. Niu had no effective mechanism of influence, as their income and promotion were beyond his influence”. “To develop a team culture, project managers stressed the need to forget about they-vs-us mentalities, and to create an environment of mutual learning and collaboration. Any discrimination, verbal or in writing, was strictly banned”.
Representation	High	“The Guangdong Branch added four more developers, but even with these 20 developers the task was still too

		heavy to bear". "In early January 2005, over a dozen developers along with a project manager from XYZ joined the project team". "In response to ABC's request, XYZ sent another expert in project management to the team". "When the need for more developers arose, the senior management at the bank picked two other smaller software companies for the development team as outsourcers, and the number of developers in the team's four groups exceeded 70 in the coding stage".
Opportunity to influence outcomes and/or process design	High	"Domain experts on the team conducted their review and evaluation, and then regrouped the functions into 10 subsystems". "In February 2005, the development of the user interfaces was completed by the four development groups. Each group had completed one subsystem's coding for an incomplete prototype".
Selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	High	"Domain experts on the team conducted their review and evaluation, and then regrouped the functions into 10 subsystems". "In February 2005, the development of the user interfaces was completed by the four development groups. Each group had completed one subsystem's coding for an incomplete prototype".
Independence and neutrality of the process	Uncertain	
Conflict resolution	High	"To further complicate the situation, the two leaders from XYZ got into a power struggle, competing against each other. Mr. Niu decided to assign the latecomer to the project supervision group, leaving the first leader in the platform group". "Since the XYZ developers did not get

		along with each other well, they were split into different development groups, which was also thought helpful for them to build a collaborative relationship with the domain experts". "When XYZ developers initially worked in their own group, there was a tendency of communication breakdown with the domain experts. After the restructuring, the personnel from the two sides had better communications and improved their attitudes".
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
			X		"The Guangdong Branch added four more developers, but even with these 20 developers the task was still too heavy to bear. The team decided to outsource, and the first choice came to their mind was XYZ Software Company. Starting from this point, the project switched to a joint development mode. In February 2005, the development of the user interfaces was completed by the four development groups. Each group had completed one subsystem's coding for an incomplete prototype". "Domain experts on the team conducted their review and evaluation, and then regrouped the functions into 10 subsystems".

OUTPUT

Output	Evidence
A management accounting information system	"The Finance Department of ABC Bank started a fullscale business requirements analysis for the entire bank, with the objective of eventually installing comprehensive management accounting information systems". "Six weeks later, the system went online in the Guangdong branch and worked smoothly".

OUTCOME

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"The adherence to the user-centered design principles proved to be extremely useful. They have played an important role in insuring the project a success". "The project team had done some right things and made mistakes in the process of completing the difficult task with reasonable success".
Recognised impacts	High	"They contributed to the entire process of system development, from requirements definition, construction of the system model and architecture, functional point analysis, prototype of user interfaces, preparation of use cases and test cases, to acceptance tests".
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The Finance Department of ABC Bank started a fullscale business requirements analysis for the entire bank, with the objective of eventually installing comprehensive management accounting information systems". "The project team had done some right things and made mistakes in the process of completing the difficult task with reasonable success". "The case is also a good example of user-driven project management, and exhibited the associated benefits. It was not clear in this case whether it was by design or coincidence. However, the end-users' earlier access to the system from the design stage was instrumental for the business

		process redesign, which would benefit future adoption in terms of feasibility and high impact and return". "They contributed to the entire process of system development, from requirements definition, construction of the system model and architecture, functional point analysis, prototype of user interfaces, preparation of use cases and test cases, to acceptance tests. Exactly one year later after the project kickoff, the project team was ready for user acceptance tests. Subsequent kickoff, preparation, and training, data conversion, demos, and installation of the production environment went smoothly. Six weeks later, the system went online in the Guangdong branch and worked smoothly".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

Case study 16

PROCESS

"The first element of developing the community-based child health IS commenced with the participatory situational assessment in November 1999 and with a monitoring and evaluation workshop early the following year. The process of specifically developing and designing the community-based child health IS commenced in 2002 and the implementation of the revised IS in the first half of 2003. An evaluation of the district health IS, of which the community-based child health IS was a component, took place in November 2003".

"This action research process can be summarized with four categories: establishment of research processes and boundaries, such as the exit strategy; problem diagnosis; action intervention; and reflective learning (Lau, 1997)".

"A workshop was held in Bergville in February 2000 to explore the existing district health IS in relation to the monitoring and evaluation of the vision for child health. The next stage was to discover the underlying meanings of community members in terms of the vision surrounding the attainment of "holistic health and well-being" for their children. In this respect, a total of 10 interviews, 15 FGDs, and one meeting took place between July and September 2002 in order to understand the community's information needs, who should participate in the design and use of the IS, and the format in which the information should be communicated” **(SCOPE)**.

Scope phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	High	“Local people acted as facilitators during the discussions and interviews, for example community health workers, community field facilitators, and orphan group “mothers” who had an understanding of the local norms and values”. “In the initial stages, because of differences in status and roles within the community, groups comprising, for example, mothers, children, councilors and facilitation staff met separately to discuss what they wanted for children. These meetings were conducted in the local language and held near the homes or workplaces of the individuals. At a later stage, representatives from the various groups met jointly to share the findings arising from the research and to discuss the way forward”.
Representation	High	“It is not only the users of the IS who should participate, but also those individuals who are affected by the IS, even when those individuals have no direct interaction with the system itself”. “The following groups of people were identified through this exercise and therefore participated in the research: children, community health workers, clinic health committees, traditional leaders and healers, councilors, social workers, early childhood practitioners, mothers (including teenagers), fathers, grandmothers, and TDCSP staff”. WORKSHOP 2000: “participants included mothers, fathers, Community Health Committee members, local and district government representatives, university staff, international and national NGOs, and TDCSP staff”. INTERVIEWS and FGDs: “the duty bearers and role players who were identified in the situational assessment were included in the various groups of research participants. Because of the small

		number of children involved in previous discussions, an additional FGD with children was conducted in May 2003".
Opportunity to influence outcomes and/or process design	High	"Initial meetings helped to determine a local term for indicators, which was izinkomba. In terms of measuring at-risk and well-being, the discussions explored broad areas of measurement rather than developing precise formulations of indicators. From the FGDs and interviews, various izinkomba for well-being and at-risk were suggested and subsequently grouped into common areas or themes".
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	High	"One of the interesting aspects of this workshop was a discussion on the vision that had been previously determined. Agreement on the objectives for the attainment of this vision were necessary if we were to design an IS that could assist with the monitoring of the vision". "Workshop participants were asked to arrange themselves into groups and to discuss the following question: If we are achieving these objectives, what can we SEE, HEAR, and how can we MEASURE what is happening?" "Another helpful aspect was the analysis of the factors and practices that contribute to these situations, how the situations can be identified and measured, what action can be taken, and by whom it should be taken".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	High	"Different community members expressed views that helped facilitate a greater understanding of the meanings of the terms well-being and at risk for a child".
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"It became apparent that the original objectives did not represent the views of this particular group of workshop participants. Once agreement had been reached on the objectives…"

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"A workshop was held in Bergville in February 2000 to explore the existing district health IS in relation to the monitoring and evaluation of the vision for child health. The next stage was to discover the underlying meanings of community members in terms of the vision surrounding the attainment of "holistic health and well-being" for their children. In this respect, a total of 10 interviews, 15 FGDs, and one meeting took place between July and September 2002 in order to understand the community's information needs, who should participate in the design and use of the IS, and the format in which the information should be communicated".

OUTPUTS

Output	Evidence
A community-based health information system for children	"The system implemented has built upon the traditions and culture in practice and therefore is primarily a paper-based and orally communicated IS. Using an observation form, the community health worker assesses and registers the risk or well-being of the child at the monthly household visits and discusses the situation with the caregiver present. Advice is given immediately, possible solutions identified, referrals made, and, if necessary, assistance provided in household decisions".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Low	"Therefore, the linkages among community, health facility, and the different spheres of government still need to be enhanced in this case study".
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The system implemented has built upon the traditions and culture in practice and therefore is primarily a paper-based and orally communicated IS. Using an observation form, the community health worker assesses and registers the risk or well-being of the child at the monthly household visits and discusses the situation with the caregiver present. Advice is given immediately, possible solutions identified, referrals made, and, if necessary, assistance provided in household decisions".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	"Given that the community-based IS had only recently been implemented, it was really too early to judge its impact on broader health system outputs, such as child health".
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 17

PROCESS

“Challenges involved in incorporating GIS applications into the decision-making process within the non-profit (public) health sector include a lack of financial resources for software acquisition and training for nonspecialists to use such tools. This on-going project has two primary phases. This paper critically reflects on Phase 1: the participatory design (PD) process of developing a collaborative web-based GIS tool. This paper describes an ongoing project to evaluate the extent that web-based mapping software and maps – as tools for research transfer – can be used to support evidence-based decision-making for program planning and policies in OEYCs, and perhaps within the health services sector more generally. The focus of this paper is on Phase 1 of the project, the collaborative and participatory design process used to develop a web-based GIS tool, called EYEMAP, to meet the established requirements of OEYC”.

“Phase 1 involves the iterative and collaborative design and implementation of the web-based mapping software (EYEMAP) based on a participatory design (PD) process through a modified user and task analysis [46] and cooperative prototyping”.

“A case study design is being used whereby the case (i.e., the unit of analysis) is defined as the data analyst and manager dyad in selected OEYCs (n=9)”.

“The user and task analyses conducted in this phase helped us to refine a collaborative mapping prototype and associated support system to meet the specific needs of data analysts and managers” **(SCOPE)**.

“The second and third meetings involved a similar process. The second half-day meeting with participants was to conduct some proof of concept demonstrations of opensource software and what was being developed for participants. This second meeting was important as it allowed us to refine the participants' 'wish-list' into something that could be functionally implemented” **(PROTOTYPE)**.

“The third meeting presented a preliminary EYEMAP prototype to obtain additional feedback from participants” **(USABILITY)**.

Scope phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	
Representation	High	“A case study design is being used whereby the case (i.e., the unit of analysis) is defined as the data analyst and manager dyad in selected OEYCs. Multiple cases are used to support the reliability of findings. Presently, nine producer/ user pairs are participating in this project”.
Opportunity to influence outcomes and/or process design	High	“With the data analysts, the project team was interested in the technical aspects of their data and mapping perceptions and needs, and what

		functionality they would like to see in mapping software". "For the managers, the user and task analysis focused on evaluating skills in map reading and spatial data analysis, determining the type of maps they would want to receive for decision-making purposes, as well as the assessing the perceived usefulness of maps to represent local data".
Quality and selection of information and resources in general	Moderate	"The developers required more explicit information regarding the functionality users needed, however to get this, users required a better understanding of the types of questions a GIS can help answer (i.e. spatial vs. aspatial). This issue became apparent during the PD process and user testing, and often led to changes of the prototype on an ad-hoc basis".
Challenging status quo and fostering creative thinking	High	"At this first meeting, based on a group discussion with participants, the project team collected participants' 'wish list' of what the ideal GIS tool would be for them. Participants also expressed what they felt were the limitations of the mapping software that they used (for those who had access to such software), as well as what basics they needed a mapping tool to do in order to assist them with their day-to-day tasks".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"Participatory design involves gathering information on each user and/or task, including experience level, capability, data access, data requirements and steps involved related

					to the task". "The user and task analyses conducted in this phase helped us to refine a collaborative mapping prototype and associated support system to meet the specific needs of data analysts and managers"

Prototype phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	
Representation	High	"A case study design is being used whereby the case (i.e., the unit of analysis) is defined as the data analyst and manager dyad in selected OEYCs. Multiple cases are used to support the reliability of findings. Presently, nine producer/ user pairs are participating in this project".
Opportunity to influence outcomes/and/or process design	High	"Ensuring a secure platform was considered an essential constraint to the OEYCs' use of the web mapping tool and was the primary focus of email discussions with participants before the third meeting".
Quality and selection of information and resources in general	Moderate	"The developers required more explicit information regarding the functionality users needed, however to get this, users required a better understanding of the types of questions a GIS can help answer (i.e. spatial vs. aspatial). This issue became apparent during the PD process and user testing, and often led to changes of the prototype on an ad-hoc basis".
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the	Uncertain	

process		
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			“The second and third meetings involved a similar process. The second half-day meeting with participants was to conduct some proof of concept demonstrations of opensource software and what was being developed for participants. This second meeting was important as it allowed us to refine the participants' 'wish-list' into something that could be functionally implemented”

Usability phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	
Representation	High	“A case study design is being used whereby the case (i.e., the unit of analysis) is defined as the data analyst and manager dyad in selected OEYCs. Multiple cases are used to support the reliability of findings. Presently, nine producer/ user pairs are participating in this project”.
Opportunity to influence outcomes and/or process design	High	“Obtaining more specific participant feedback at this stage was important to ensure that any design constraints and assumptions were made clear to the data analysts”.
Quality and selection of information and resources in general	Moderate	“The developers required more explicit information regarding the functionality users needed, however to get this, users required a better understanding of the types of questions a GIS can help answer (i.e. spatial vs. aspatial). This issue

		became apparent during the PD process and user testing, and often led to changes of the prototype on an ad-hoc basis".
Challenging status quo and fostering creative thinking	High	"Data analysts held discussions with the two primary developers from the research team to assess more technical elements such as those described above. For the managers, from whom the project team still required buy-in for their full participation in the project, it was important to collect some baseline data".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"The third meeting presented a preliminary EYEMAP prototype to obtain additional feedback from participants"

OUTPUTS

Output	Evidence
A web-based mapping tool (EYEMAP)	"Using PD, this project developed a web-based mapping tool (EYEMAP) that was easy to use, protected proprietary data, and permit limited and controlled sharing between participants".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	High	"Despite these concerns, relationship building during this first meeting engendered initial buy-in".

Acceptance of process and/or outcomes	High	"Both the PD process and two key features of EYEMAP – data/map sharing functionalities and the interoperability of the tool – are considered as key successes in this project".
Recognised impacts	High	"The framework for the mapping tool, user interface, and functionality was designed following the above requirements".
Social learning	Uncertain	

Factual outcomes

Criteria	**Evaluation**	**Evidence**
Objectives met	High	"The majority of EYEMAP's functionality has been operationalised and participants have received two one-day training sessions on its use". "Both the PD process and two key features of EYEMAP – data/map sharing functionalities and the interoperability of the tool – are considered as key successes in this project".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

Case study 18

PROCESS

"The formalized method includes planning techniques for releases and iterations called planning games, user stories and story cards to specify user requirements (in XP formally the customer writes the stories onto simple index cards), onsite customers to support customer-developer communication, short daily stand-up meetings of the whole project team to support team communication, pair programming, re-factoring, collective ownership, continuous integration and testing of code to develop the software proper and tuning workshops to improve the development processes regularly".

"In a first 12 months exploration phase prototypes catching requirements and possible solutions were developed **(SCOPE)**. This led to the development of the realization concept by the customer organization and their decision to contract AgDev also for the development of the OMS proper".

“In the OMS project a first software release was provided after three months with the others to be delivered every three to six months. Each release was organized in iterations of three to six weeks duration, meaning that at the time of our investigation each subproject had at least gone through two iterations” **(PROTOTYPE)**.

“The AgDev project manager explained that in the project between two iterations there was always a test phase which was a ‘post’ activity of the preceding iteration. He confirmed that the acceptance tests were run by the onsite customers, meaning that the onsite customers had the responsibility, and decision power, for, and in, these tests” **(TESTING)**.

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	Low	“A sophisticated management structure with one subproject manager acting as contact person from AgDev and one subproject manager acting as onsite customer from WaterWorks for each of the four subprojects was, in addition to two overall project managers, one from each company, established”. “*Yesterday he said something and today he says something else. Requirements have to be clear at the beginning of an iteration, and cannot change right in the middle of it*”. “To this end, customer and user participation took place on an ongoing basis during what the AgDev project leader himself”. “Some AgDev subproject managers even felt that through the WaterWorks engagement the project participants from the WaterWorks somehow developed the OMS themselves”.
Representation	High	“A team of about 12 development staff with multiple roles such as project manager, subproject manager, analyst, customer contact, and developer worked onsite”. “The project also comprised a varying number of other users, representing operational staff, from the different divisions”.
Opportunity to influence outcomes and/or process design	High	“The planning games and story cards, the (presentation of) working software as well as the acceptance tests structured in parts the continuous day-to-day-contacts, communication and collaboration”.
Quality and selection of information and resources in general	High	“At the start of phase two a number of different documents existed which were all comparable short and concise. From a customer perspective

		these were related as follows: An overall realization concept built the basis for the development contract with the customer. The realization concept was refined into requirements lists. These lists governed what should be the outcome of an iteration, and what should be the basis for the acceptance tests. Individual requirements or groups of requirements were then described as a story and each story was written down on a story card". "In this context the WaterWorks subproject managers saw their role as facilitators and communicators. To back up the development of the OMS based on an agreement with the staff council and with management, some of them had been assigned fulltime to the project to be available and involved in the project whenever necessary".
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	High	"The story cards represented the final detailed plans and specifications for the developers' work tasks and processes".
Transparency	High	"The WaterWorks subproject managers did not develop the requirements at their own discretion, but held a strong contact with the employees in their divisions and carried the requirements from their divisions into the project. They also prepared the prioritization of the requirements according to their importance and the available budget".
Independence and neutrality of the process	High	"An AgDev subproject manager talked about the difficulties of converting the requirements into design and declared that making design proposals was the task of the AgDev subproject managers and developers: *it nearly becomes our design task as contact partners it's not easy to find out from the WaterWorks people what they want; when I say do you want it this way, they say yes, and when I ask do you rather want it that way, they also say yes. And they say we have this and this problem, but to design an interface out of this information is our problem*".
Conflict resolution	Uncertain	

Develop a shared vision and goals	Low	“Yesterday he said something and today he says something else. Requirements have to be clear at the beginning of an iteration, and cannot change right in the middle of it”.

Inform	Consult	Involve	Partner	Empower	Evidence
			X		“However, the design was always developed with close participation of the WaterWorks subproject managers and other users and always under the mandate of the WaterWorks subproject managers. While the AgDev subproject managers had the liberty to make proposals the onsite customers could always say *no*, and with really important issues, AgDev would always get back to the onsite customers before they would go forward”.

Prototype phase

Criteria	Evaluation	Evidence
Structured group interaction	Moderate	“Feedback about and change requests for the software design were brought forward by the onsite customers in weekly feedback loops which were built into an iteration based on presentations and demonstrations of working software”. “The AgDev project manager described how the working software, which was produced story card by story card attracted the WaterWorks subproject managers and how they seamlessly participated in the development process. He confirmed that beyond the scheduled weekly meetings for all subproject managers some of the WaterWorks subproject managers turned up at the project nearly on a daily basis while others came at least on a regular basis and looked over the shoulders of the

		developers”. “As a consequence the onsite customers and the other operational staff end users developed trust and a feeling that they had an impact on the development of the information system and even the employees in the divisions who did not directly participate in the development team got quickly integrated into the project”.
Representation	High	“Thus the set up with at least 4 subproject managers who also acted as onsite customers was supplemented with other user representatives”. “As a consequence the onsite customers and the other operational staff end users developed trust and a feeling that they had an impact on the development of the information system and even the employees in the divisions who did not directly participate in the development team got quickly integrated into the project”.
Opportunity to influence outcomes and/or process design	High	“Feedback about and change requests for the software design were brought forward by the onsite customers in weekly feedback loops which were built into an iteration based on presentations and demonstrations of working software”.
Quality and selection of information and resources in general	High	“Feedback about and change requests for the software design were brought forward by the onsite customers in weekly feedback loops which were built into an iteration based on presentations and demonstrations of working software”. “Beyond these contacts with the onsite customers the working software was also presented, as presentations to one onsite customer were not considered sufficient, to larger groups of prospective operational staff end users”.
Challenging status quo and fostering creative thinking	High	“In addition, using a similar format, the onsite customer representatives regularly performed “road shows” with the working software in the user departments to collect feedback and ideas and proposals for improvements”.
Clear mandates and goals	Uncertain	
Transparency	High	“The AgDev subproject managers also sought direct contact with the operational staff end users and one of

		them reported that he had seated himself for two weeks in the duct operation station with the objective to extensively put the software on trial onsite and to look how well it actually fitted the operation. This resulted in the direct participation of those employees onsite who arranged or actually performed the cleaning the ducts. Another AgDev subproject manager had chosen the same strategy and even engaged some of his developers in the process. After installing a release at one division, they went there several times for some days, discussed with the users, registered bugs, and then re-built the software accordingly". "The frequent feedback loops were taken very serious and immediately responded to with action".
Independence and neutrality of the process	High	"Beyond these contacts with the onsite customers the working software was also presented, as presentations to one onsite customer were not considered sufficient, to larger groups of prospective operational staff end users". "The AgDev project manager summarized the situation: *Well, at latest when an iteration is finished, sometimes already in the middle of it, or whenever, presentations are run for users. Well, not always in front of many users, but the customer subproject manager gets some people together and says: Here, look, do we develop in the right direction?*".
Conflict resolution	High	"After a clarification of the roles in an agile development project the cooperation between the different groups of project participants then continued without further problems".
Develop a shared vision and goals	Moderate	"But the working software also brought to light some initial problems related to the distribution of roles in the project. The WaterWorks subproject managers expected that AgDev's developers would bring more of their own ideas into the project and that they would come up with smart technical solutions. They were frustrated about that the AgDev developers always just did what the onsite customers told them to do, because they saw this as a sign that the developers were not competent enough to develop their own

		proposals. After a clarification of the roles in an agile development project the cooperation between the different groups of project participants then continued without further problems”.

Inform	Consult	Involve	Partner	Empower	Evidence
			X		“Feedback about and change requests for the software design were brought forward by the onsite customers in weekly feedback loops which were built into an iteration based on presentations and demonstrations of working software. This always led to smaller changes”. “The AgDev subproject managers also sought direct contact with the operational staff end users and one of them reported that he had seated himself for two weeks in the duct operation station with the objective to extensively put the software on trial onsite and to look how well it actually fitted the operation. This resulted in the direct participation of those employees onsite who arranged or actually performed the cleaning the ducts. Another AgDev subproject manager had chosen the same strategy and even engaged some of his developers in the process. After installing a release at one division, they went there several times for some days, discussed with the users, registered bugs, and then re-built the software accordingly”. “The frequent

					feedback loops were taken very serious and immediately responded to with action”.

Testing phase

Criteria	Evaluation	Evidence
Structured group interaction	High	“The tests were similar to the formal presentations of the working software, but they were performed according to a protocol and they always comprised end users”. “An acceptance test, was then always led by a responsible WaterWorks subproject leader”.
Representation	High	“The tests were similar to the formal presentations of the working software, but they were performed according to a protocol and they always comprised end users”. “Thus, customer and user participation also took place during and in form of the acceptance tests”. “As valid feedback was considered important operational staff end users, not just the WaterWorks onsite customers as represented by the subproject leaders, were performing the tests”. “A typical acceptance test lasted just one day where four to six people participated. Two or three divisional managers and other employees who owned the task and had to work with it, but who were not members of the project team were present and tested”.
Opportunity to influence outcomes and/or process design	High	“The requests for changing the software design which came up during the scheduled acceptance test sessions were dealt with in the next iteration”.
Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	Uncertain	
Clear mandates and goals	Uncertain	
Transparency	High	“An acceptance test, was then always

		led by a responsible WaterWorks subproject leader, who also approved, or rejected, the new version of the system”. “There the responsible WaterWorks subproject manager’s approval, conditional approval or rejection as a test leader was documented together with what was missing, and where, to achieve a full approval”.
Independence and neutrality of the process	High	“There the responsible WaterWorks subproject manager’s approval, conditional approval or rejection as a test leader was documented together with what was missing, and where, to achieve a full approval”.
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			“An acceptance test, was then always led by a responsible WaterWorks subproject leader, who also approved, or rejected, the new version of the system”.

OUTPUTS

Output	Evidence
An information system	“A case of customer and user participation in an agile software development project, which produced a tailor-made information system for workplace support”. “The emerging information system afforded, in the words of one of WaterWorks subproject managers, to identify synergies among the various departments and in particular in the duct department it enabled improved planning that resulted in the possibility to dispose cleaning vehicles and reduce related staff”.

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	High	"The interaction between the different stakeholder groups went well: The onsite customers sought contact with the operational staff users, the development organization's subproject managers and the rest of development team who in turn sought contact with the onsite customers and the other users on informal occasions, in feedback meetings, in road shows, during test sessions, and during system operation in the divisions".
Acceptance of process and/or outcomes	High	"The OMS project was described by both the customer and the development organization as a success". "With regard to the focus of this paper one of the WaterWorks subproject managers explicated that their end users had been very satisfied". "Various comments were made about reaching the right balance of customer collaboration and user participation with regard to the degree of agility, project progress and product quality". "The employees involved in the tests stated that they could imagine to work with the system, and that they liked it better than the earlier proposed ERP-based solution".
Recognised impacts	High	"As a consequence the onsite customers and the other operational staff end users developed trust and a feeling that they had an impact on the development of the information system". "The acceptance tests had a significant influence on the further design of the system components as request for changes and new requirements always came up as a result of a test and were dealt with in the next iteration".
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The emerging information system afforded, in the words of one of WaterWorks subproject managers, to identify synergies among the various departments and in particular in the duct department it enabled improved planning that resulted in the possibility to dispose cleaning vehicles and reduce related staff". "The identified form of user participation supported the achievement of a balance between flexibility and project progress and resulted in a in project which was considered successful in terms of scope, quality, resources and time by both the customer and the development organization and a product which enabled the users to carry out their work to their own satisfaction and in an effective, efficient and economical manner".
Uptake of the tool/s	High	"The identified form of user participation supported the achievement of a balance between flexibility and project progress and resulted in a in project which was considered successful in terms of scope, quality, resources and time by both the customer and the development organization and a product which enabled the users to carry out their work to their own satisfaction and in an effective, efficient and economical manner".
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	High	"The emerging information system afforded, in the words of one of WaterWorks subproject managers, to identify synergies among the various departments and in particular in the duct department it enabled improved planning that resulted in the possibility to dispose cleaning vehicles and reduce related staff". "A product which enabled the users to carry out their work to their own satisfaction and in an effective, efficient and economical manner".

CASE STUDY 19

PROCESS

Traditional community-based OSS development project

“It has shown clear interest in improving the usability of the solution and in involving users to do so; it is listed on a website requesting usability support from HCI specialists for OSS projects. In addition, a usability discussion forum has been established on the project website, asking users of the OSS to take part in further improving the program by offering suggestions on how to improve usability and outlining annoying issues in the current user interface (UI)” **(USABILITY)**.

“The discussion forum is the place where non-developer media application users are invited to take part in the project; therefore, this article examines the communication – altogether around 1600 posts, 400 topics and 600 message sender nicknames – taking place there”.

Usability phase

Criteria	Evaluation	Evidence
Structured group interaction	Uncertain	“A usability discussion forum has been established on the project website, asking users of the OSS to take part in further improving the program by offering suggestions on how to improve usability and outlining annoying issues in the current user interface (UI)”. “The developers invited the users to contribute”.
Representation	High	“This article examines the communication – altogether around 1600 posts, 400 topics and 600 message sender nicknames – taking place there”.
Opportunity to influence outcomes and/or process design	High	“A usability discussion forum has been established on the project website, asking users of the OSS to take part in further improving the program by offering suggestions on how to improve usability and outlining annoying issues in the current user interface (UI)”. “Different kinds of features are requested, from issues of appearance (how it ought to look) to behaviour (how it ought to behave) and integration (with what it ought to operate)”.
Quality and selection of information and resources in general	Uncertain	“Probably rather technically competent users, they are capable of contributing by utilising the means already available”.

Challenging status quo and fostering creative thinking	Low	"A usability discussion forum has been established on the project website, asking users of the OSS to take part in further improving the program by offering suggestions on how to improve usability and outlining annoying issues in the current user interface (UI)". "Different kinds of features are requested, from issues of appearance (how it ought to look) to behaviour (how it ought to behave) and integration (with what it ought to operate)".
Clear mandates and goals	High	"The existence of a discussion forum dedicated to usability issues, initiated by asking users to participate, indicates that developers have invited users into a consultative role on the project: to provide improvement ideas and feedback".
Transparency	Low	"Probably rather technically competent users, they are capable of contributing by utilising the means already available; furthermore, not even these users are allowed to make decisions regarding the solution. The possible project leader and 'core team' of developers make all decisions related to what to include in the code base in OSS projects". "The developers invited the users to contribute, but **they alone** decided what to include in the solution. The developers may reply to the users' design solutions or remarks that they 'simply don't like them' – because they are 'too cluttered' or they just 'suck'. On the other hand, they may implement certain ideas quickly, even in the same day, replying to the user simply that it was a good idea".
Independence and neutrality of the process	Uncertain	"The messages also offer some data on the users and their work practices: in some, the senders describe at length their needs, preferences, characteristics, usage habits and contexts, and steps they had taken in trying to use the OSS". "The developers invited the users to contribute, but **they alone** decided what to include in the solution. The developers may reply to the users' design solutions or remarks that they 'simply don't like them' – because they are 'too cluttered' or they just 'suck'. On the other hand, they may implement certain ideas quickly, even

		in the same day, replying to the user simply that it was a good idea”.
Conflict resolution	Uncertain	
Develop a shared vision and goals	Low	“The developers invited the users to contribute, but they alone decided what to include in the solution. The developers may reply to the users’ design solutions or remarks that they ‘simply don’t like them’ – because they are ‘too cluttered’ or they just ‘suck’. On the other hand, they may implement certain ideas quickly, even in the same day, replying to the user simply that it was a good idea”.

Inform	Consult	Involve	Partner	Empower	Evidence
	X				“Probably rather technically competent users, they are capable of contributing by utilising the means already available; furthermore, not even these users are allowed to make decisions regarding the solution. The possible project leader and ‘core team’ of developers make all decisions related to what to include in the code base in OSS projects”. “The developers invited the users to contribute, but they alone decided what to include in the solution. The developers may reply to the users’ design solutions or remarks that they ‘simply don’t like them’ – because they are ‘too cluttered’ or they just ‘suck’. On the other hand, they may implement certain ideas quickly, even in the same day, replying to the user simply that it was a good idea”. “The users rarely offered insights into their characteristics or current practices, nor

					did they have any decision-making power regarding the solution".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	Uncertain	
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Moderate	"Forums were especially useful in gathering user feedback; this type of user data gathering could be experimented with in other distributed contexts. This would necessitate setting up a forum and an active community around it, which is not an easy task".
Impact on users' practice	Uncertain	

CASE STUDY 20

Company cooperating with traditional OSS development project

"This analysis focuses on those projects that have developed applications for end-users who do not necessarily have programming skills or interest".

"We *sat there together for an hour and brainstormed and then they [the HCI specialists] left and came back within a couple of days and asked that would it be like this?*

(Manager). The developers and the HCI make collaborative decisions about the design solutions: *When we were able to produce something finished by our opinion, we went to present it to the developers and asked that is this possible?'* (HCI specialist)".

"*First we produce rough UI (…) and afterwards (…) we carry out expert evaluation. In them, we use one or more usability specialists and modify the UI according to them, and then move it to a more detailed level. After that, we make a simulation of the UI and carry out a traditional usability test in a laboratory with a sufficient amount of users, from 6 to 10 per iteration*".

"PD includes understanding, designing and evaluating activities, aiming to improve the functionality and usability of the solution" **(USABILITY)**.

Usability phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	High	"The users involved in development have been invited to the working location or have been members of OSS communities, and are thus distributed physically, organisationally and temporally". "The project is carried out face-to-face in one location in this case. The project personnel communicate with OSS communities through email and discussion forums". "*We sat there together for an hour and brainstormed and then they [the HCI specialists] left and came back within a couple of days and asked that would it be like this?*"
Representation	High	"The personnel of the projects analysed in this article consist of developers, testers, HCI specialists and managers, all hired by the company". *"We make a simulation of the UI and carry out a traditional usability test in a laboratory with a sufficient amount of users, from 6 to 10 per iteration*".
Opportunity to influence outcomes and/or process design	High	"The external OSS communities are utilised as providers of OSS components and as providers of feedback and design ideas for application in the later phase of the development". "*We sat there together for an hour and brainstormed and then they [the HCI specialists] left and came back within a couple of days and asked that would it be like this?*"
Quality and selection of information and resources in general	Uncertain	

Challenging status quo and fostering creative thinking	Low	"The external OSS communities are utilised as providers of OSS components and as providers of feedback and design ideas for application in the later phase of the development". "*We sat there together for an hour and brainstormed and then they [the HCI specialists] left and came back within a couple of days and asked that would it be like this?*"
Clear mandates and goals	Uncertain	
Transparency	Uncertain	"The communities are not necessarily enthusiastic about the developers' contributions. *[An OSS project] is not very open*. *There is a maintainer, it is his personal project and he decides what he wants. If you want a feature and start doing it, he does not necessarily let you*".
Independence and neutrality of the process	Uncertain	"*We sat there together for an hour and brainstormed and then they [the HCI specialists] left and came back within a couple of days and asked that would it be like this?*" *"It was with the implementation team like we just went there and asked. We did not produce a list to be discussed in a meeting. It was like active communication all the time"* "The communities are not necessarily enthusiastic about the developers' contributions. *[An OSS project] is not very open*. *There is a maintainer, it is his personal project and he decides what he wants. If you want a feature and start doing it, he does not necessarily let you*".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
	X				"The OSS projects' discussion forums are thus utilised in a similar way as in the community OSS project described earlier. However, it is also acknowledged that some kind of classifying and ranking of messages is needed: *These open*

					source software, they create a lot of communities, so it's a really, really rich place to gather user feedback". *"Users can make plug-ins. The infrastructure has been built* (Developer). On the other hand, the developers contribute back to the OSS communities: *In practice, we evaluated it and checked it and spotted pure bugs and of course we fixed them*". "The communities are not necessarily enthusiastic about the developers' contributions. *[An OSS project] is not very open*. *There is a maintainer, it is his personal project and he decides what he wants. If you want a feature and start doing it, he does not necessarily let you*". "The HCI specialists also took active part in decision-making in the design of new practices and technological solutions".

OUTCOMES

Personal outcomes

Criteria	**Evaluation**	**Evidence**
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	

Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"*We were able during much earlier phase to handle the finished software*".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Moderate	"Forums were especially useful in gathering user feedback; this type of user data gathering could be experimented with in other distributed contexts. This would necessitate setting up a forum and an active community around it, which is not an easy task".
Impact on users' practice	Uncertain	

Case study 21

PROCESS

Washington case study

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"At the event (Fig. 2), 300 participants were divided into groups of ten that represented both the geographic and interest group diversity in the region. At each table, participants gathered around a large tabletop map of the region, color-coded to represent the existing population and employment density, major highways, subway and commuter rail lines and stations, parklands and other protected conservation areas". "A trained scribe/computer operator and a trained facilitator staffed each table".
Representation	High	"The invited participants included,

		civic leaders, business leaders, environmentalists and elected officials, and their numbers and locations were balanced – weighted by population of the sub-regions of their main activity. A group of organizers was responsible for getting a set of diverse participants”.
Opportunity to influence outcomes and/or process design	High	“Each table was given a box with a number of colored blocks that represented the total growth projected to come to the region. The task on each table was to allocate all the blocks to the map while trying to build consensus with the rest of the group”.
Quality and selection of information and resources in general	High	“They were given tools to develop spatially explicit growth scenarios. Later on the same day, impacts of growth such as proximity of new development to transit, net future densities, etc., were computed and presented back to the group”. “At each table, participants gathered around a large tabletop map of the region, color-coded to represent the existing population and employment density, major highways, subway and commuter rail lines and stations, parklands and other protected conservation areas”.
Challenging status quo and fostering creative thinking	High	“The participants’ task was to envision allocating 2 million new residents and 1.6 million new jobs in the Metropolitan Washington region (forecasts for 2030 by the Metropolitan Planning Organization) in three hours”. “During the event, discussion among participants reflected multiple aspects of the sustainability debate ranging from equity in investment of public funds to negative impacts of land use controls on economic development, particularly in rural counties”.
Clear mandates and goals	Moderate	“The participants were presented with a brief overview of the planning issues of the region and the structure of the exercise”.
Transparency	Uncertain	“At the conclusion of the exercise, the scribes and facilitators entered the number of blocks into the spreadsheet model, which then automatically updated the GIS database. In the end, 30 unique scenarios, one from each table, were fed into the GIS database for overall analysis. Since the outputs varied by tables and region, the results were aggregated in multiple

		ways. This included taking an average of all the tables by adding the final population and employment numbers in each grid cell and dividing the sum by the total number of tables and taking a standard deviation of each grid across the tables. The presentation to participants included a comparison of their stated principles with quantitative assessments of the impacts of their development visions".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	"A report in the Baltimore Sun noted the agreements on principles but disagreements on location and density of new developments, while acknowledging the *lively debate, with some members pushing for more open space and others saying property rights must not be forgotten*".
Develop a shared vision and goals	High	"Before considering where to accommodate growth, participants were asked to reach consensus on a set of principles to guide their decisions". "Each table was given a box with a number of colored blocks that represented the total growth projected to come to the region. The task on each table was to allocate all the blocks to the map while trying to build consensus with the rest of the group". "The Washington Post reported: *despite the diverse interests at the 30 map tables, the solutions reached by afternoon shared a remarkable number of Themes*".

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
		X			"Scale of the map around a table that fits an area greater than 5000 square miles, number of colored blocks that could be practically placed in less than three hours and a range of related questions raised by the attendees, helped us adjust many parameters of the process. As another example, many

					stakeholders questioned the validity of projected growth numbers (developed by the regional planning organization) that they were asked to use. This is a valid question given the projected growth was based on an extension of past trends, and assumptions on future policies. The organizers of the Washington exercise, however, made the growth projections nonnegotiable".

OUTPUTS

Output	Evidence
Various planning scenarios	"Still the outcomes were successful in demonstrating measurable differences among scenarios created by different groups and, scenarios developed external to the participatory process".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	*"As a professional of business, I knew it [projected growth] was big but until I saw it physically, on a map, I did not realize how big it really is!"* *"It's going to have an impact as it is a really ingenious way of using maps and physical demonstration that exemplify these issues of land use and density".*
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	Uncertain	"The visions generated during the exercise were not intended for a finer-level analysis. There was no clear plan of further engaging the participants of the exercise and few planning agencies involved in the process showed any interest in connecting the momentary success of the exercise to any policy related initiative. This could be blamed, in part, to the lack of effective policy focus in visioning exercises, something intrinsic to the scale of such processes. In other words, deriving specific policy outcomes was not an explicit objective of the exercise".
Uptake of the tool/s	Uncertain	
Legacy	High	"Many concurrent processes have since emerged whose existence could be partly credited to Reality Check Maryland. This includes an ongoing effort to build a statewide transportation model and a statewide land use model, which will together provide the capability to assess impacts of land use and transportation investment policy. Other models that assess impacts of development on the Chesapeake Bay's water quality, regional air quality, fiscal impacts of growth under different scenarios are also under development. The process continues engage many of the earliest participants through regular public forums and an open source information exchange portal".
Impact on policy making	Low	"There was no clear plan of further engaging the participants of the exercise and few planning agencies involved in the process showed any interest in connecting the momentary success of the exercise to any policy related initiative".
Impact on users' practice	Uncertain	

CASE STUDY 22

PROCESS

Maryland case study

Scope phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	High	"In the new format, the state was divided into four regions (Fig. 3) in each of which a separate event was held". "While assigning participants by individual tables careful attention was paid to mix interests and backgrounds".
Representation	High	"The first set of events was in 2006, the year of gubernatorial election and many legislative elections in Maryland. It provided a good opportunity to enhance the visibility of the effort by inviting prominent candidates. Several of them accepted the invitation, including then Mayor of Baltimore (and present Governor of Maryland) and another leading candidate for the same post. This provided added visibility to the events that helped attract other invited participants". "The event engaged more than 100 organizations in a leadership role and close to a 1000 invited participants during the four exercises. The participants represented diverse sections of the society including ethnic and geographic groups".
Opportunity to influence outcomes and/or process design	High	"This exercise used blocks of four different colors to represent the growth projections for each region. Again, each table was given a box with exactly enough colored blocks to represent the total growth projected to come to the region".
Quality and selection of information and resources in general	High	"This exercise used blocks of four different colors to represent the growth projections for each region. Again, each table was given a box with exactly enough colored blocks to represent the total growth projected to come to the region".
Challenging status quo and fostering	High	"Participants were then asked to reflect upon the results of their own

creative thinking		and other scenarios with respect to their stated development principles".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	"Since the outputs varied by tables and regions, after all the exercises were completed a method was devised to aggregate everything into a single, statewide scenario. For each region, all the tables were averaged to create a final, aggregate regional scenario. All the regional scenarios were finally joined and the resulting statewide grid was named the Reality Check scenario".
Independence and neutrality of the process	Uncertain	"The participants were presented with the outcomes of each table, an aggregate vision for the region and a compilation of guiding principles. However, this time two additional scenarios were developed, exogenously, for the participants to consider and compare to their own version".
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	"Participants were then asked to reflect upon the results of their own and other scenarios with respect to their stated development principles". "This somewhat took away the possibility of generating radically different scenarios but kept focus on regional issues and helped establish a common ground across the table. Thus, when the principles that emerged from different tables were analyzed, there was a high-degree of agreement".

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"Since the outputs varied by tables and regions, after all the exercises were completed a method was devised to aggregate everything into a single, statewide scenario. For each region, all the tables were averaged to create a final, aggregate regional scenario. All the regional scenarios were finally joined and

					the resulting statewide grid was named the Reality Check scenario". "The participants were presented with the outcomes of each table, an aggregate vision for the region and a compilation of guiding principles. However, this time two additional scenarios were developed, exogenously, for the participants to consider and compare to their own version".

OUTPUTS

Output	Evidence
Various planning scenarios	"Still the outcomes were successful in demonstrating measurable differences among scenarios created by different groups and, scenarios developed external to the participatory process". "Three hypothetical yet plausible alternative futures that were then compared on a set of quality-of-life indicators".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	Uncertain	
Recognised impacts	Uncertain	
Social learning	High	"Many participants, especially representatives of rural communities, developers and minority leaders, admitted attending such an event for the first time and getting a better sense of regional issues".

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"Three hypothetical yet plausible alternative futures that were then compared on a set of quality-of-life indicators". "RC Maryland addressed many of the shortcomings identified in RC Washington. In general, it presented a new model for large group interaction efforts subsequently adopted in several regional exercises including, RC-Tampa, Vision North Texas, RC Charleston, SPAN Europe". "In the months following the exercise, the success of the event acted as a foundation to develop multiple initiatives ranging from analysis to advocacy. These involved old and new collaborators".
Uptake of the tool/s	Uncertain	
Legacy	High	"In general, it presented a new model for large group interaction efforts subsequently adopted in several regional exercises including, RC-Tampa, Vision North Texas, RC Charleston, SPAN Europe".
Impact on policy making	High	"In the months following the exercise, the success of the event acted as a foundation to develop multiple initiatives ranging from analysis to advocacy. These involved old and new collaborators".
Impact on users' practice	Uncertain	

CASE STUDY 23

PROCESS

"To understand and guide the effects of bioenergy markets on agricultural landscapes, communities, and economies, we engaged leaders in the Corn Belt state of Iowa in a participatory workshop and follow-up interviews to develop future policy scenarios".

"We conducted a participatory workshop and follow-up interviews to integrate the insights of Corn Belt leaders with the results of regional social and ecological research, including companion studies investigating how rural stakeholders perceive agricultural landscapes and perennial conservation practices".

Scope phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"We then facilitated a 2.5 hour dialogue on current and future land use practices, institutions, and policies in Iowa".
Representation	High	"Strategic sampling and assistance from agency and nonprofit partners were used to select key leaders in agriculture, conservation, and policy in Iowa as workshop participants. Participants held positions of influence in organizations that encompass the multiplicity of perspectives that drive state-level land use decisions (Table 1). Sixteen of the 17 leaders whom we invited agreed to participate. The remaining 14 invitees participated in the workshop".
Opportunity to influence outcomes and/or process design	Moderate	"We integrated these workshop themes with the results of rural stakeholder interviews and other social and ecological research (Fig. 2) to further develop a heuristic model illustrating how desired multiobjective regional outcomes hinge upon the interactions among key social and ecological variables (Fig. 3, Table 2). This model provided the underlying causal framework upon which future policy scenarios were built (Fig. 2)". "Results of preliminary analyses, including workshop themes and written scenarios, were presented to all workshop participants and their feedback was recorded in individual interviews".
Quality and selection of information and resources in general	High	"To provide a common starting point, the workshop began with a brief presentation outlining our research objectives and highlighting the results of companion studies exploring stakeholders' perspectives on land use and perennial conservation strategies". "Results of preliminary analyses, including workshop themes and written scenarios, were presented to all workshop participants and their feedback was recorded in individual interviews".
Challenging status quo and fostering	High	"Upon arrival, participants filled out a questionnaire that probed individual perspectives on agricultural land use

creative thinking		change”. “We then facilitated a 2.5 hour dialogue on current and future land use practices, institutions, and policies in Iowa”.
Clear mandates and goals	High	“To provide a common starting point, the workshop began with a brief presentation outlining our research objectives and highlighting the results of companion studies exploring stakeholders’ perspectives on land use and perennial conservation strategies”.
Transparency	High	“We integrated these workshop themes with the results of rural stakeholder interviews and other social and ecological research (Fig. 2) to further develop a heuristic model illustrating how desired multiobjective regional outcomes hinge upon the interactions among key social and ecological variables (Fig. 3, Table 2). This model provided the underlying causal framework upon which future policy scenarios were built (Fig. 2)”. “The discussion was recorded using audio and visual media, but anonymity of participants’ comments in research reports was guaranteed to foster a candid dialogue”. “Although these scenarios were written by our research team, all of their narrative content was gathered from themes that arose directly from qualitative analysis of the policy workshop and rural stakeholder interviews”. “As part of the qualitative analysis process, scenarios were further shaped by comparing and contrasting workshop and interview data and themes with resilience theory”. “Results of preliminary analyses, including workshop themes and written scenarios, were presented to all workshop participants and their feedback was recorded in individual interviews”.
Independence and neutrality of the process	High	“The discussion was recorded using audio and visual media, but anonymity of participants’ comments in research reports was guaranteed to foster a candid dialogue”. “Although these scenarios were written by our research team, all of their narrative content was gathered from themes that arose directly from

		qualitative analysis of the policy workshop and rural stakeholder interviews". "Results of preliminary analyses, including workshop themes and written scenarios, were presented to all workshop participants and their feedback was recorded in individual interviews".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"We integrated these workshop themes with the results of rural stakeholder interviews and other social and ecological research (Fig. 2) to further develop a heuristic model illustrating how desired multiobjective regional outcomes hinge upon the interactions among key social and ecological variables (Fig. 3, Table 2). This model provided the underlying causal framework upon which future policy scenarios were built (Fig. 2)". "Although these scenarios were written by our research team, all of their narrative content was gathered from themes that arose directly from qualitative analysis of the policy workshop and rural stakeholder interviews". "As part of the qualitative analysis process, scenarios were further shaped by comparing and contrasting workshop and interview data and themes with resilience theory".

					"Results of preliminary analyses, including workshop themes and written scenarios, were presented to all workshop participants and their feedback was recorded in individual interviews".

OUTPUTS

Output	Evidence
A heuristic model	"Analysis of workshop and interview data, in conjunction with the results of regional social and ecological research, was used to develop a heuristic model outlining interactions between key drivers and outcomes of regional landscape change".
Three policy scenarios	"Three policy scenarios were built on this framework and included the following approaches: tweak, adapt, and transform".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"To move beyond this nearsightedness, these leaders emphasized the importance of the systems approach used in the heuristic models underlying scenarios".
Recognised impacts	High	"Although these scenarios were written by our research team, all of their narrative content was gathered from themes that arose directly from qualitative analysis of the policy workshop and rural stakeholder interviews". "As part of the qualitative analysis process, scenarios were further shaped by comparing and contrasting workshop and interview data and themes with resilience theory". "Results of preliminary analyses, including workshop themes and written scenarios, were presented

		to all workshop participants and their feedback was recorded in individual interviews”.
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	“These models were developed into the following policy scenarios: (1) tweak, (2) adapt, and (3) transform”. “The heuristic model developed in this research (Fig. 3) advances understanding of how the Corn Belt social-ecological system may respond to the bioeconomy by integrating knowledge from stakeholders who view this system from different scales and perspectives (Table 2)”.
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

CASE STUDY 24

PROCESS

“The scenario development consisted of two stages: first an exploratory stage with stakeholder engagement and second a modeling stage with forecasting-type scenarios”.

“For Austria as a whole and two local communities in the southeast of Austria, a participatory process with experts and stakeholders was undertaken to develop renewable energy scenarios for 2020 **(SCOPE**) and to evaluate them along the sustainability dimensions. The resulting ranking of the MCA helps to inform the discussion and decision process on sustainable energy futures ongoing in Austria” **(THIS PART IS NOT ANALYSED BECAUSE IT BELONGS TO THE DECISION MAKING STAGE AND NOT TO THE TOOL DEVELOPMENT STAGE)**.

“The preferences of national and local energy stakeholders were included in the form of criteria weights derived from interviews and participatory group processes, respectively”.

“In the final stage of the appraisal process, the information from the assessment matrix and criteria weights is used to calculate a ranking of the scenarios”.

“In essence, the analysis involved the following five main steps: (1) developing a limited number of scenarios for sustainable (renewable) energy futures; (2) producing a detailed list of criteria for the assessment of the social, economic, environmental and technical impacts of RETs; (3) assessing impacts with life-cycle-analyses; (4) eliciting individual stakeholders’ preferences and group preferences; and (5) applying a multi-criteria aggregation method (here: PROMETHEE II) to obtain rankings of the scenarios considered”.

Scope phase: national level

Criteria	**Evaluation**	**Evidence**
Structured group interaction	Uncertain	“An interdisciplinary research team of six researchers worked on two parallel case studies in cooperation with energy stakeholders and experts. Workshops and personal interviews were the main elements of the transdisciplinary research design”. “For the purpose of scenario development and discussion, and for the deliberation of criteria and weights, two workshops and a total of 25 interviews with Austrian stakeholders and experts were undertaken”. “Four energy scenarios with the focus on different RETs as well as on energy efficiency were developed and evaluated according to their expected impacts on sustainable development”.
Representation	High	“An interdisciplinary research team of six researchers worked on two parallel case studies in cooperation with energy stakeholders and experts”. “Invited stakeholders were identified in a stakeholder analysis based on two dimensions: (1) high influence of the institution on a change of the energy system and (2) strong effect on the institution from a change in the energy system”. “The national case study involved representatives from different interest groups and institutions as well as experts from the energy field (for the list of participating stakeholders in the national case study see *Table C.1* in *Appendix C*)”.
Opportunity to influence outcomes and/or process design	High	“The scenario themes plus their key RETs and the scenario parameters were agreed in this phase”.
Quality and selection of information and resources in general	Uncertain	

Challenging status quo and fostering creative thinking	High	"At this stage the role of stakeholders was to discuss and inform about the key alternative renewable energy pathways for Austria as a whole and for the two Styrian communities".
Clear mandates and goals	Uncertain	
Transparency	High	"During the second stage of scenario development, the research team transformed the descriptive scenarios into forecasting scenarios consisting of a qualitative storyline and a modeled quantitative representation. The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes". "The final national scenarios were taken up by an ongoing Austrian research project on participatory modelling of energy scenarios". "Four energy scenarios with the focus on different RETs as well as on energy efficiency were developed and evaluated according to their expected impacts on sustainable development".
Independence and neutrality of the process	High	"During the second stage of scenario development, the research team transformed the descriptive scenarios into forecasting scenarios consisting of a qualitative storyline and a modeled quantitative representation. The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes". "The stakeholders adapted the scenario parameters and selected the most relevant scenarios for detailed elaboration and modelling towards forecasting scenarios".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
			X		"The ARTEMIS team developed jointly with Austrian energy stakeholders five renewable energy scenarios".

OUTPUTS

Output	Evidence
Alternative energy scenarios at national and local level for Austria	"The main outcomes of the ARTEMIS project are the development of an impact matrix and an MCA procedure for the exploration of different energy scenarios by decision-makers at two spatial levels". "The ARTEMIS project delivered rankings of alternative future energy scenarios on the national and local level for Austria".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"The ARTEMIS project demonstrated that the combined methodology of scenario development and participatory MCA responds successfully to these challenges".
Recognised impacts	Moderate	"The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes. However, it was not possible to capture every aspect of the storyline in the models".
Social learning	High	"The learning of participants was monitored in repeated surveys for both case studies. We observed different types of learning – cognitive learning, learning from others and learning about the decision process methods".

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The ARTEMIS project demonstrated that the combined methodology of scenario development and participatory MCA responds successfully to these challenges".
Uptake of the	Uncertain	

tool/s		
Legacy	Uncertain	
Impact on policy making	High	"On the local level, the project results had immediate impact. The communities decided to become a member of the E5 programme and started work on a plan for their energy future based on the recommendation resulting from the ARTEMIS case study. On the national level, the ARTEMIS case study contributed to the ongoing energy discourse mainly by generating an assessment of energy scenarios that is based on life cycle analysis".
Impact on users' practice	Uncertain	

CASE STUDY 25

PROCESS

"The scenario development consisted of two stages: first an exploratory stage with stakeholder engagement and second a modeling stage with forecasting-type scenarios".

"For Austria as a whole and two local communities in the southeast of Austria, a participatory process with experts and stakeholders was undertaken to develop renewable energy scenarios for 2020 **(SCOPE**) and to evaluate them along the sustainability dimensions. The resulting ranking of the MCA helps to inform the discussion and decision process on sustainable energy futures ongoing in Austria" **(THIS PART IS NOT ANALYSED BECAUSE IT BELONGS TO THE DECISION MAKING STAGE AND NOT TO THE TOOL DEVELOPMENT STAGE)**.

"The preferences of national and local energy stakeholders were included in the form of criteria weights derived from interviews and participatory group processes, respectively".

"In the final stage of the appraisal process, the information from the assessment matrix and criteria weights is used to calculate a ranking of the scenarios".

"In essence, the analysis involved the following five main steps: (1) developing a limited number of scenarios for sustainable (renewable) energy futures; (2) producing a detailed list of criteria for the assessment of the social, economic, environmental and technical impacts of RETs; (3) assessing impacts with life-cycle-analyses; (4) eliciting individual stakeholders' preferences and group preferences; and (5) applying a multi-criteria aggregation method (here: PROMETHEE II) to obtain rankings of the scenarios considered".

Scope phase: local level

Criteria	Evaluation	Evidence
Structured group interaction	High	"On the local level, stakeholders attended three workshops and a final meeting where results were presented; moreover, they had some self-organised meetings". "The research team worked together with LEA (Local Energy Agency), local decision-makers, local experts, and the general public, in organizing participatory workshops, information events and in conducting interviews". "The design of the workshops, which were led by professional facilitators, ensured that all participating stakeholders had opportunities to speak and that minority views were also heard".
Representation	High	"The research team worked together with LEA, local decision-makers, local experts, and the general public, in organizing participatory workshops, information events and in conducting interviews (for the local stakeholder list see *Appendix C, Table C.2*)".
Opportunity to influence outcomes and/or process design	High	"The four workshops focused on scenario development; criteria definition; social preferences and weights for the criteria". "The scenario themes plus their key RETs and the scenario parameters were agreed in this phase".
Quality and selection of information and resources in general	High	"The research team worked together with LEA (Local Energy Agency), local decision-makers, local experts, and the general public, in organizing participatory workshops, information events and in conducting interviews".
Challenging status quo and fostering creative thinking	High	"At this stage the role of stakeholders was to discuss and inform about the key alternative renewable energy pathways for Austria as a whole and for the two Styrian communities".
Clear mandates and goals	Uncertain	
Transparency	High	"On the local level, stakeholders attended three workshops and a final meeting where results were presented". "During the second stage of scenario development, the research team transformed the descriptive scenarios into forecasting scenarios consisting of a qualitative storyline and a

		modeled quantitative representation. The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes".
Independence and neutrality of the process	Uncertain	"During the second stage of scenario development, the research team transformed the descriptive scenarios into forecasting scenarios consisting of a qualitative storyline and a modeled quantitative representation. The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
			X		"The research team worked together with LEA (Local Energy Agency), local decision-makers, local experts, and the general public, in organizing participatory workshops, information events and in conducting interviews". "During the second stage of scenario development, the research team transformed the descriptive scenarios into forecasting scenarios consisting of a qualitative storyline and a modeled quantitative representation. The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes".

OUTPUTS

Output	Evidence
Alternative energy scenarios at national and local level for Austria	“The main outcomes of the ARTEMIS project are the development of an impact matrix and an MCA procedure for the exploration of different energy scenarios by decision-makers at two spatial levels”. “The ARTEMIS project delivered rankings of alternative future energy scenarios on the national and local level for Austria”.

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	“The ARTEMIS project demonstrated that the combined methodology of scenario development and participatory MCA responds successfully to these challenges”.
Recognised impacts	Moderate	“The role of the stakeholders was to critically reflect on the modeling assumptions and to discuss the quantitative interpretation of the scenario themes. However, it was not possible to capture every aspect of the storyline in the models”.
Social learning	High	“The learning of participants was monitored in repeated surveys for both case studies. We observed different types of learning – cognitive learning, learning from others and learning about the decision process methods”.

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	“The ARTEMIS project demonstrated that the combined methodology of scenario development and participatory MCA responds successfully to these challenges”.
Uptake of the	Uncertain	

tool/s		
Legacy	Uncertain	
Impact on policy making	High	"On the local level, the project results had immediate impact. The communities decided to become a member of the E5 programme and started work on a plan for their energy future based on the recommendation resulting from the ARTEMIS case study. On the national level, the ARTEMIS case study contributed to the ongoing energy discourse mainly by generating an assessment of energy scenarios that is based on life cycle analysis".
Impact on users' practice	Uncertain	

CASE STUDY 26

PROCESS

"This paper reports on outputs generated from the AgWater Solutions (http://awm-solutions.iwmi.org) Project. One activity within this project has been the development and piloting of participatory geographic information system (PGIS) techniques to facilitate decision making. This paper discusses the development of these PGIS methods in relation to a specific Tanzanian case study concentrating on assessing current livelihood activities linked to possible future development scenarios".

"The assessment of livelihood and future development scenarios utilised PGIS techniques to capture information in a spatial framework".

"The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with 'experts' at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management" **(SCOPE. Two processes: community level and watershed level with experts)**.

Community mapping

Criteria	Evaluation	Evidence
Structured group interaction	High	"Community mapping exercises were undertaken with local stakeholders representing the main livelihood approaches specific for each village with additional women-only groups to assess any gender specific livelihood dependencies. The predominant livelihoods present in each community were identified in

		discussion with the village councils".
Representation	High	"To assess in detail the range of farm based livelihoods active in the watershed a survey of communities across the study area was undertaken. Survey locations were selected after discussions between the project team and the district authority. Communities were identified based on criteria including: their position in the watershed (both upstream and downstream; upslope and downslope); accessibility of surface water; access to different water management technologies; the range of farm based livelihood strategies present in each location (including crop producers and livestock specialists) and ease of engagement (both physical access and existing linkages to village institutions). In total four communities were identified". "In total 125 individuals participated across the four communities including 77 women who were included in livelihood strategy groups (together with men) and in specific women only mapping activities".
Opportunity to influence outcomes and/or process design	High	"The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with 'experts' at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management"
Quality and selection of information and resources in general	High	"Mapping was undertaken on simplified, village centred topographic maps and overseen by trained facilitators using a standardised set of questions".
Challenging status quo and fostering creative thinking	High	"The community mapping was undertaken, not to produce the definitive assessment of livelihoods across the watershed, but rather to provide a representative sample of strategies in detail. These were used to develop generalised 'narratives' that provided an overview of the current situation across the watershed".
Clear mandates and goals	High	"Each community was visited to introduce the research team and project objectives".

Transparency	Uncertain	“The outputs from the community and expert level activities were taken away for post processing in the GIS and analysed qualitatively to produce a consistent watershed scale livelihood assessment”.
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			“The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with ‘experts’ at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management. “The outputs from the community and expert level activities were taken away for post processing in the GIS and analysed qualitatively to produce a consistent watershed scale livelihood assessment”.

OUTPUTS

Output	Evidence
Three scenarios	“The research team (including the local academic project partners) developed three possible starting points in terms of technologies that might be introduced or expanded in the Mkindo watershed”. “Three scenarios were developed reflecting a range of possible future changes affecting different stakeholders”.

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"This Tanzanian case study shows that nesting mapping and outputs generated at differing spatial scales can successfully produce relevant information at spatial extents that are most useful for environmental management decision making and policy settings".
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	"The AWM Solutions project's aim was to identify options for investment in agricultural water management technologies with the overall goal of improving rural livelihoods of small holder farmers". "Three scenarios were developed reflecting a range of possible future changes affecting different stakeholders".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	"New information was generated and made available to policy makers in a followup stakeholder dialogue in Morogoro, 12–13 August 2010".
Impact on users' practice	Uncertain	

CASE STUDY 27

PROCESS

“This paper reports on outputs generated from the AgWater Solutions (http://awm-solutions.iwmi.org) Project. One activity within this project has been the development and piloting of participatory geographic information system (PGIS) techniques to facilitate decision making. This paper discusses the development of these PGIS methods in relation to a specific Tanzanian case study concentrating on assessing current livelihood activities linked to possible future development scenarios”.

“The assessment of livelihood and future development scenarios utilised PGIS techniques to capture information in a spatial framework”.

“The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with ‘experts’ at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management” **(SCOPE. Two processes: community level and watershed level with experts)**.

Watershed expert mapping

Criteria	Evaluation	Evidence
Structured group interaction	High	“The discussions were streamlined by presenting the community derived narratives at the beginning, asking the experts to focus on the differences between what was found in the four communities and what in their experience occurred in similar livelihood strategies across the watershed”.
Representation	High	“Six experts were identified representing a cross-section of water management, agricultural extension and forestry disciplines”.
Opportunity to influence outcomes and/or process design	High	“From these starting points the expert participants were asked to develop believable stories of future outcomes based on driving forces operating in the watershed and region alongside the uncertainties of how these forces might change into the future”.
Quality and selection of information and resources in general	High	“Narrative and map overviews for each livelihood strategy were presented individually to the expert participants highlighting the resources utilised; the incomes and products these strategies generated; their relative reliance on water; the inputs made in terms of fertilisers, pesticides, etc. and their resilience”.
Challenging status	High	“For each of the three main livelihoods identified at the community

quo and fostering creative thinking		level the experts were asked to map locations: Where that specific activity was being undertaken; to describe and locate what other resources were utilised by people participating in that strategy (for example, livestock grazing, vegetable gardens, forest resources, fish ponds, etc.); estimate how many people in the watershed undertook these activities (as a proportion); describe the cropping patterns, inputs (fertilisers, pesticides, mechanization) particularly focussing on the water management aspects; estimate the yields and how they varied across the study area; and in relation to the outputs discuss their usage in terms of cash income generation, household food or other applications. The experts were then asked to describe the challenges related to the livelihood activities including issues such as market access, crop storage and processing of production, human capital issues (diseases), finance issues and physical asset issues (e.g. mechanization, absence of farm roads, etc.). Finally the experts were asked to consider from their perspective how resilient (particularly in relation to environmental but also social and financial stresses) they considered each livelihood approach to be".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	"The outputs from the community and expert level activities were taken away for post processing in the GIS and analysed qualitatively to produce a consistent watershed scale livelihood assessment".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with 'experts' at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management". "The outputs from the community and expert level activities were taken away for post processing in the GIS and analysed qualitatively to produce a consistent watershed scale livelihood assessment".

OUTPUTS

Output	Evidence
Three scenarios	"The research team (including the local academic project partners) developed three possible starting points in terms of technologies that might be introduced or expanded in the Mkindo watershed". "Three scenarios were developed reflecting a range of possible future changes affecting different stakeholders".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	

Acceptance of process and/or outcomes	High	"This Tanzanian case study shows that nesting mapping and outputs generated at differing spatial scales can successfully produce relevant information at spatial extents that are most useful for environmental management decision making and policy settings".
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	**Evaluation**	**Evidence**
Objectives met	High	"The AWM Solutions project's aim was to identify options for investment in agricultural water management technologies with the overall goal of improving rural livelihoods of small holder farmers". "Three scenarios were developed reflecting a range of possible future changes affecting different stakeholders".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	"New information was generated and made available to policy makers in a followup stakeholder dialogue in Morogoro, 12–13 August 2010".
Impact on users' practice	Uncertain	

CASE STUDY 28

PROCESS

"As a first step, in three sub-catchments of the Havel River (distinguished by different physical characteristics) detailed surveys were carried out to investigate the various interests of the stakeholders. The interviews were used to identify the key problems of each area with respect to water quality and quantity and facilitated stakeholder engagement with the catchment planning issues in the Havel River Basin **(SCOPE)**. The information from the stakeholder interviews was used to determine the initial conditions for the land use scenarios which were developed to demonstrate possible changes to land use for achieving better water quality. The land use scenarios also were required as an input into the hydrological modelling of their effects on water quality and to calculate their socio-economic effects. In a second survey, the results of the scenarios and the hydrological modelling were presented to the stakeholders. The consultation process identified the priorities of the stakeholders which could then be taken into account when developing management options” **(TESTING)**.

“For this purpose the targets and environmental quality standards of a broad range of relevant expert groups as well as the measures related to them were identified for the investigation areas and were related to the respective landscape-ecological units. Simultaneously, potential conflicts that could be shown in the scenarios were identified”.

Scope phase

Criteria	**Evaluation**	**Evidence**
Structured group interaction	High	“Structured interview guidance was developed that included aspects such as an appraisal of the qualitative and quantitative availability of water resources within each focus area given from the different stakeholder’s perspectives”. “In this first poll, extensive interviews of approximately one and a half to 2 h were made with 29 stakeholders in the Hammerfließ area, 39 stakeholders in the Lower Havel River area and 28 stakeholders in the Do llnitz/Kleiner Rhin area”. “As a first step in this process a regional conference was arranged in each focus area. The conferences served to increase awareness about the project, gather information from stakeholders and the public, to inform people about the project and to establish contacts for helping with the project and for management of the catchment beyond the life of the project”.
Representation	High	“The relevant stakeholder groups that were involved in the survey were farmers, representatives of the forestry division, nature conservationists, water resource managers, fisheries and local authorities”.
Opportunity to influence outcomes and/or process design	High	“The users of land and water were furthermore asked to denote and mark on a map those areas in which there were problems with the water from their point of view”. “The evaluated interviews were submitted to the stakeholders for comments, so that they had the opportunity to make further additions or modifications”.
Quality and selection of information and	Uncertain	

resources in general		
Challenging status quo and fostering creative thinking	High	"The stakeholders were asked about their own proposals for improving the situation, about their respective attitudes towards possibilities of communication and cooperation among each other and about their level of awareness of the WFD".
Clear mandates and goals	High	"As a first step in this process a regional conference was arranged in each focus area. The conferences served to increase awareness about the project, gather information from stakeholders and the public, to inform people about the project and to establish contacts for helping with the project and for management of the catchment beyond the life of the project".
Transparency	Uncertain	"The results from the interviews were used to get information about characteristic problems in the three areas and to design the scenarios".
Independence and neutrality of the process	High	"The users of land and water were furthermore asked to denote and mark on a map those areas in which there were problems with the water from their point of view". "The evaluated interviews were submitted to the stakeholders for comments, so that they had the opportunity to make further additions or modifications". "The stakeholders were asked about their own proposals for improving the situation, about their respective attitudes towards possibilities of communication and cooperation among each other and about their level of awareness of the WFD".
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	**Consult**	**Involve**	**Partner**	**Empower**	**Evidence**
		X			"As a first step, in three sub-catchments of the Havel River (distinguished by different physical characteristics) detailed surveys were carried out to investigate the various interests of the stakeholders. The

					interviews were used to identify the key problems of each area with respect to water quality and quantity and facilitated stakeholder engagement with the catchment planning issues in the Havel River Basin. The information from the stakeholder interviews was used to determine the initial conditions for the land use scenarios which were developed to demonstrate possible changes to land use for achieving better water quality.

Testing phase

Criteria	Evaluation	Evidence
Structured group interaction	High	"The structured interviews now included questions about the scenarios themselves, if they were understood, regarding the degree of concern with each scenario, which positive and negative aspects were attributed to them and under which conditions one would agree to the implementation either of each scenario or to the several types of actions attributed to them".
Representation	High	"The second survey was carried out on different scales, addressing stakeholders in the three focus areas and also those responsible for the whole river basin". "In addition to the stakeholders included in the first enquiry relating to the three river catchment areas, a further total of 18 organisations, associations, planning associations and local authorities, concerned with regional issues for the federal state of Brandenburg, were asked".
Opportunity to influence outcomes and/or process design	High	"…were asked to evaluate the land use scenarios as well as the ways in which these were represented and modelled and the resulting impacts for the entire river catchment".

Quality and selection of information and resources in general	Uncertain	
Challenging status quo and fostering creative thinking	High	"The structured interviews now included questions about the scenarios themselves, if they were understood, regarding the degree of concern with each scenario, which positive and negative aspects were attributed to them and under which conditions one would agree to the implementation either of each scenario or to the several types of actions attributed to them".
Clear mandates and goals	Uncertain	
Transparency	Uncertain	"The aim of the whole process was to create a final scenario called ''Optimised water quality management'' that should try to bring the requirements of WFD into agreement with socio-cultural aspects like the requirements of land use and nature conservation and also to identify those fields where conflicts remain and further solutions (like financial compensation) have to be developed".
Independence and neutrality of the process	Uncertain	
Conflict resolution	Uncertain	
Develop a shared vision and goals	Uncertain	

Inform	Consult	Involve	Partner	Empower	Evidence
		X			"In a second survey, the results of the scenarios and the hydrological modelling were presented to the stakeholders. The consultation process identified the priorities of the stakeholders which could then be taken into account when developing management options".

OUTPUTS

Output	Evidence
Water management scenarios	"The results from the interviews were used to get information about characteristic problems in the three areas and to design the scenarios".
Final optimised water management scenario	"The aim of the whole process was to create a final scenario called ''Optimised water quality management'' that should try to bring the requirements of WFD into agreement with socio-cultural aspects like the requirements of land use and nature conservation and also to identify those fields where conflicts remain and further solutions (like financial compensation) have to be developed". "The derived land use scenario (see Optimal scenario in *Fig. 4*) is based on scenario G, modified with respect to acceptance, costs and effects".
DSS with the scenarios **(not as part of this project, but of another one)**	"The mapping of the scenarios and their results (from the modelling and from the stakeholder enquiry) thus became part of a decision support system (DSS) that was developed as a result of the research project (Lahmer, 2003)".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Low	"Lack of communication between the stakeholders and difficulties in understanding the issues from all different perspectives leads to considerable coordination problems for water and land use planning managers".
Acceptance of process and/or outcomes	Moderate	"The presentation of the scenarios and the appropriateness of the method as a way of communicating land use change concepts were predominantly appraised by the stakeholders as being good to very good. In the total area, 14 out of 18 interviewed people gave this opinion (77%). In the focus areas, above all, it was the representatives from the fields of agricultural and forestry management that commonly evaluated the appropriateness of the scenarios for this reported application as mediocre to good". "*Table 3* shows a comparison of the evaluation of the scenarios by the

		stakeholders in the Hammerfließ area and the stakeholders at a catchment management level, in a five-step ordinal scale. This shows differences not only between the groups of stakeholders, but partially also between the focus areas and the scale of enquiry”.
Recognised impacts	High	“The results from the interviews were used to get information about characteristic problems in the three areas and to design the scenarios”. “The aim of the whole process was to create a final scenario called ‘‘Optimised water quality management’’ that should try to bring the requirements of WFD into agreement with socio-cultural aspects”. “The evaluated interviews were submitted to the stakeholders for comments, so that they had the opportunity to make further additions or modifications”.
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	High	“The results from the interviews were used to get information about characteristic problems in the three areas and to design the scenarios”. “The aim of the whole process was to create a final scenario called ‘‘Optimised water quality management’’ that should try to bring the requirements of WFD into agreement with socio-cultural aspects like the requirements of land use and nature conservation and also to identify those fields where conflicts remain and further solutions (like financial compensation) have to be developed”. “The mapping of the scenarios and their results (from the modelling and from the stakeholder enquiry) thus became part of a decision support system (DSS) that was developed as a result of the research project (Lahmer, 2003)”. “The derived land use scenario (see Optimal scenario in Fig. 4) is based on scenario G, modified with respect

		to acceptance, costs and effects".
Uptake of the tool/s	High	"The mapping of the scenarios and their results (from the modelling and from the stakeholder enquiry) thus became part of a decision support system (DSS) that was developed as a result of the research project (Lahmer, 2003)".
Legacy	Uncertain	
Impact on policy making	High	"The approach informs the decision-making process and formulates programmes of measures for implementing the WFD". "The stakeholder interviews also provide information for the design of the participation process for the public, as required by article 14 of the WFD". "Although the overarching framework for implementing the WFD has not been altered, methods for realising its aims are identified".
Impact on users' practice	High	"The different evaluation of scenarios that was demonstrated in the interviews carried out for this study shows that slightly different communication strategies need to be applied for stakeholders at each scale of planning, whether at the catchment level or the local level".

CASE STUDY 29

PROCESS

Scope phase

Only this phase is included because of the following:

"Three workshops were held with different stakeholder groups. The first workshop was attended by representatives of all government organisations involved with agriculture in the basin while the remaining two were attended by different farmers from the head and tail of the basin respectively (see Table 2). Each workshop was designed to meet the practical objectives of the wider investigation as well as to answer the research questions of the DSS study. The practical objectives of the wider study were defined as:
1. identifying the agricultural problems in the Deduru Oya basin,
2. investigating the impact of possible solutions to these problems, and
3. identifying which of these solutions are most effective at solving the problems".

However, government workshop and farmer workshops happened differently and the process is analysed for both separately.

Farmer workshops

Criteria	Evaluation	Evidence
Structured group interaction	High	"Each workshop lasted for around 4.5 h and was facilitated by social science specialists from the International Water Management Institute in Colombo". "Facilitating stakeholders to construct BNs directly (as had been done with the policy makers) was felt to be inappropriate. Instead, it was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop".
Representation	High	"At both workshops, participants were invited by field staff from the Department of Agrarian Services to be representative of the range of farmers and farming activities in the area (*see Table 2*)". "The surprising level of agreement between the two farmer groups implies that both groups share the same problems and also implies that each group was sufficiently representative. The groups in this study were selected to include a range of farmers in the hope that this would provide a properly holistic perspective and this appears to have worked".
Opportunity to influence outcomes and/or process design	Low	"It was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop".

Quality and selection of information and resources in general	Uncertain	“Each workshop lasted for around 4.5 h and was facilitated by social science specialists from the International Water Management Institute in Colombo”. “Facilitating stakeholders to construct BNs directly (as had been done with the policy makers) was felt to be inappropriate. Instead, it was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram”.
Challenging status quo and fostering creative thinking	Low	“Facilitating stakeholders to construct BNs directly (as had been done with the policy makers) was felt to be inappropriate. Instead, it was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop”.
Clear mandates and goals	Uncertain	“At both workshops, participants were invited by field staff from the Department of Agrarian Services to be representative of the range of farmers and farming activities in the area (see Table 2)”. “Facilitating stakeholders to construct BNs directly (as had been done with the policy makers) was felt to be inappropriate. Instead, it was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop”.
Transparency	Low	“It was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram

		created would represent the perceptions expressed by the farmers at each workshop. On completion of this process, notes taken during the workshop were used to develop the BN flow diagram”.
Independence and neutrality of the process	Uncertain	“This paper reports a study to develop a DSS to help manage the agricultural system in the Deduru Oya river basin in Sri Lanka, using a tool called a Bayesian network. The main aim of the study was to investigate whether Bayesian networks, together with approaches to help people use them, could provide the generic framework envisaged above. Recognising the importance of participation, the study also looked at the best ways of involving other stakeholders in the construction of the DSS so that their understanding of the system could be recognised and, potentially, incorporated into the DSS”. “It was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop. On completion of this process, notes taken during the workshop were used to develop the BN flow diagram”. “Additionally, one of the BN flow diagrams was shown to the Deputy Director of the Irrigation Department to gauge his reaction to it as a policy maker”.
Conflict resolution	Uncertain	
Develop a shared vision and goals	High	“The surprising level of agreement between the two farmer groups implies that both groups share the same problems and also implies that each group was sufficiently representative”. “Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would

		represent the perceptions expressed by the farmers at each workshop".

Inform	**Consult**	**Involve**	**Partnership**	**Empower**	**Evidence**
		X			"Three workshops were held with different stakeholder groups. The first workshop was attended by representatives of all government organisations involved with agriculture in the basin while the remaining two were attended by different farmers from the head and tail of the basin respectively (see Table 2). Each workshop was designed to meet the practical objectives of the wider investigation as well as to answer the research questions of the DSS study". "These objectives were presented to the stakeholders at the start of the workshops. The main aim of the study, however, was to use Bayesian networks to help stakeholders address these objectives and so answer the principal research questions". "The research questions were answered by an assessment of the ways in which the method helped the participants address the practical objectives. This assessment was carried out, by both the research team and the participants, in terms of the logic

					and comprehensiveness of the outputs, as well as the ease with which they were produced". "It was decided to use a semistructured discussion to elicit the information necessary for the facilitators to construct a BN flow diagram. Additional questions were also asked by the facilitators to clarify a number of details and ensure that the BN flow diagram created would represent the perceptions expressed by the farmers at each workshop. On completion of this process, notes taken during the workshop were used to develop the BN flow diagram".

OUTPUTS

Output	Evidence
Bayesian networks (BN) and "cause and effect diagrams" from the workshops, showing problems and solutions in the basin.	"Comparing the farmer BN flow diagrams with the cause and effect diagrams produced by the groups at the government workshop, showed that perceptions of problems and solutions are largely shared". "Due to the limited time available for the government workshop, only Group 1 was able to finish the whole process (BN). All the other groups, however, reached Step 6 and produced ''cause and effect'' diagrams expressing the relationships between the problems and the potential solutions".

OUTCOMES

Personal outcomes

Criteria	Evaluation	Evidence
Relationships and social capital building	Uncertain	
Acceptance of process and/or outcomes	High	"At the end of the workshop, the farmers thanked the facilitators for providing them with an opportunity to express their opinions and asked for reassurance that their ideas would be forwarded to the responsible authority".
Recognised impacts	Uncertain	
Social learning	Uncertain	

Factual outcomes

Criteria	Evaluation	Evidence
Objectives met	Moderate	"From the detailed notes produced, it was straightforward for the facilitators to develop a BN flow diagram with some confidence that it properly represented the perceptions of the farmers. Although it was impossible to develop this into a fully functioning BN (as no numbers had been elicited for the CPTs), the research team found the farmer flow diagram useful in that it facilitated a comparison between farmer and policy maker perspectives. However, due to the amount of information elicited from the farmers, the diagram was quite complicated. This proved to be a problem for the Deputy Director of the Irrigation Department who did not find it helpful in understanding farmer perspectives on the basin". "Lack of time was not quite so much of an issue for the farmer workshops, largely as a consequence of the limited objectives set for them. However, although the BN flow diagrams produced were useful for comparing stakeholder perspectives (at least for the research team) they were not validated by the farmers and did not

		allow any quantitative analysis as they lacked any input to the CPTs".
Uptake of the tool/s	Uncertain	
Legacy	Uncertain	
Impact on policy making	Uncertain	
Impact on users' practice	Uncertain	

Annex 3. Complete description of the criteria of sustainable forest management identified

This appendix exposes the criteria of sustainable forest management (SFM) under Mediterranean conditions identified in this research, applicable at the forest management unit (FMU) scale. In the following pages some tables have been developed, one for each criterion. These tables show the name of the criterion in the first row, it s description in the second row, and examples of actions and procedures to accomplish the criterion in the third row. Some tables include a fourth row of remarks to clarify some concepts and to set the scope of the criterion to avoid overlaps with other criteria.

ECONOMIC CRITERIA

Persistence and stability of forest resources
Silviculture guarantees that a minimum quantity of the forest resources that are utilised for profitability at the forest management unit stays permanently in it and continues after pests and diseases.
- Harvesting combines opening up spaces with soil and new plants protection (Madrigal, 2003). - Keep suitable densities according to species and site quality (Madrigal, 2003). - Diversity at different levels: population (genetic diversity), species diversity and landscape diversity. There is no need either to substitute species or to create mixed forests, but to get young forests made of several species, some of them principal resources and some of them secondary in terms of exploitation but with an important ecological function for the principal ones (Madrigal, 2003). - Silviculture is applied along the whole lifecycle of the forest (Madrigal, 2003). - Species adapted to site (soil and climate) (Generalitat Valenciana, 2011). - Avoid dead wood with cork after silvicultural treatments and

forest fires (Generalitat Valenciana, 2011).

- Genetic diversity and improvement: silviculture focuses not only on individuals which grow faster or which have the best morphological characteristics (Thompson, 2011).
- Seed origin control of material used for forestations or enrichment plantations[10] (Ruano, 2003).
- The integration of the conservation of genetic resources into the management requires the application of “on site” methods (in the natural distribution area), both with a dynamic character (which promote continuous evolution of genetic resources in natural environments) and static (outstanding individuals); those are complemented with methods from out of the natural distribution area with a dynamic character (introduced populations plantations) (Strasbourg S2, 1990; *in* Generalitat Valenciana, 2011b). These genetic conservation and improvement programs affect in the following way to the forest manager (Generalitat Valenciana, 2011b):
    - *Promote the correct use of genetic resources for natural environments restoration and in productive sectors.*
    - *The participation of forest owners is required in conservation actions that affect them.*

Profitability of forest resources

When planning the management it has to be considered obtaining in-kind incomes (products) and money incomes, annual or periodic, variable or constant.

- The silvicultural organisation model establishes the obtention of in-kind incomes (Madrigal, 2003).
- To get money incomes it is necessary to know production costs, market prices, study the demand and commertialise the products (Madrigal, 2003).
- The accomplishment of this criterion implies considering possible subsidies and payments for ecosystem services (PES)[11] available for the FMU. Both will be included as part of the money incomes.

[10]These are plantations carried out under the forest canopy whose objective is to increase the number of species of the tree layer (Madrigal, 2003).
[11]They are agreements between producers of an ecosystem service and people (or their representatives) who are benefiting from it. By means of the agreement the beneficiaries pay a prearranged money quantity to the producers (Generalitat Valenciana, 2010).

COMMENT: this criterion has to be accomplished at the FMU level (neither stand level nor regional level) and it does not necessarily imply getting annual constant incomes. For in-kind annual constant incomes, a balanced tree age or tree dimension distribution in the FMU has to be achieved. However, for constant incomes a minimum forest area is needed in order to obtain a balanced organisation of trees. Forest properties are generally small in Spain, making it difficult to comply with this criterion at the FMU level. This criterion can be achieved at a higher level (county, regional); therefore, it is recommended to promote association among forest owners and regional/county management of forests, but this is out of the scope of this research.

Diversified exploitation of forests

As part of the management an inventory of present and potential goods and services of the forest has to be done and the best use of them has to be determined.

- Study of possible uses and compatibilities and establishment of priorities among them (Deshler, 1979).
- Optimisation techniques (Madrigal, 2003).
- Multi-criteria analysis (MCA) techniques.
- Explore new products and their markets.
- It contributes to comply with this criterion having a mosaic of diverse vegetation formations (tress, scrubs, pastures) (Madrigal, 2003).

Economic criteria refer to all forest resources (goods and services) that can be managed to commertialise and sell. They correspond to provisioning services. However, there are provisioning services that do not provide any incomes to the forest owner: decoration or aromatic plants (moss, holly, mistletoe, rosemary, etc.), asparagus, snails, fungi, berries and so on. If in the future there exist economic compensations for them (because of direct selling or because of PES), and an active management is developed for their exploitation, that management will be included in this three criteria.

SOCIAL CRITERIA

Employment and working conditions
The number of job posts (and thus, employees) in the FMU is appropriate to the management tasks that are carried out, employees working conditions are good and they have suitable training to develop their functions.

- Development of the management in a profitable way so that it generates or maintains the number of job posts.
- Avoid temporary contracts as far as possible (Madrigal, 2003).
- There is a risk prevention plan and all workers know the prescriptions that affect them. Reference documents for health and safety matters are:
  • International Labour Organisation prescriptions (ILO, 1998; ILO, 2005).
  • *Manual para la asistencia técnica en prevención de riesgos laborales. Sector forestal* (EUROQUALITY y ASEMFO, 2002).
  • *Trabajos forestales* (MESS, 2006).

Recreation
There are infrastructures in the FMU for its social use in different ways: leisure (picnic, walking, trekking, fauna watching, camping), sports or hunting.
- Maintenance and improvement of the infrastructures for the activities mentioned in the description: picnic and camping areas, walking paths, climbing walls. - Creation of new infrastructures if there exist demand for their use and they are economically affordable. - Management of hunting fauna: places for the animals to eat and to drink, fences, species and populations inventories, establishment of the number of individuals from each species to hunt per time period.
COMMENT: in many Spanish Mediterranean forests hunting represents the only, or the most important, income source. Nevertheless, in this research it is kept in "recreation" and "social criteria" because its practice has more of a cultural meaning than of a provisioning and feeding one (Generalitat Valenciana, 2011). It happens the same with mushroom and berry picking;

however, hunting has some sportive features (challenge, competitiveness, watching and shooting the press) that make it more suitable for this criterion.

Visual character

Management maintains the visual features of the FMU that identify and make it attractive and improves them when they have been degraded.

- Outstanding visual elements of the landscape, either due to their natural appearance or due to human action, will be conserved (Council of Europe, 2000).
- Unwished contrasts will be avoided (Madrigal, 2003).
- Some visual diversity will be looked for (but nor excessive, because it could lead to a feeling of disorder – Madrigal, 2003) both vertical (strata) and horizontal (mosaics of vegetation formations) (MARM, 2002).
- A balanced tree age or tree dimension distribution assures visual continuity of the landscapes (Madrigal, 2003).
- In reference to visual considerations, it corresponds to the forest manager to identify management guidelines and silvicultural treatments to comply with the visual prescriptions of those planning regulations that affect the FMU. If these regulations do not exist or they are not very specific, the forest manger will establish his/her own rules to conform to this criterion.

COMMENT: in order to agree to maintain the visual character and to get constant incomes, it is convenient to get those balanced tree ages that Madrigal (2003) proposes. However, people feels more attracted to tree formations where the tree layer is made by individuals with similar ages and heights. Thus, this equilibrium will have to be considered at FMU level, with interstand heterogeneity but intrastand homogeneity with respect to tree age and size, so that there are some places with mature and high trees (very attractive for people); places holding these characteristics can be prioritised near picnic areas, paths or roads.

Historical and cultural heritage

Management preserves the features and places of the FMU holding a historical or cultural meaning, either tangible (charcoal kilns) or intangible (pilgrimages), natural or artificial.

- The meaningful features of the landscape that represent a historical or cultural meaning, either due to their natural appearance or due to human action, will be preserved (Council of Europe, 2000).
- Inventory of elements and places with a historical or cultural heritage character.
- The forest manager establishes conservation procedures. Also, restoration ones if it is appropriate.
- Participatory processes can be of great help for the inventory of elements, traditions and places with a historical or cultural meaning, and to decide how to carry out their conservation.
- The law on Spanish Historical Heritage (*ley 16/1985, de patrimonio histórico español* – Gobierno de España, 1985), defines what constitutes the ethnographic heritage (related to customs and traditions) and establishes economic subsidies for the conservation and recovery of the historical and cultural heritage. Likewise, the law on Spanish Natural Heritage and Biodiversity (*ley 42/2007, del patrimonio natural y de la biodiversidad* – Gobierno de España, 2007), determines the cultural character derived from the use of certain biological, geological and other natural resources, and it provides subsidies and procedures for their conservation.

Participatory processes

Take account of stakeholders and affected people's experience and points of view in forest management decisions.

- It stays open to the necessities of each case (except when it is compulsory because of laws or planning regulations) the way in which the process will be carried out, the stakeholders to include, over which management matters the process will be about, and how will the input from participants be included in the final decisions.

Education
Forest management favours society's education and awareness on the cultural, environmental and economic significance of forestry and natural areas.
- Information boards and desks (information desks mainly in protected areas or FMU with outstanding features) to inform about the fauna, flora, meaningful historical and cultural characteristics, the resources of the FMU and good behaviour procedures (Generalitat Valenciana, 1993; MARM, 2002; Gobierno de España 2003). - The use with an educational goal by education centres and institutions, associations, clubs and travel agencies. It would be interesting to have mechanisms for forest owners to offer their FMUs for this purpose and to get an economic compensation for that.

Research
The use of forests as an object of scientific studies, either to improve the management (and the information on its goods and services) or to increase the knowledge of other disciplines (ecology).
- As an object of forest policy more forest research is promoted, and more forest information (statistics) (Generalitat Valenciana, 1993; MARM, 2002; Gobierno de España, 2003). - It would be interesting to have mechanisms for forest owners to offer their FMUs for scientific research and to get an economic compensation for that. - Monitoring, assessment and information on the degree of accomplishment of management objectives and the state of the forests, in a periodic and systematic way. Templates to fill in should be publicly available or, at least, accessible to researchers and managers. This information pick up (statistics) constitutes a starting point for research.

This group of criteria refers to cultural ecosystem services plus two requisites of sustainable management: “employment and working conditions” and “participatory processes”. Both in the social and the ecological groups, there are criteria that correspond to ecosystem services that are not provisioning, but which could provide money incomes to the FMU by means of PES or subsidies. These are: “recreation”, “visual character”, “education”, “research” or “biodiversity and habitats”. When this situation comes, incomes derived from managing such criteria will be included as part of the money incomes (as it has been mentioned in the criterion “profitability of forest resources”), but their management (their objectives and the way to meet them) will remain in the criteria group where they originally were.

ECOLOGICAL CRITERIA

Biodiversity and habitats
Management keeps species and habitats diversity and habitats connectivity in order to maintain and improve forest capacity to recover after disturbances.
- The achievement of this criterion depends upon the accomplishment of six subcriteria which are described next.

Flora diversity
Maintenance and improvement of vegetation diversity in grass and scrub layers.
- Inventory of vegetation species and development of conservation procedures. - If diversity is going to be increased, the effects of the introduction of new species on the ecology of the system should be studied: an increase in the number of individuals in a population and in the number of species in an ecosystem has to be compatible with the management objectives and the stability of the system (AENOR, 2007).
COMMENT: this subcriterion refers only to grass and scrub layers because tree layer is considered as an economic resource and its diversity has been taken into account in the criterion “persistence and stability of forest resources”.

Fauna diversity

Maintenance and improvement of wild animal species diversity existing in the FMU.

- Inventory of wild animal species and development of conservation procedures.
- The same preventive measures as the ones indicated for the subcriterion "flora diversity" have to be taken if it is necessary to introduce individuals of one species or to increase the number of species (AENOR, 2007).

COMMENT: the management of hunting fauna is not included in this subcriterion.

Endangered species

The management maintains and increases the populations of these species in the FMU.

- Revise the "List of Wild Species under a Special Protection Status" (scientific, ecologic, cultural, outstanding values, rare or endangered species) and, inside this list, the species included in the "Spanish List of Endangered Species", and the existence of endemic species (Gobierno de España, 2007; 2011); also revise the "Valencian List of Endangered Flora Species" (Generalitat Valenciana, 2009) and the "Valencian List of Endangered Fauna Species" (Generalitat Valenciana, 2004b).
- Inventory of species included in the previous lists that are present in the FMU and development of conservation procedures.

Alien species

Cautious introduction of alien species and control of existing ones to avoid that they become invasive.

- Study the effects of introducing alien species, and avoid them if they are expected to change noticeably

the ecology of the FMU (European Union, 2010).
- Invasive species will be eliminated or their spreading will be controlled (European Union, 2010).
- If it is ecologically advisable and economically affordable: reintroduce species that have been moved aside by invasive species.

Habitats

Knowledge, maintenance and improvement of the different habitats existing in the FMU (lakes, rocky walls).

- Inventory of habitats and development of conservation procedures.
- Special care should be paid to threatened habitats, habitats having endangered species and habitats having economically important species (Council of Europe, 1992).

Ecological connectivity

Management avoids habitat fragmentation and favours connection among habitats.

- Continuity among different vegetation structures, avoiding barriers to fauna movements and seed dispersal (MARM, 2002; Gobierno de España, 2003).
- Green corridors between distant natural ecosystems (MARM, 2002; Gobierno de España, 2003).

Hydrological regulation

An important element of the hydrological cycle is vegetation that increases infiltration and reduces the quantity and speed of runoff. This attribute of vegetation offers important services: controls erosion, reduces the number and magnitude of floods and refills aquifers. The aim of this criterion is to maintain and improve these services through the management of vegetation structure and composition.

- The achievement of this criterion depends upon the accomplishment of five subcriteria which are described next.

Erosion

Management keeps erosion rates under bearable levels.

- Erosion stays under a bearable level of soil loss which is different depending on the area, and this level is constantly monitored (Generalitat Valenciana, 2011).
- Preventive techniques should be applied (soil protection covers) where there is a potential erosion risk and corrective techniques where soil losses are above a bearable level (Generalitat Valenciana, 2011).
- Keep, protect and broaden vegetation covers made of several strata, in order to reduce runoff speed (Generalitat Valenciana, 2011).
- Reduce damage to scrubs and grass, and avoid soil compaction when carrying out silvicultural treatments (Generalitat Valenciana, 2011).

Soil productivity

Management does not change soil productivity and improves it whenever necessary (reforestations) if the soil is short of nutrients[12].

- Leave rests of silvicultural treatments (dead Wood, leaves and branches) to provide nutrients and organic material to the soil (Pemán y Navarro, 1998; Madrigal, 2003).
- In reforestations and enrichment plantations: avoid (in case of plough, etc.) big affections to soil texture, structure and soil profile except when site conditions require it (Pemán y Navarro, 1998; Madrigal, 2003).
- If fertilisers are necessary (reforestations, enrichment plantations, poor soils, plant nurseries), only recommended quantities will be used and authorised products having the lesser impact on the environment;

[12]Soil productivity is defined by soil texture, structure, organic material content, depth, nutrients and water storage capacity (FAO, 2005).

the products will be used in suitable timing. The objective of these prescriptions is to reduce nutrient decay (AENOR, 2007).

- In general, to comply with this subcriterion, soil preservation and improvement procedures can be applied, like: bioengineering techniques or enriching mud (Generalitat Valenciana, 2011).

COMMENT: forestry does not act directly on the soil. Indirectly, silvicultural treatments can cause compaction due to machinery, or they can cause surface cracks because of vegetation drag. But forest management does not affect directly on the soil profile and fertilisers are not usually applied. An exception to the previous are reforestations, enrichment plantations and intensive exploitations (plantations, nurseries); in all of them it can be necessary, not always, the use of fertilisers and, just in reforestations and enrichment plantations, to vary slightly some soil properties (horizons, hydrology).

COMMENT 2: organic detritus are favourable for the accomplishment of some criteria (this one or *biodiversity and habitats*) and unfavourable for pest spread. As a tradeoff, it is proposed to avoid dead wood with cork and establish maximum quantities for the other detritus, so that the habitat is improved but the ecosystem stability is not altered.

Aquifer filling

Management favours vegetation structures that maintain or increase aquifer filling rates.

- Maintain, protect and increase forest covers with several strata (Generalitat Valenciana, 2011).
- Vegetation structures whose characteristics (densities, ages, species) optimize the area covered by vegetation, so that infiltration is maximised and water consumption is minimised. The aim is to reduce evapotranspiration. All this implies that vegetation densities will not be the maximum possible ones, but medium densities in order to have some extra water in the soil which percolates for groundwater recharge (Generalitat Valenciana, 2011).

COMMENT: due to the type of silviculture required, this subcriterion is in conflict with flood control, erosion prevention and profitability. For three of them, higher densities of the tree layer than for aquifer filling are necessary. It is necessary when planning forest management to establish clearly the objectives and the priorities among them and to divide the FMU into zones, each zone with a different main objective. This choice of objectives will not be possible when a regulation coming from an upper level establishes the need to manage a specific forest area for groundwater recharge because its water fills overexploited aquifers or aquifers supplying a lot of inhabitants.

Floods

Create vegetation structures that avoid floods or reduce their negative impacts.

- Higher vegetation density (especially the tree layer) which increases infiltration and reduces runoff speed (Generalitat Valenciana, 2011).
- Vegetation structures with several strata, and broadleaves if possible (Generalitat Valenciana, 2011).
- There are no obstacles to free water drainage in the FMU, except the construction of transverse dykes, which retain water and reduce discharge rates (see COMMENT).

COMMENT: the forest owner is responsible for dyke construction only when there are private water streams or riverbeds inside the FMU. Even in these cases, dyke construction will have been previously recommended or ordered by an upper level authority.

Mass flows

Management prevents landslides and avalanches.

- Preventive techniques: slope drainages, moorings, geometric correction of the slope profile, etc. (Ayala *et al*., 2006).
- Planning and management divide into zones considering risk maps and create forest covers that contribute to soil stability: strata, densities, species, etc. (Ayala *et al*., 2006).

Forest fires
Management prevents forest fires and facilitates extinction, so as to keep the frequency, intensity and consequences of forest fires in an ecologically sustainable and socially acceptable level.
- Extinction aid infrastructures: tracks, firebreak areas, water diposits (Generalitat Valenciana, 2011). - Silviculture reduces the amount of fuel, vertical vegetation continuity (between strata) and horizontal vegetation continuity (inside the same vegetation structure and in the limit between vegetation structures) (Generalitat Valenciana, 2011).

Carbon storage
Forest management contributes to global climate change mitigation through maximising biomass synthesis and maintaining soil carbon storage capacity.
- The achievement of this criterion depends upon the accomplishment of two subcriteria which are described next.

Vegetation
Vegetation structure and composition that favour biomass synthesis.
- Higher percentages of areas covered by trees[13] compared to areas not covered by trees or covered by scattered trees (Generalitat Valenciana, 2011). - Promote young vegetation structures in zones whose main objective in to maximise carbon storage[14]. It is

[13]Carbon storage capacity in ecosystems covered by trees is about 73t CO_2/ha, and in ecosystems not covered by trees 17t CO_2/ha. Low density scrubs store more carbon tan high density ones but, in general, the types of vegetation structure that store more carbon are those where scrubs storage contribution is less (between 2% and 7%) than that of the trees (Generalitat Valenciana, 2011).

[14]Forest ecosystems capture CO_2 when they are young. However, as they get more mature the growing rate is reduced and so does CO_2 storage, until it becomes almost nothing. In general, young conifer vegetation structures, especially if thinnings are

recommended to tend to young conifers vegetation structures under thinning programs (Generalitat Valenciana, 2011).
- Diversify species in mature vegetation structures (Generalitat Valenciana, 2011).
- Maintain densities that favour tree carbon synthesis: high percentages of area covered by trees in pure mature vegetation structures, and medium for mixed ones; the area covered by scrubs in vegetation structures including a tree layer must be small (Generalitat Valenciana, 2011).

Soils

Maintain and improve soil capacity to store carbon[15].

- Avoid frequent and big changes of soil structure in reforestation, enriching plantations and track and firebreaks developments: it has to be said that reforestation works, most of them use machinery, often imply soil disturbances which can derive in soil carbon losses in the first years of the reforestation (Generalitat Valenciana, 2011)[16].
- Promote vegetation structures with broadleaves or, if not possible, mixed ones[17] (Generalitat Valenciana, 2011).

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applied, and riparian forests consisting of fast growing trees, are those with the highest carbon storage capacity. Also, pure mature vegetation structures whose area covered by trees is between 70% and 100% have less carbon storage capacity than the same vegetation structures with less area covered by trees (Generalitat Valenciana, 2011).

[15]Most carbon stored by forests is in the soil, which contains around three times more carbon than vegetation. Dead leaves, small branches and harvest detritus get into the soil structure and decomposes into stable organic aggregates, which can stay thousands of years (Generalitat Valenciana, 2011).

[16]Soil carbon losses are caused by climatic factors – mainly temperature – erosion, organic material mineralization, and carbon leakage (Generalitat Valenciana, 2011). Breaking soil structure favours contact between stable organic aggregates and oxygen, and increases soil carbon losses (FAO, 2002).

[17]In arid and Mediterranean climates, the highest average soil carbon content appears in vegetation structures with a deciduous tree layer, which doubles that of pastures and scrubs, and it is 60% more than in vegetation structures with a conifer tree layer (Generalitat Valenciana, 2011).

Annex 4. References that inspired each of the indicators

ECONOMIC CRITERIA

Persistence and stability of forest resources

Aspects	**Indicators**	**Sources**
New plants	Number of new plants in harvested area a certain time after harvesting.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1999; Kotwal *et al*., 2008; Montréal Process, 2007.
Tree layer	Number of tree plants per area unit.	Commonwealth of Australia, 1998; FAO, 1999; Montréal Process, 2007.
	Vigour/vitality of the trees of each species.	ATO/ITTO, 2003; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
Species diversity	Number of trees of each tree species per area unit.	AENOR, 2007; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001.
Genetic diversity	Number of individuals of the population of each tree species.	Commonwealth of Australia, 1998; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006;

		PNUD/FAO/SADC, 1999.
	In case of reforestations and enrichment plantations, the trees or seeds employed must be labelled and authorised.	AENOR, 2007; Commonwealth of Australia, 1998; GTC-FSC, 2007; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; PNUD/FAO/SADC, 1999.
	In case of reforestations and enrichment plantations, trees or seeds come from the same region where the forest is located.	AENOR, 2007; Commonwealth of Australia, 1998; GTC-FSC, 2007; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; PNUD/FAO/SADC, 1999.
	In case of reforestations and enrichment plantations, the origin of trees or seeds must be varied.	AENOR, 2007; Commonwealth of Australia, 1998; GTC-FSC, 2007; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; PNUD/FAO/SADC, 1999.
	Thinnings are not focused just on fast-growing individuals or those with a favourable morphology.	Thompson, 2011.
Disturbances	Area affected by disturbances.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1997; FAO,

		1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999.
	Species are adapted to site conditions (soil and climate).	GTC-FSC, 2007.
	A maximum time for harvest remainders is to stay in the forest is detrmined.	GTC-FSC, 2007.
	Integrated pest management: chemical treatments are not used in a preventative manner and always used when there is no possible alternative way.	GTC-FSC, 2007; SFI, 2010.
	Forest managers notice and inform on the existence of pests and diseases in their forests.	AENOR, 2007b; GTC-FSC, 2007.

Profitability of forest resources

Aspects	Indicators	Sources
In-kind incomes	Current value of resources present in the forest.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; PNUD/FAO/SADC, 1999; Pokharel y Larsen, 2007.
	Percentage of forest managed for production.	PROPOSED.
Money incomes	Incomes resulting from selling forest resources produced.	AENOR, 2007; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the

		Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; PNUD/FAO/SADC, 1999; Pokharel y Larsen, 2007.
	Expenses resulting management operations.	PROPOSED.
	Incomes due to subsidies and other sources different from forest resources produced.	PROPOSED.
Commercialisation	Demand estimation for the forest resources produced.	AENOR, 2007b; Commonwealth of Australia, 1998; Kotwal *et al*., 2008; Montréal Process, 2007; PNUD/FAO/SADC, 1999.
	Existing selling contracts.	PROPOSED.

Diversified exploitation of forests

Aspects	Indicators	Sources
Diversification	Forest area managed for the provision of each of the existing forest resources.	ATO/ITTO, 2003; International Expert Meeting on Monitoring, Assessment and Reporting on the

		Progress towards Sustainable Forest Management, 2001; FAO, 1999; SFI, 2010.
	Identification of possible resources to manage and sell.	ATO/ITTO, 2003; FAO, 1999; SFI, 2010.
	Demand estimation of possible resources to manage and sell.	PROPOSED.
Efficiency	The exploitation of forest resources respects the maximum quantity per period that management plans establish.	ATO/ITTO, 2003; Commonwealth of Australia, 1998; FAO, 1997; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999.
	Estimation of the exploitation of possible resources to manage and sell.	PROPOSED.
	Estimated value of possible resources to manage and sell.	AENOR, 2007.

SOCIAL CRITERIA

Employment and working conditions

Aspects	**Indicators**	**Sources**
Job opportunities	Number of employees in the forest.	AENOR, 2007; ATO/ITTO, 2003; Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; Pokharel y Larsen, 2007.
	Number of job posts is suitable to the activities required for the management.	ATO/ITTO, 2003; Commonwealth of Australia,

		1998; FAO, 1997; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; Pokharel y Larsen, 2007.
Training	Workers' training is suitable for their posts.	AENOR, 2007, ATO/ITTO, 2003; Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management,

		2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; Pokharel y Larsen, 2007.
	Training programs for workers and managers.	ATO/ITTO, 2003; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; OIMT-ITTO, 2005; SFI, 2010.
Contract conditions	Salaries and incentives respect collective agreements and are in accordance with regional standards.	ATO/ITTO, 2003; Commonwealth of Australia, 1998; GTC-FSC, 2007; Montréal Process, 2007; Mrosek *et al*, 2006;
	Working hours and extra work incentives are established in the contract.	PROPOSED.

	Types of contracts depending on contract length and number of contracts of each type.	PROPOSED.
Health and safety	There is a work risk prevention plan.	ATO/ITTO, 2003; GTC-FSC, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; SFI, 2010.
	Number of working accidents in a certain time period.	AENOR, 2007; Commonwealth of Australia, 1998; Montréal Process, 2007.
	Number of working diseases produced in a certain time period.	PROPOSED.

Recreation

Aspects	**Indicators**	**Sources**
Hunting fauna	Hunting species inventory.	AENOR, 2007.
	Captures number per species and time period.	AENOR, 2007.
	Hunting fauna infrastructures inventory.	PROPOSED.
Social use	Forest area managed for recreational use.	AENOR, 2007; Commonwealth of Australia, 1998; FAO,

		1997; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
	Number of visits for recreational purposes.	Commonwealth of Australia, 1998; Montréal Process, 2007.
Infrastructures	Recreational infrastructures inventory.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1997; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
Diversification	Types of recreational activities offered in the forest.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1997; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
Demand	Study potential recreational activities.	PROPOSED.
	Estimate demand of potential recreational activities.	PROPOSED.

Visual character

Aspects	Indicators	Sources
Outstanding elements	Visual outstanding elements inventory.	Mrosek *et al*, 2006.
Watching areas	Main watching areas inventory.	PROPOSED.
Views	Watching areas views valuation by means of participatory processes.	PROPOSED.
Diversity	Total forest area harvested the previous year.	SFI, 2010.
	Length of tracks and firebreaks in the forest.	SFI, 2010.
	Inventory of human elements (aerials, constructions, surveillance towers).	Madrigal, 2003.
	Forest area not covered by trees.	AENOR, 2007; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; Kotwal *et al*., 2008; Madrigal, 2003.
	Forest area covered by trees.	AENOR, 2007; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; Kotwal *et al*., 2008; Madrigal, 2003.
	Forest area covered by scattered trees.	AENOR, 2007; Commonwealth

		of Australia, 1998; Eriksson y Lindhagen, 2001; Kotwal *et al*., 2008; Madrigal, 2003.
Visual integration	Visual integration of recent human activities a little time after they have occurred.	Madrigal, 2003.
	Unpleasant visual contrasts inventory.	PROPOSED.

Historical and cultural heritage

Aspects	**Indicators**	**Sources**
Elements	Tangible heritage elements inventory (natural o artificial).	AENOR, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; SFI, 2010.
Traditions	Customs, traditions and resource rights of use inventory.	ATO/ITTO, 2003; GTC-FSC, 2007; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; Pokharel y Larsen, 2007.

	Customs, traditions and resource right of use maintenance valuation by means of participatory processes.	AENOR, 2007; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.
Places character	Inventory of places holding a religious, spiritual or inspirational value.	AENOR, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; SFI, 2010.
	Valuation by means of participation of the maintenance of the character of the places holding a religious, spiritual or inspirational value.	AENOR, 2007; FAO, 1999; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards

		Sustainable Forest Management, 2001; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.

Participatory processes

Aspects	**Indicators**	**Sources**
Representation	Number of participating stakeholder groups.	ATO/ITTO, 2003; FAO, 1997; FAO, 1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
	Participants number (total and by stakeholder groups).	ATO/ITTO, 2003; FAO, 1997; FAO, 1999;

		International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; Pokharel y Larsen, 2007; SFI, 2010.
	Management issues whose decision making includes participatory processes.	AENOR, 2007; ATO/ITTO, 2003; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; OIMT-ITTO, 2005; SFI, 2010.

Leadership	Conflicts and their causes.	Blackstock *et al*, 2007.
	Solved conflicts.	ATO/ITTO, 2003; Blackstock *et al*, 2007; GTC-FSC, 2007; OIMT-ITTO, 2005;
	Topics addressed in the participatory process.	ATO/ITTO, 2003; Menzel *et al*, 2012; Rowe y Frewer, 2000; Tuler y Webler, 1999.
	Stakeholder groups or participants that have actively participated in the discussions.	ATO/ITTO, 2003; Menzel *et al*, 2012; Rowe y Frewer, 2000; Tuler y Webler, 1999.
	Agreements achieved.	Blackstock *et al*, 2007.
Information	Quality of the information on the topics to decide that participants have received.	International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management,

		2001; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
Objectives	Quality of the information on the objectives and expected development of the process that participants have received.	International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
Transparency	Participants understand how decisions are made when they do not take part in the final decision.	Mrosek *et al*, 2006.
Acceptance	Participants' level of acceptance of decisions made, once different points of view and process difficulties are understood.	Blackstock *et al*, 2007; Menzel *et al*, 2012; Moote *et al*, 1997.
Impact	Participants perceive their input in the final decisions.	ATO/ITTO, 2003; Blackstock *et al*, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on

		the Progress towards Sustainable Forest Management, 2001; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.

Education

Aspects	**Indicators**	**Sources**
Activities	Number of visits per time period with educational objectives.	PROPOSED.
	Number of informative sessions per period time.	PROPOSED.
	Existing agreements for educational visits and informative sessions.	GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; OIMT-ITTO, 2005; SFI, 2010.

Infrastructures	Forest educational infrastructures inventory.	GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; OIMT-ITTO, 2005; SFI, 2010.

Research

Aspects	**Indicators**	**Sources**
Monitoring	Regularity in data gathering for monitoring.	AENOR, 2007; ATO/ITTO, 2003; Commonwealth of Australia, 1998; GTC-FSC, 2007; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
	The information on the monitoring process is publicly reported.	GTC-FSC, 2007; Kotwal *et al*., 2008.
Research	Forest area where research projects take	OIMT-ITTO,

projects	part.	2005.
	Existing agreements for research projects.	AENOR, 2007; Commonwealth of Australia, 1998; FAO, 1997; Montréal Process, 2007; SFI, 2010.

ECOLOGICAL CRITERIA

Biodiversity and habitats

Aspects	**Indicators**	**Sources**
Flora diversity	Flora species inventory (diversity and abundance).	AENOR, 2007; ATO/ITTO, 2003; Commonwealth of Australia, 1998; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
	Vegetation layers in each vegetation formation.	PROPOSED.

Fauna diversity	Wild fauna species inventory (diversity and abundance).	AENOR, 2007; ATO/ITTO, 2003; Commonwealth of Australia, 1998; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; SFI, 2010.
Endangered species	Rare, endangered and endemic species inventory (species and abundance).	AENOR, 2007; ATO/ITTO, 2003; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.
	Biodiversity conservation sites	International Expert Meeting on

	inventory.	Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005.
Alien species	Alien species inventory.	ATO/ITTO, 2003; Eriksson y Lindhagen, 2001; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; SFI, 2010.
	Study on the convenience and dangers of introducing alien species.	PROPOSED.
	Inventory of species affected or disappeared because of alien species.	Pokharel y Larsen, 2007.
Habitats	Habitat conservation sites invnetory.	AENOR, 2007; GTC-FSC, 2007; International Expert Meeting on

		Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005.
	Forest habitats inventory.	AENOR, 2007; ATO/ITTO, 2003; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; SFI, 2010.
	Forest prioritary or relevent habitats inventory.	AENOR, 2007; ATO/ITTO, 2003; GTC-FSC, 2007; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007;

		Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.
	Motor vehicles and forest machinery circulation restrictions.	GTC-FSC, 2007.
	Presence of wood, dead trees and other habitat elements (stumps) where harvesting activities have occurred.	Eriksson y Lindhagen, 2001; SFI, 2010.
Ecological connectivity	Vegetation formations and their limits inventory.	PROPOSED.
	Continuity/naturalness of vegetation formations limits determination.	Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; GTC-FSC, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
	Fauna movement limitations exist to protect new plants or other justified cases.	GTC-FSC, 2007.

Hydrological regulation

Aspects	Indicators	Sources
Erosion	Forest area affected by compaction.	ATO/ITTO, 2003; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
	Forest area affected by erosion.	ATO/ITTO, 2003; Commonwealth of Australia, 1998; Eriksson y Lindhagen, 2001; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
	Determination of the erosion types that occur in each case.	PROPOSED.
	Erosion vulnerable areas identification.	AENOR, 2007; Commonwealth of Australia, 1998; Kotwal *et al*., 2008; OIMT-ITTO, 2005; SFI, 2010.
	Compaction vulnerable areas identification.	AENOR, 2007; Commonwealth of Australia, 1998; Kotwal *et al*., 2008; OIMT-ITTO, 2005; SFI, 2010.
	Forest area managed for protection	Commonwealth of Australia, 1998;

	functions.	FAO, 1997; FAO, 1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.
Soil productivity	Nutrient inventory in plots regularly distributed in the forest every certain time.	AENOR, 2007; ATO/ITTO, 2003; Commonwealth of Australia, 1998; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; Pokharel y Larsen, 2007.
	Pollutants inventory every certain time where fertilisers or pesticides have been applied.	Commonwealth of Australia, 1998; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006.
	Restrictions for the application of fertilisers and pesticides: quantity, composition, time of the year and allowed products.	AENOR, 2007; SFI, 2010.
Aquifer filling	Forest area managed to generate water surpluses for aquifer filling.	Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; International Expert Meeting on

		Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.
	Forest area suffering from soil infiltration problems.	ATO/ITTO, 2003; Commonwealth of Australia, 1998; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; Pokharel y Larsen, 2007.
Floods	Human infrastructures (tracks, bridges) allow free water circulation in hillsides and natural water channels.	GTC-FSC, 2007; OIMT-ITTO, 2005; SFI, 2010.
	Flood control infrastructures inventory.	ATO/ITTO, 2003; FAO, 1999.
	Vegetation quality in areas managed for protection functions.	PROPOSED.

Mass flow

Aspects	Indicators	Sources
Infrastructures	Mass flow regulation infrastructures inventory.	AENOR, 2007; ATO/ITTO, 2003; FAO, 1999.
Vegetation	Forest cover state in areas managed to prevent mass flow.	AENOR, 2007; ATO/ITTO, 2003; FAO, 1999.
Cartography and inventory	Mass flow risk areas identification.	AENOR, 2007.
	Inventory of mass flow events that have taken place.	AENOR, 2007.
	Forest area managed to prevent mass flow.	Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Montréal Process, 2007; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999; SFI, 2010.

Forest fires

Aspects	Indicators	Sources
Preventative silviculture	Fuel discontinuities (including harvesting remainders) between vegetation layers.	AENOR, 2007; GTC-FSC, 2007; PNUD/FAO/SADC, 1999.
	Bush density.	AENOR, 2007; GTC-FSC, 2007; PNUD/FAO/SADC, 1999.
Extinction aid infrastructures	Extinction aid infrastructures inventory.	AENOR, 2007; GTC-FSC, 2007; Pokharel y Larsen, 2007.
Affected forest	Forest area per time unit affected by forest fires.	Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; International Expert Meeting on Monitoring, Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999.
	Types and magnitude of forest fires occurred.	Commonwealth of Australia, 1998; FAO, 1997; FAO, 1999; International Expert Meeting on Monitoring,

		Assessment and Reporting on the Progress towards Sustainable Forest Management, 2001; Kotwal *et al*., 2008; Montréal Process, 2007; Mrosek y Balsillie, 2001; Mrosek *et al*, 2006; OIMT-ITTO, 2005; PNUD/FAO/SADC, 1999.
	Forest fires causes.	PROPOSED.

Carbon storage

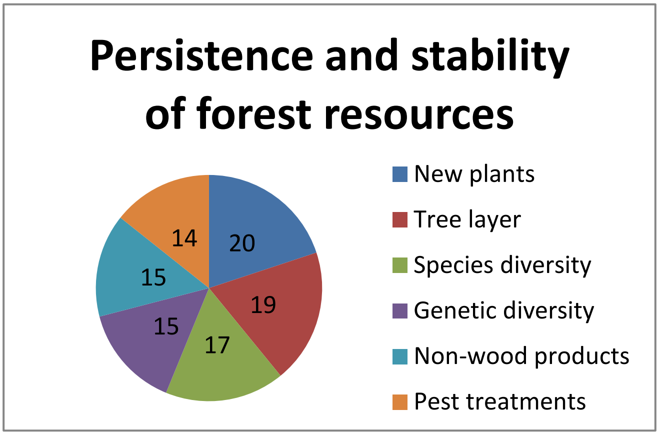
Aspects	**Indicators**	**Sources**
Vegetation	Total biomass in the forest (trunk, branches and leaves).	Commonwealth of Australia, 1998; FAO, 1997; OIMT-ITTO, 2005.
	Number of trees in young vegetation formations in areas managed to maximise biomass synthesis.	Generalitat Valenciana, 2011.
	Number of trees in adult vegetation formations in areas managed to maximise biomass synthesis.	Generalitat Valenciana, 2011.
	Bush density in bush formations in areas managed to maximise biomass synthesis.	Generalitat Valenciana, 2011.

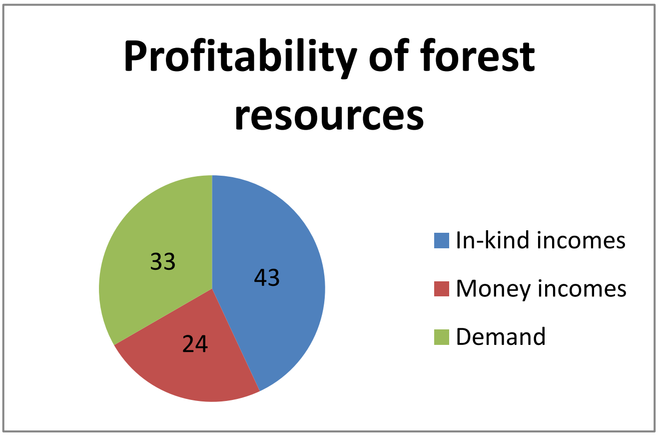
	Forest area managed to maximise biomass synthesis.	FAO, 1997.
Soils	Forest area showing dry and cracked soils.	FAO, 2002.
	Forest area where soil structure has been broken or altered.	PROPOSED.

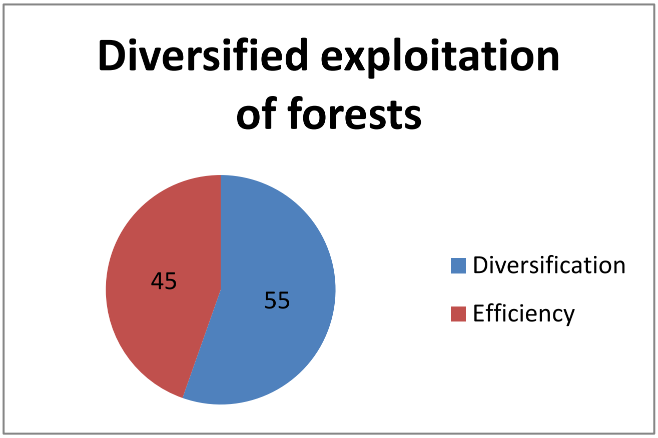
Annex 5. Results of the participatory process

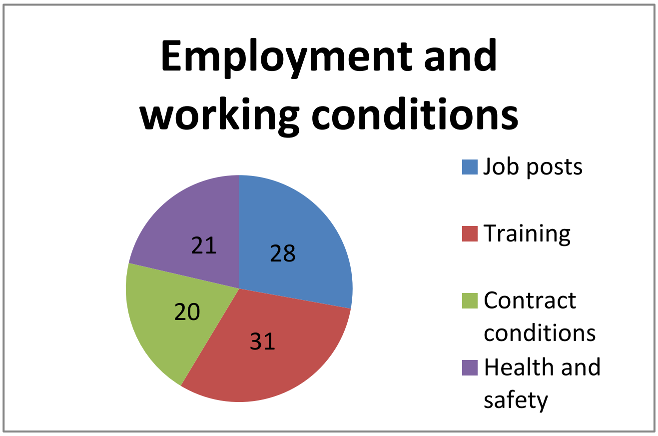
In this appendix, the aggregated weights (expressed in %) of the elements of each question of the participatory process are displayed in graphs.

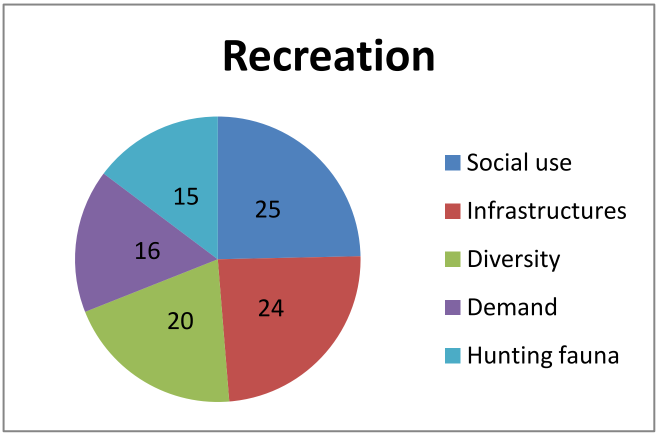
Aspects of the criteria

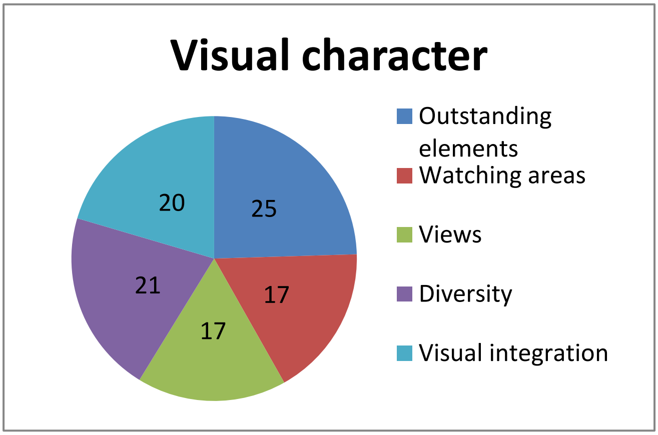


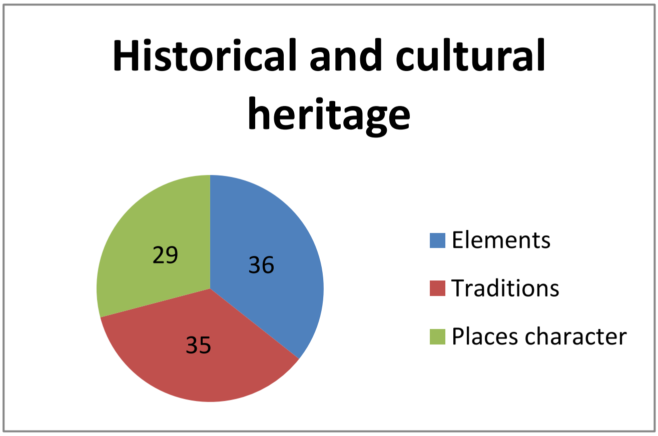


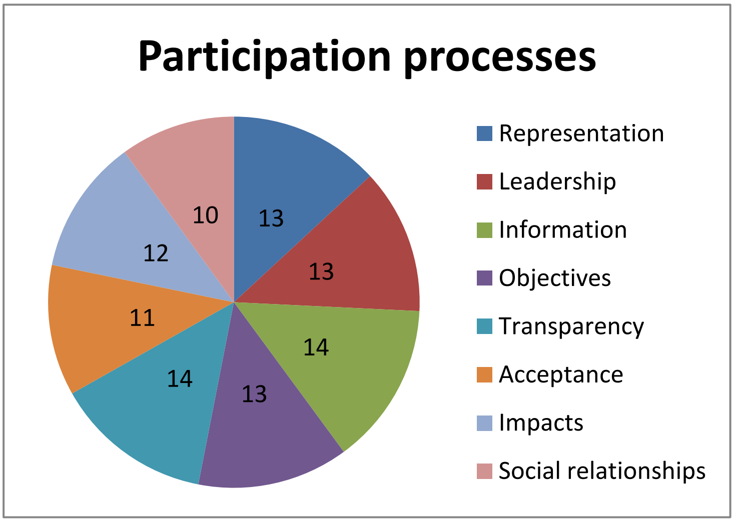

Diversified exploitation of forests
45
55
Diversification
Efficiency

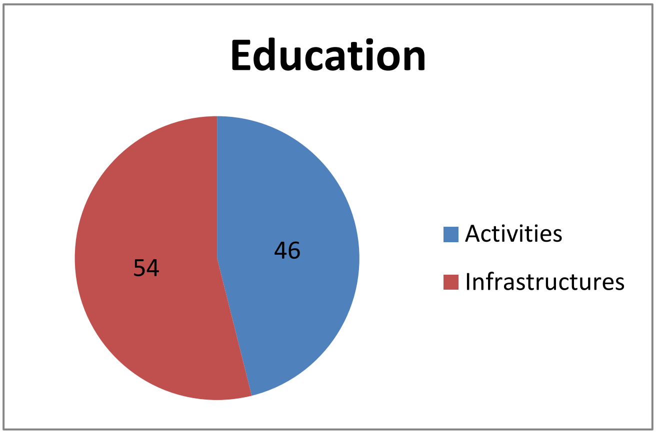

Employment and working conditions
21
28
20
31
Job posts
Training
Contract conditions
Health and safety

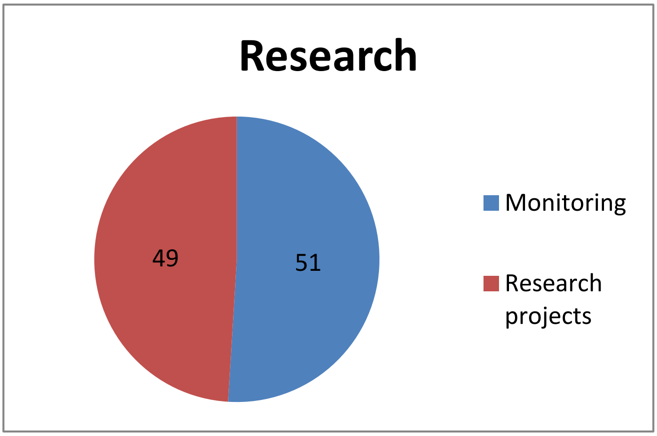

Recreation
15
25
16
20
24
Social use
Infrastructures
Diversity
Demand
Hunting fauna

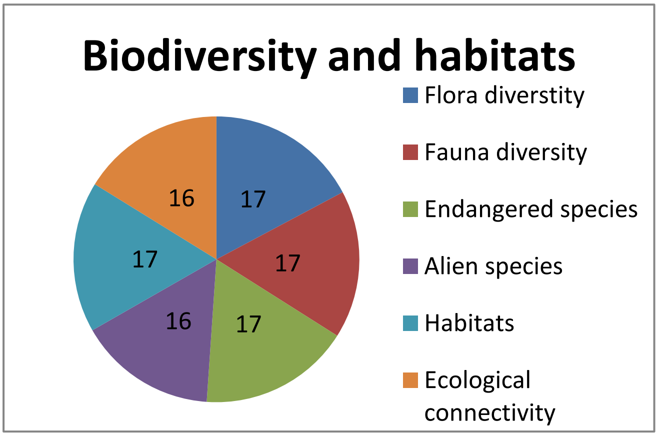

Visual character
Outstanding elements
Watching areas
Views
Diversity
Visual integration
25
17
17
21
20

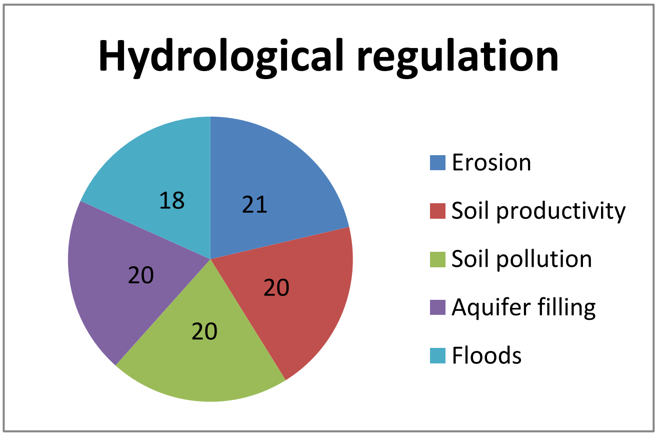

Historical and cultural heritage
Elements
Traditions
Places character
36
35
29

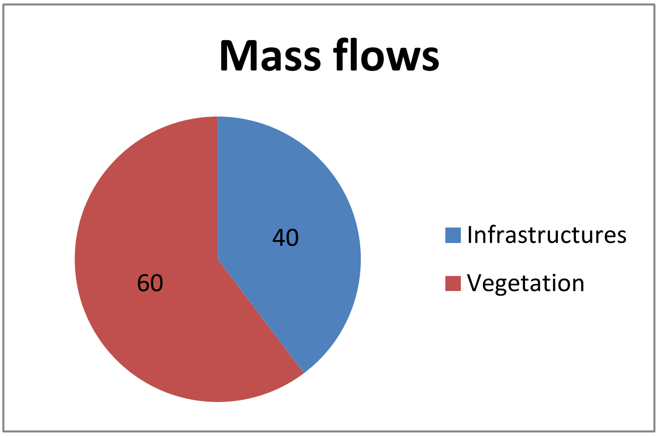

Participation processes
Representation
Leadership
Information
Objectives
Transparency
Acceptance
Impacts
Social relationships
13
13
14
13
14
11
12
10

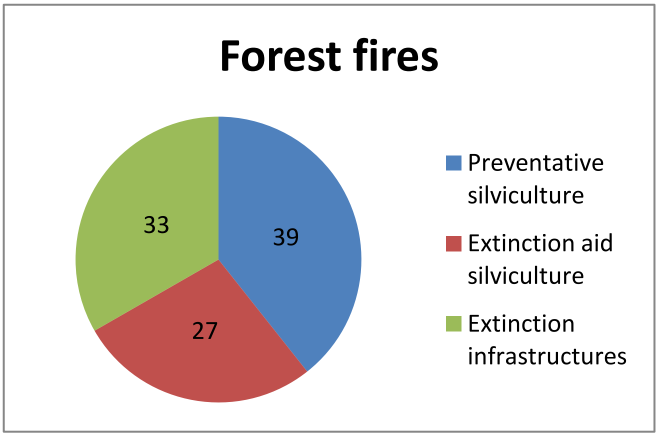

Education
46
54
Activities
Infrastructures

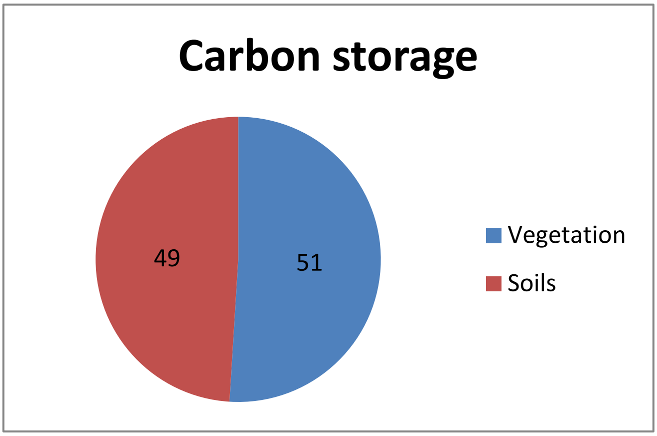

Research
49
51
Monitoring
Research projects


Biodiversity and habitats
16
17
17
17
16
17
Flora diverstity
Fauna diversity
Endangered species
Alien species
Habitats
Ecological connectivity

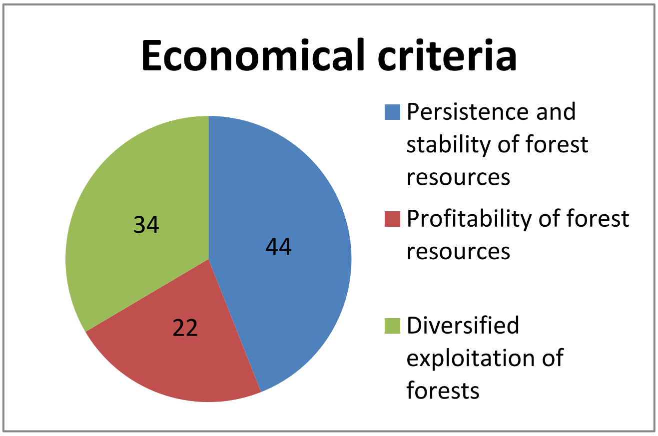

Hydrological regulation
21
20
20
20
18
Erosion
Soil productivity
Soil pollution
Aquifer filling
Floods

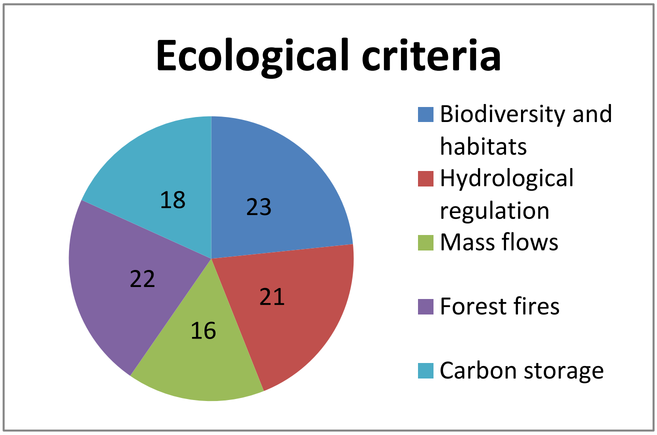

Mass flows
40
60
Infrastructures
Vegetation

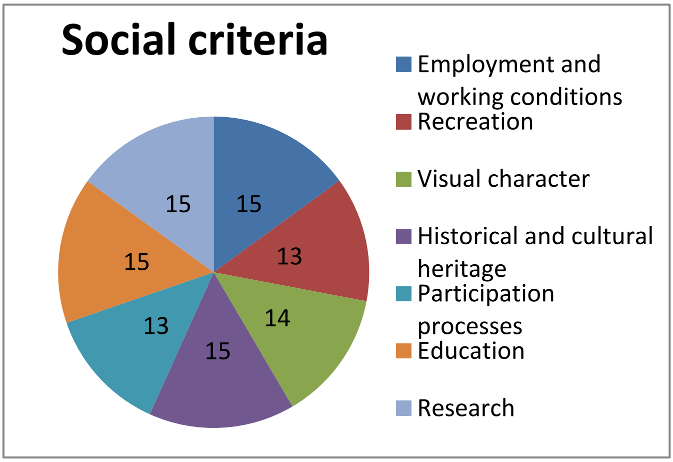

Forest fires
39
27
33
Preventative silviculture
Extinction aid silviculture
Extinction infrastructures

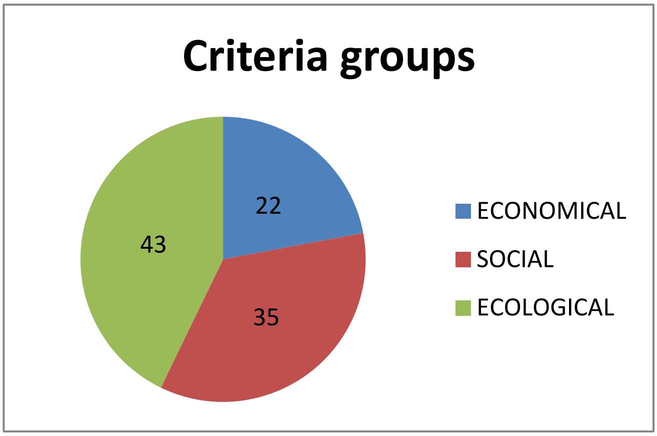


Criteria of each group and groups of criteria






Social criteria
15
15
13
14
15
13
15
Employment and working conditions
Recreation
Visual character
Historical and cultural heritage
Participation processes
Education
Research


Criteria groups
22
35
43
ECONOMICAL
SOCIAL
ECOLOGICAL

Annex 6. AHP questionnaire of indicators to experts

INDCIATORS OF SUSTAINABLE FOREST MANAGEMENT UNDER MEDITERRANEAN CONDITIONS APPLICABLE AT THE FOREST MANAGEMENT UNIT SCALE

This questionnaire exists in the framework of a PhD thesis[18] and a research project[19] whose objective is to identify criteria and indicastors of sustainable forest management under Mediterranean conditions and applicable at the forest management unit scale.

In this step of the research it is intended to prioritise the indicators previously identified taking into account the relevance that experts in forest management (or related disciplines) give to them. The selected method has been developed by Thomas Saaty, and it is known as Analytical Hierarchy Process (AHP); it consists of comparing the elements proposed (in this case indicators) grouped in pairs, and of determining which of the elements of the pair is more important and how much more important depending on the experience and knowledge of the respondent. The valuation is carried out according to a scale that is displayed two pages ahead.

The criteria identified are grouped in three categories: *economic criteria*, *social criteria* and *ecological criteria*. Later on, a pairwise comparison of the indicators of each criterion is asked. PLEASE, PROVIDE A VALUE TO ALL THE COMPARISONS

[18] Granted (*VALi+d*) by the Regional Ministry of Education, Culture and Sports of the Region of Valencia (ref. ACIF/2010/248).
[19] The project is named *Multicriteria Techniques and Group Decision Making for a Sustainable Management* (ref. ECO2011-27369) and it is funded by the Spanish Ministry of Economy and Competitiveness.

IN ORDER FOR THE QUESTIONNAIRE TO BE CONSIDERED VALID. Highlight the selected option by your preferred means: italics, underline, change of colour, etc.

To make the questionnaire faster only one indicator of each criterion is compared against the others of the same criterion. The rationale behind this procedure is that, for example, given three elements to compare in pairs: A, B and C. If the respondent says that A is 3 times more important than B, and that A is 7 times more important than C, and he is consistent, he will say that B is 4 times more important than C. Therefore, all the other comparisons are deduced from comparing just one indicator of every criterion against the others of the same criterion.

In the last page of the questionnaire a space is provided to make comments. In that space, optionally, comments related to the indicators of any criterion are welcome: writing, apects considered, proposal of other indicators or clarifying any of the valuations made.

Thank you very much for your participation.

SCALE TO MAKE THE COMPARISONS IN EACH INDICATOR PAIR

Intensity of the relevance of an indicator compared with another one	Definition	Explanation
1	Same relevance	Both indicators hold the same relevance.
2		Intermediate relevance between 1 and 3.
3	Moderate relavance	Experience and pinion slightly in favour of the first indicator against the second one.
4		Intermediate relevance between 3 and 5.
5	Strong relevance	Experience and opinion strongly in favour of the first indicator of the pair.
6		Intermediate relevance between 5 and 7.
7	Much more relevance	Experience and opinion give much more relevance to the first indicator of the pair.
8		Intermediate relevance between 7 and 9.
9	Extreme relevance	Evidence in the highest posible degree in favour of the fisrt indicator against the second one in the pairwise comparison.
1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8 y 1/9	These values are selected when a **higher relvance** is given **to the second indicator of each pair**. The value of the denominator depends on the relative relevance of the second indicator against the first one according to the same scale displayed in this table.	

Source: Saaty, T.L., 2006. *Fundamentals of decision making and priority theory with the analytic hierarchy process.* RWS Publications. Pittsburgh (USA), 478pp.

PERSONAL DATA

REMARK: the information provided in the questionnaires will be analysed anonymously. The aim of these general questions is to describe the profiles of the respondents. It is optional to answer them but, if possible, it is asked to fill the information concerning **occupation**, **forest property** and **job position**.

Sex	M	F				
Age	< 20	20-29	30-39	40-49	50-59	> 60
Occupation	University	Authorities	Research Centre			
	Public Enterprise	Freelance	Private Enterprise			
Forest Owner	YES	NO				
Background	Highshool	Professional Training	Graduate	Master	PhD	
Job Position	Boss	Technician				

ECONOMIC CRITERIA

1. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management persistence and stability of forest resources.

Definition of the criterion: management guarantees that certain quantities of the resources which imply incomes to the forest management unit stay constantly in the forest and survive pests and diseases.

Indicators:

1. Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
2. Vigour/vitality of a sample of the trees of each species per unit of area.
3. Inventory of tree species populations.
4. In case of reforestations and enrichment plantations, the trees or seeds employed must be labelled and authorised.
5. In case of reforestations and enrichment plantations, trees or seeds come from the same region where the forest is located.
6. In case of reforestations and enrichment plantations, the origin of trees or seeds must be varied.
7. Thinning is not focused just on fast-growing individuals or those with a favourable morphology.
8. A maximum time for harvest remainders to stay in the forest is determined.
9. Integrated pest management: chemical treatments are not used in a preventive manner and they are always used when there is no other possible way.

<table>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
Vigour/vitality of a sample of the trees of each species per unit of area.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
Inventory of tree species populations.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
</table>

<table>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
In case of reforestations and enrichment plantations, the trees or seeds employed must be labelled and authorised.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
In case of reforestations and enrichment plantations, trees or seeds come from the same region where the forest is located.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
In case of reforestations and enrichment plantations, the origin of trees or seeds must be varied.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
<tr><td rowspan="2">Number of new plants per species of the tree layer in harvested area a certain time after harvesting.
vs.
Thinnings are not focused just on fast-growing individuals or those with a favourable morphology.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>1/2</td><td>1/3</td><td>1/4</td><td>1/5</td><td>1/6</td><td>1/7</td><td>1/8</td><td>1/9</td></tr>
<tr><td>Number of new plants per species of the tree layer in harvested area a certain time after</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
</table>

harvesting. **vs.** **A maximum time for harvest remainders to stay in the forest is determined.**		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of new plants per species of the tree layer in harvested area a certain time after harvesting. **vs.** **Integrated pest management: chemical treatments are not used in a preventative manner and always used when there is no possible alternative way.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

2. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management profitability of forest resources.

Definition: when planning forest management it has to be considered obtaining in-kind incomes and money incomes, annual or periodic, variable or constant.

Indicators:

1. Current value of resources present in the forest (not harvested).
2. Percentage of forest area managed for production.
3. Incomes resulting from selling the forest resources harvested.
4. Expenses resulting from management operations.
5. Incomes due to subsidies and other sources different from forest resources produced.
6. Estimation of the demand of the forest resources produced.
7. Selling contracts that exist between the forest managers and enterprises.

Current value of resources present in the forest (not harvested). **vs.** **Percentage of forest area managed for production.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Current value of resources present in the forest (not harvested). **vs.** **Incomes resulting from selling the forest resources harvested.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Current value of resources present in the forest (not harvested). **vs.** **Expenses resulting from management operations.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Current value of resources present in the forest (not harvested). **vs.** **Incomes due to subsidies and other sources different from forest resources produced.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Current value of resources present in the forest (not harvested). **vs.** **Estimation of the demand of the forest resources produced.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Current value of resources present in the forest (not harvested). **vs.** **Selling contracts that exist between the forest managers and enterprises.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

3. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management diversified exploitation of forests.

Definition: as part of the management an inventory of present and potential goods and services has to be donde and the best use of them has to be determined.

Indicators:

1. Forest area managed for the provision of each of the existing forest resources.

2. Exploitation (harvest or use) per period of time of each of the existing forest resources.
3. Identification of potential resources to manage and sell (nowadays they are not managed nor sold).
4. Estimation of the demand of potential resources to manage and sell.
5. Estimation of the exploitation of potential resources to manage and sell.

Forest area managed for the provision of each of the existing forest resources. vs. Exploitation (harvest or use) per period of time of each of the existing forest resources.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for the provision of each of the existing forest resources. vs. Identification of potential resources to manage and sell (nowadays they are not managed nor sold).	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for the provision of each of the existing forest resources. vs. Estimation of the demand of potential resources to manage and sell.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for the provision of each of the existing forest resources. vs. Estimation of the exploitation of potential resources to manage and sell.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

SOCIAL CRITERIA

4. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management employment and working conditions.

Definition: the number of job posts (and thus, employees) in the FMU is appropriate to the management tasks that are carried out, employees' working conditions are good and they have suitable training to develop their functions.

Indicators:

1. Number of employees in the forest.
2. Workers' training is suitable for their posts.
3. Salaries and incentives respect collective agreements and are in accordance with regional standards.
4. Working hours and extra work incentives are established in the contract.
5. Types of contracts depending on contract length and number of contracts of each type.
6. There is a working risks prevention plan.
7. Number of working accidents in a certain period of time.
8. Number of working diseases produced in a certain period of time.

Number of employees in the forest. vs. Workers' training is suitable for their posts.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of employees in the forest. vs. Salaries and incentives respect collective agreements and are in accordance with regional standards.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of employees in the forest. vs. Working hours and extra work incentives are established in the contract.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of employees in the forest. vs. Types of contracts depending on contract length and number of contracts of each type.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Number of employees in the forest. vs. There is a working risks prevention plan.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of employees in the forest. vs. Number of working accidents in a certain period of time.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of employees in the forest. vs. Number of working diseases produced in a certain period of time.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

5. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management recreation.

Definition: there are infrastructures in the FMU for its social use in different ways: leisure (picnic, walking, trekking, fauna watching, camping), sports or hunting.

Indicators:

1. Forest area managed for recreational use.
2. Hunting species inventory.
3. Hunting fauna infrastructures inventory: number, type and conservation state.
4. Captures number per species and period of time.
5. Number of visits for recreational purposes.
6. Recreational infrastructures inventory: state of conservation.
7. Types of recreational activities offered in the forest.
8. Study of potential recreational activities (which could be offered but they are not).
9. Estimation of the demand of potential recreational activities.

Forest area managed for recreational use. vs. Hunting species inventory.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Forest area managed for recreational use. vs. Hunting fauna infrastructures inventory: number, type and conservation state.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Captures number per species and period of time	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Number of visits for recreational purposes.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Recreational infrastructures inventory: state of conservation.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Types of recreational activities offered in the forest.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Study of potential recreational activities (which could be offered but they are not).	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for recreational use. vs. Estimation of the demand of potential recreational activities.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

6. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management visual character.

Definition: management maintains the visual features of the FMU that identify it and make it attractive and improves them when they have been degraded.

Indicators:

1. Main watching areas inventory: number and state of conservation.
2. Valuation of the views from the main watching areas by means of participatory processes.
3. Total forest area harvested the previous year.
4. Length of paths, small roads and firebreaks in the forest.
5. Inventory of human elements (aerials, constructions, surveillance towers).
6. Forest area not covered by trees (scrubs, pastures).
7. Forest area covered by trees.
8. Forest area covered by scattered trees.
9. Valuation by means of participation of the visual integration of recent human activities.

Main watching areas inventory: number and state of conservation. vs. Valuation of the views from the main watching areas by means of participatory processes.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. vs. Total forest area harvested the previous year.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. vs. Length of paths, small roads and firebreaks in the forest.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Main watching areas inventory: number and state of conservation. **vs.** **Inventory of human elements (aerials, constructions, surveillance towers).**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. **vs.** **Forest area not covered by trees (scrubs, pastures).**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. **vs.** **Forest area covered by trees.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. **vs.** **Forest area covered by scattered trees.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Main watching areas inventory: number and state of conservation. **vs.** **Valuation by means of participation of the visual integration of recent human activities.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

7. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management historical and cultural heritage.

Definition: management preserves the features and places of the FMU holding a historical or cultural meaning, either tangible (charcoal kilns) or intangible (pilgrimages), natural or artificial.

Indicators:

1. Tangible heritage elements inventory (natural o artificial): state of conservation.
2. Valuation by means of participation of the maintenance of customs, traditions and right of use of forest resources.

3. Valuation by means of participation of the maintenance of the character of the places holding a religious, spiritual or inspirational significance.

Tangible heritage elements inventory (natural o artificial): state of conservation. vs. Valuation by means of participation of the maintenance of customs, traditions and right of use of forest resources.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Tangible heritage elements inventory (natural o artificial): state of conservation. vs. Valuation by means of participation of the maintenance of the character of the places holding a religious, spiritual or inspirational significance.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

8. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management participatory processes.

Definition: take account of stakeholders and affected people's experience and points of view in forest management decisions.

Indicadores:

1. Number of stakeholder groups and number of participants of each group in every participatory process.
2. Management issues that include participatory processes in the decision making process.
3. Conflicts that have been solved in each participatory process.
4. Stakeholder groups or participants that have participated actively in the discussions.
5. Agreements achieved.
6. Quality of the information on the topics to make decisions that participants have previously received.
7. Quality of the information on the objectives and expected development of the process that participants have received.
8. When final decisions are made by managers after the participatory process, participants know and understand how these decisions are made.

9. Participants perceive that the final decision-making has considered their contributions during the process.

Number of stakeholder groups and number of participants of each group in every participatory process. vs. Management issues that include participatory processes in the decision making process.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. vs. Conflicts that have been solved in each participatory process.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. vs. Stakeholder groups or participants that have participated actively in the discussions.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. vs. Agreements achieved.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. vs. Quality of the information on the topics to make decisions that participants have previously received.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Number of stakeholder groups and number of participants of each group in every participatory process. **vs.** **Quality of the information on the objectives and expected development of the process that participants have received.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. **vs.** **When final decisions are made by managers after the participatory process, participants know and understand how these decisions are made.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of stakeholder groups and number of participants of each group in every participatory process. **vs.** **Participants perceive their input in the final decisions.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

9. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management <u>education.</u>

<u>Definition:</u> forest management favours society's education and awareness on the cultural, environmental and economic significance of forestry and natural areas.

<u>Indicators:</u>

1. Number of visits per period of time with educational objectives.
2. Number of informative sessions per period of time that take place in the forest.
3. Agreements for educational visits and informative sessions that exist between the forest managers and enterprises or educational institutions.

4. Forest educational infrastructures inventory: state of conservation.

Number of visits per period of time with educational objectives. vs. Number of informative sessions per period of time that take place in the forest.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of visits per period of time with educational objectives. vs. Agreements for educational visits and informative sessions that exist between the forest managers and enterprises or educational institutions.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Number of visits per period of time with educational objectives. vs. Forest educational infrastructures inventory: state of conservation.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

10. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management research.

Definition: the use of forests as an object of scientific studies, either to improve the management (and the information on its goods and services) or to increase the knowledge of other disciplines (ecology).

Indicators:

1. The information of statistical or research interest that has been gathered for monitoring and assessment processes is publicly reported.
2. Forest area where research projects are being carried out.
3. Agreements that exist for research projects between forest managers and universities, research centres and other public or private institutions or enterprises.

The information of statistical or research interest that has been gathered for monitoring and assessment processes is publicly reported. **vs.** **Forest area where research projects are being carried out.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
The information of statistical or research interest that has been gathered for monitoring and assessment processes is publicly reported. **vs.** **Agreements that exist for research projects between forest managers and universities, research centres and other public or private institutions or enterprises.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

ECOLOGICAL CRITERIA

11. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management biodiversity and habitats.

Definition: management keeps species and habitats diversity and habitats connectivity in order to maintain and improve forest capacity to recover after disturbances.

Indicators:

1. Flora species inventory.
2. Vegetation layers in each vegetation formation.
3. Wild fauna species inventory.
4. Rare, endangered and endemic species inventory.
5. Alien species inventory.
6. Forest habitats inventory: state of conservation.
7. Motor vehicles and forest machinery circulation restrictions.
8. Presence of wood, dead trees and other habitat elements (stumps) where harvesting activities or silvicultural treatments have taken place.

9. There are no barriers to fauna movements nor to seed dispersal, except when it is necessary to protect new plants or for other justified reasons.

Flora species inventory[20]. vs. Vegetation layers in each vegetation formation.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Wild fauna species inventory[21].	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Rare, endangered and endemic species inventory.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Alien species inventory.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Forest habitats inventory: state of conservation.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Motor vehicles and forest machinery circulation restrictions.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Flora species inventory. vs. Presence of wood, dead trees and other habitat elements (stumps) where harvesting activities or silvicultural treatments have taken place[22].	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

[20] This indicator refers only to bushy and herbaceous species because tree species have been included in the criterion *persistence and stability of forest resources.*
[21] Wild fauna refers to not hunting fauna.
[22] This indicator is in contradiction with the indicator of the criterion *persistence and stability of forest* resources: "a maximum time for harvest remainders to stay in the forest is determined". Remainders improve the habitat but favour the entrance of pests. It is advisable to establish maximum quantities of remainders to stay in the forest, a maximum stay time for bigger quantities and avoid remainders with bark.

Flora species inventory. **vs.** **There are no barriers to fauna movements nor to seed dispersal, except when it is necessary to protect new plants or for other justified situations.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

12. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management hydrological regulation.

Definition: management keeps infrastructures and vegetation in a state that protects soil quantity and quality, and regulates on-site (infiltration, runoff speed) and off-site (aquifer filling, flood control) water flows.

Indicators:

1. Forest area managed for protection functions: avoid erosion and floods.
2. Forest area affected by different types of erosion: laminar, trails, gullies.
3. Forest area affected by compaction.
4. Nutrient inventory every certain time in plots regularly distributed in the forest.
5. Restrictions to the application of fertilisers and pesticides: quantity, composition, time of the year and allowed products.
6. Forest area managed to generate water surpluses for aquifer filling.
7. Forest area suffering from soil infiltration problems.
8. Human infrastructures (paths and small roads, bridges) allow free water flow in hillsides and natural water channels.
9. Flood control infrastructures inventory: adequate number and state of conservation (when the forest manager is responsible for their construction and maintenance).

Forest area managed for protection functions: avoid erosion and floods. **vs.** **Forest area affected by different types of erosion: laminar, trails, gullies.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. **vs.** **Forest area affected by compaction.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Forest area managed for protection functions: avoid erosion and floods. vs. Nutrient inventory every certain time in plots regularly distributed in the forest.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. vs. Restrictions to the application of fertilisers and pesticides: quantity, composition, time of the year and allowed products.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. vs. Forest area managed to generate water surpluses for aquifer filling.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. vs. Forest area suffering from soil infiltration problems[23].	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. vs. Human infrastructures (paths and small roads, bridges) allow free water flow in hillsides and natural water channels.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Forest area managed for protection functions: avoid erosion and floods. vs. Flood control infrastructures	1	2	3	4	5	6	7	8	9

[23] Soils suffering from soil infiltration problems difficult aquifer filling and may favour runoff if they are on a slope, besides other problems like bad soil oxygenation.

inventory: adequate number and state of conservation (when the forest manager is responsible for their construction and maintenance).		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

13. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management mass flows.

Definition: management prevents landslides and avalanches.

Indicators:

1. Mass flow regulation infrastructures inventory: state of conservation.
2. Forest cover state in areas managed to prevent mass flows.
3. Inventory of mass flow events that have taken place per period of time and damages produced.
4. Forest area managed to prevent mass flows.

<table>
<tr><td rowspan="2">Mass flow regulation infrastructures inventory: state of conservation.
vs.
Forest cover state in areas managed to prevent mass flows.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
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vs.
Inventory of mass flow events that have taken place per period of time and damages produced.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
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<tr><td rowspan="2">Mass flow regulation infrastructures inventory: state of conservation.
vs.
Forest area managed to prevent mass flows.</td><td rowspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
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14. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management forest fires.

Definition: Management prevents forest fires and facilitates extinction, so as to keep their frequency, intensity and consequences in an ecologically sustainable and socially acceptable level.

Indicators:

1. Fuel discontinuities (including harvest remainders) between vegetation layers.
2. Bush density.
3. Fire prevention and extinction aid infrastructures inventory: number and state of conservation.
4. Forest area per period of time affected by forest fires.
5. Types of forest fires occurred: soil fire, superficial fire or tree crown fire.
6. Causes of forest fires.

Fuel discontinuities (including harvest remainders) between vegetation layers. vs. Bush density.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Fuel discontinuities (including harvest remainders) between vegetation layers. vs. Fire prevention and extinction aid infrastructures inventory: number and state of conservation.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Fuel discontinuities (including harvest remainders) between vegetation layers. vs. Forest area per period of time affected by forest fires.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

Fuel discontinuities (including harvest remainders) between vegetation layers. **vs.** **Types of forest fires occurred: soil fire, superficial fire or tree crown fire.**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Fuel discontinuities (including harvest remainders) between vegetation layers. **vs.** **Causes of forest fires[24].**	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

15. State the relative importance of the following indicator pairs for monitoring and assessing the criterion of sustainable forest management carbon storage.

Definition: forest management contributes to global climate change mitigation through maximising biomass synthesis and maintaining soil carbon storage capacity.

Indicators:
1. Total biomass in the forest (trunks, branches and leaves).
2. Number of trees in young vegetation formations in areas managed to maximise biomass synthesis.
3. Percentage of area under a tree canopy in adult vegetation formations in areas managed to maximise biomass synthesis.
4. Quocient between area occupied by young vegetation formations and adult vegetation formations in areas managed to maximise biomass synthesis.
5. Species composition of the tree layer that optimises carbon storage, considering climate and soil limitations, in areas manged to maximise biomass synthesis.
6. Forest area managed to maximise biomass synthesis.
7. Forest area showing dry and cracked soils.
8. Forest area where soil structure has been broken or altered because of reforestations or paths or small roads construction.
9. In areas managed to comply with this criterion harvest and silvicultural treatment are avoided or minimised so as to keep soil carbon.

[24] In order to determine if the reason and magnitude of the fire could have been avoided with a better management or it would have happened anyway.

Total biomass in the forest (trunks, branches and leaves). vs. Number of trees in young vegetation formations in areas managed to maximise biomass synthesis[25].	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. Percentage of area covered by trees in adult vegetation formations in areas managed to maximise biomass synthesis[26].	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. Quocient between area occupied by young vegetation formations and adult vegetation formations in areas managed to maximise biomass synthesis.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. Species composition of the tree layer that optimises carbon storage, considering climate and soil limitations, in areas manged to maximise biomass synthesis.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

[25] Young vegetation formations, when they have suitable densities, synthesise the most biomass; however, if they have very high densities tree growth blocks.

[26] En masas adultas puras con fracción de cabida cubierta entre el 70% y el 100% la captura de carbono es menor que con fracciones de cabida cubierta menores.

Total biomass in the forest (trunks, branches and leaves). vs. Forest area managed to maximise biomass synthesis.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. Forest area showing dry and cracked soils	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. Forest area where soil structure has been broken or altered because of reforestations or paths or small roads construction.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
Total biomass in the forest (trunks, branches and leaves). vs. In areas managed to comply with this criterion harvest and silvicultural treatment are avoided or minimised so as to keep soil carbon.	1	2	3	4	5	6	7	8	9
		1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

COMMENTS