UNIVERSITÀ DEGLI STUDI DELLA TUSCIA

Dipartimento di Scienze dell'Ambiente Forestale
e delle sue Risorse (DISAFRI)

A Multicriteria Decision Framework: Assessing synergies among the Rio Conventions at forestry project level

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CORSO DI DOTTORATO DI RICERCA IN
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Abstract

Multilateral Environmental Agreements, in particular de Rio Conventions (UNFCCC, CBD and UNCCD) have the challenge to implement synergies at different levels (international, national and local). The objective of this research was the identification of an appropriate approach to evaluate synergies at forestry project level. Attention was given to the social, economic, and environmental aspects from the forestry sector as well as the forestry ecosystem services. A decision aiding process was triggered, implying the problem definition, problem formulation, evaluation model, and final recommendations. A multi-criteria approach (*Multicriteria Decision Aid, MCDA*) was adopted as the suitable scientific framework. For improving the quality of the decision aiding process, different decision support tools were used, namely the international questionnaire, the interview with national and international forestry experts, discussions with operational research experts and multivariate statistical analysis. The coherence of forestry projects with the objectives of sustainable development and the Rio Conventions were evaluated with a Multi Criteria Sorting Method (ELECTRE TRI), which allowed obtaining a compromise solution. Moreover, different information and expectations was aggregated, and multiple criteria with conflicting, multidimensional and incomparable characteristics in the assessment of forestry projects were considered.

Key words: synergies, Rio Conventions, MCDA, forestry projects

Riassunto

Gli Accordi Ambientali Multilaterali, in particolare le Convenzioni di Rio di Janeiro (UNFCCC, CBD e UNCCD) si propongono di implementare le sinergie a diversi livelli (internazionale, nazionale e locale). L'obiettivo della ricerca è stato l'identificazione di un approccio adeguato per la valutazione delle sinergie a livello di progetti forestali. Gli aspetti sociali, economici ed ambientali del settore forestale, così come i servizi offerti dall'ecosistema forestale, sono stati considerati. E' stato avviato un processo d'aiuto alla decisione, implicante la definizione della problematica, formulazione del problema, definizione delle variabili che il modello decisionale dovrà trattare e la formulazione delle raccomandazioni finali. L'approccio multi-criteriale (*Multicriteria Decision Aid, MCDA*) è stato adottato come idoneo quadro scientifico. Per migliorare la qualità del processo d'aiuto alla decisione, diversi strumenti di supporto alla decisione sono stati utilizzati, il questionario internazionale, l'intervista con esperti forestali nazionali ed internazionali, la discussione con esperti in ricerca operativa e l'analisi statistica multivariata. La coerenza dei progetti forestali con gli obiettivi dello sviluppo sostenibile e delle Convenzioni di Rio è stata valutata mediante un metodo multi-criteriali di tipo *sorting* (ELECTRE TRI), in grado di condurre ad una soluzione di compromesso. Ciò ha permesso di aggregare diverse informazioni ed aspettative e di considerare criteri multipli con caratteristiche di conflittualità, multidimensionalità e incomparabilità nella valutazione dei progetti forestali.

Parole chiave: sinergie, Convenzioni di Rio, MCDA, progetti forestali

Resumen

Los Acuerdos Multilaterales sobre Medio Ambiente, en particular las Convenciones de Rio de Janeiro (UNFCCC, CBD y UNCCD), tienen el desafío de implementar las sinergias en diferentes niveles (internacional, nacional y local). El objetivo del trabajo de investigación ha sido identificar un enfoque apropiado para la evaluación de las sinergias a nivel de proyectos forestales. Los aspectos sociales, económicos y ambientales del sector forestal así como los servicios de los ecosistemas forestales han sido considerados. Se ha activado con un proceso de ayuda a la decisión, que ha implicado la definición de la problematica, la formulación del problema, la definición de las variables che el modelo decisional utiliza y la formulación de las recomendaciones finales. El enfoque multi-criterial (*Multicriteria Decision Aid, MCDA*) se ha adoptado como marco científico idoneo. Para mejorar la calidad del proceso de ayuda a la decisión, diferentes instrumentos de apoyo a la decisión han sido utilizados, el questionario internacional, entrevistas con espertos forestales nacionales e internacionales, discusión con expertos en investigación operativa y el análisis estadístico multivarado. La coherencia de los proyectos forestales con los objetivos del desarrollo sostenible y de las Convenciones de Rio han sido evaluados con un método multi-criterial de tipo *sorting* (ELECTRE TRI), lograndose encontrar una solución de compromiso. Esto ha permitido de agregar diferente tipo de información y de espectativas y de considerar criterios multiples con características de conflictualidad, multidimensionalidad e incomparabilidad en la evaluación de proyectos forestales.

Palabras clave: sinergias, Convenciones de Rio, MCDA, proyectos forestales

Résumé

Les Accords multilatéraux sur l'environnement, en particulier les Conventions de Rio (UNFCCC, CBD et UNCCD) ont le défi d'appliquer des synergies aux niveaux différents (international, national et local). L'objectif de cette recherche était l'identification d'une approche appropriée pour évaluer les synergies au niveau de projets forestiers. Attention a été donnée aux aspects sociaux, économiques et écologiques du secteur forestier et également aux services de l'écosystème. Un procès d'aide à la décision a été déclenché, impliquant la définition du problème, la formulation du problème, le modèle d'évaluation, et les recommandations finales. Une approche multicritère (*Aide Multicritère à la Décision*) a été adoptée comme le cadre scientifique convenable. Pour améliorer la qualité du procès d'aide à la décision, différents outils de soutien à la décision ont été utilisés, comme le questionnaire international, l'entretien avec experts forestiers nationaux et internationaux, les discussions avec les experts de recherche opérationnelle et l'analyse statistique multivariée. La cohérence des projets avec les objectifs de développement soutenable et les Conventions de Rio a été évaluée avec une méthode multicritère de type *sorting* (ELECTRE TRI), qui a permis d'obtenir une solution de compromis. En plus, l'information et les différentes espérances ont été agrégées, et on a considéré des critères multiples ayant les caractéristiques de conflictualité, multidimensionnalité et incomparabilité dans l'évaluation des projets forestiers.

Mots clés : synergies, Conventions de Rio, MCDA, projets forestiers

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Acronyms and abbreviations

CBA	Cost-benefit analysis
CBD	Convention on Biological Diversity
CCD	Convention to Combat Desertification
CEA	Cost-effectiveness analyses
CIFOR	Central for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
COP	Conference of the Parties
CPF	Collaborative Partnership on Forests
CRIC	Committee for the Review of the Implementation of the Convention
CST	Committee on Science and Technology
DAC	Development Assistance Committee
EIA	Environmental Impact Assessment
ESCAP	Economic Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
FBD	Forest Biological Diversity
FRA	Forest Resources Assessment
FSC	Forest Stewardship Council
GEF	Global Environment Facility
GHG	Greenhouse gases
GM	Global Mechanism
IPCC	Intergovernmental Panel on Climate Change
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
JLG	Joint Liaison Group
LDC	Least Developed Country
LEG	Least Developed Countries Expert Group
LULUCF	Land Use, Land Use Change and Forestry
MA	Millennium Ecosystem Assessment
MCPFE	Ministerial Conference on the Protection of Forests in Europe
MEAs	Multilateral Environmental Agreements
NAPAs	National Adaptation Programs of Action
NAPS	National Action Programmes
NBSAPS	National Biodiversity Strategies and Action Plans
NCSA	National Capacity Self Assessments
OECD	Organisation for Economic Co-operation and Development
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission on Sustainable Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nation Forum Forest
UNU	United Nations University
SBI	Subsidiary body for Implementation
SBSTA	Subsidiary body for Scientific and Technological Advice
SBSTTA	Subsidiary body on Scientific, Technical and Technological Advice
SEA	Strategic Environmental Assessment
WCMC	World Conservation Monitoring Centre
WTO	World Trade Organization
WHC	World Heritage Convention

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INTRODUCTION

In the last years, the total number of multilateral environmental agreements (MEAs) dealing with environment and sustainable development have increased, and issues such as atmosphere, biodiversity, chemical and wastes, land, water have been addressed. MEAs have to facilitate compliance and implementation of agreements, on the other, countries have implementation obligations, which are linked to the development of strategies. Some elements of compliance include: reporting, regular review, and assessment of implementation obligations. In this context, **synergies** among MEAs are a key issue to explore because it can contribute with the implementation of international agreements.

Different initiatives are enhancing the coordination and collaboration among MEAs, and these activities are relevant at different levels. For instance at global level, the *Biodiversity Liaison group*, which joins 5 biodiversity- related conventions or the *Joint Liaison Group*, which link the Rio Conventions (UNFCCC, CBD and UNCCD). Moreover, there are other global sectoral initiatives, for example, the *Collaborative Partnership on Forests*, a partnership of 14 major forest-related international organizations, institutions and convention secretariats. Besides, regional, national, local, and scientific/technical levels of implementation are relevant to be explored.

Moreover the tools or instruments needed for assessing synergies are important issues. In this context, it could be appropriate to talk about decision support tools which can assist in solving environmental decision situations. Some of these tools are already available such as the Cost-Benefit Analysis, the Cost-Effectiveness Analysis and Multicriteria analysis among others. However, supporting decision or evaluation processes involves more than just an evaluation. Therefore, the author has considered the concept of a decision aiding process, where an interaction of at least two actors allows structuring a decision process. Different activities such as the definition of the problem situation, problem formulation, model evaluation, and final recommendations are carried out in a decision aiding process.

The author has chosen to use the multiple or multicriteria approach to support the whole decision aiding process for assessing synergies, and among the MEAs, focus has been given to the Rio Conventions. Afterwards, the forestry sector together with the different environmental services have been considered and explored for assessing synergies at project level.

The aim of this PhD thesis is mainly to contribute with the process of synergies among the Rio Conventions. Therefore, a multicriteria decision framework for assessing synergies at forestry project level has been developed.

CHAPTER 1. PROBLEM STATEMENT

1.1 Background

In this research, the process of synergies among the Rio Conventions, which include the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD) and the Convention on Biological Diversity (CBD) are explored. These conventions have specific environmental objectives, but they share a common scope, which is **sustainable development**. Simultaneously, from a scientific level, evidence of the inter-linkages among different process such as climate change, desertification and biodiversity have been recognised.

In this context, lack of methodologies and tools to assess synergies has been identified. Therefore, a decision aiding process has been triggered, and the Multicriteria Decision Aid (MCDA) has been used as scientific framework for exploring synergies.

The aim of this chapter is to provide the objective and research questions, and describe the approach and methodology which have been used for this research.

1.2 Objective

The objective of the thesis is to provide a methodological tool to assess synergies among the Rio Conventions.

1.3 Research questions

The main research question:

How is it possible to contribute in a concrete way to the process of synergies among the Rio Conventions?

The following statements represent the sub-research questions:

- Question 1: What is the level of implementation which can be explored for assessing synergies?
- Question 2: What can be an interesting sector to work with while addressing synergies?
- Question 3: What is the appropriate approach that can deal with a complex environmental problem?
- Question 4: How a decision aiding process can be structured for assessing synergies at project level?

1.4 Approach and methodology

This thesis was conducted in the academic context of the Tuscia University, Viterbo and working environment of the Agency for the Protection of the Environment and Technical services, Rome (Italy). In the last years six years, the author has followed the process of synergies among the Rio Conventions, and learnt about it through the participation in the UNFCCC and UNCCD Conference of the Parties (COP) meetings. Therefore, this research is based on a **learning process**

which relies on: participation in UN meetings, personal interviews with experts; specific questionnaire with the experts participating in the Rio Conventions and UNFF process; the use of the Multicriteria Decision Aid (MCDA) approach as scientific framework. Furthermore, this research has addressed activities of a decision aiding process, specifically described for the forestry sector. Last but not the least, the author has created a database of references, which have been organised and managed in different thematic areas (Rio Conventions; forestry; MCDA).

Participation and learning process

The participation in UN meetings has allowed the author to understand the process and needs for implementing synergies among the Rio Conventions. As stated by Laurier (2003) in Sutter (2003), the credo of participant observation is to keep as close to the spatial phenomenon as possible. On the other hand, the author has been involved in European working groups related with Operational Research in order to become familiar with this scientific framework.

The author has participated in the European Working Group on Multicriteria Decision Aid[1] (EURO-MCDA) at Porto (MCDA 63) and Poznan (MCDA 65), and also in the EURO working group on Operational Research in Agriculture and Forestry Management (ORAFM), which was held during 22nd European Conference on Operational Research. In addition, fruitful discussions during December 2006 and May 2007 at Lamsade[2], the Laboratory on Analysis and Model System for Decision Aiding at the *Université Paris IX Dauphine*, and direct contact with the experts on Operational Research took place.

Personal interviews

During this research, interviews were conducted in 3 phases (see Appendix 5). The first interviews were held during the first year of the research. The objective was to gather information of concrete implementation activities on synergies among the Rio Conventions in the forestry sector, and at different levels (international, regional and national). The second phase of interviews took place in Peru, during the second year of research, where local forestry stakeholders were identified and contacted. The objective was to interview stakeholders related with the implementation of forestry projects in Peru. These two initial interviews comprised in addressing a few issues and allowing a conversation with the participant on specific topics.

Finally, a third phase of interviews was held during the last year of research. The objective was to validate the indicators and scales constructed for forestry decision criteria used for assessing synergies at project level together with forestry experts. These personal interviews were based on a power point presentation, which contained information on the multicriteria method, and a scale of evaluation for each forestry decision criterion.

[1] EURO-MCDA, founded in 1975, this group meets twice a year in some European city; working languages are French and English.
[2] LAMSADE, Laboratoire d'Analyse et Modélisation de Systèmes pour l'Aide à la Décision

During the interviews, the author of the research has realised the need for an specific approach, able to summarize a complex problem, simultaneously considering expectations from different stakeholders. Thus, an open and flexible approach was required, which could establish a connection between application and methodological aspects.

On the other hand, synergies among the Rio Conventions is a complex topic; therefore, there was the necessity to find an appropriate approach which can deal with this environmental decision problem. After a deep research and discussions, the multicriteria approach was identified as the most appropriate approach to explore synergies, and a decision aiding process was triggered.

Decision aiding process

This research emphasized a whole decision aiding process; therefore, a description of the different activities is presented. The decision aiding process consisted of defining the problem situation, problem formulation, evaluation model, and final recommendations.

Multicriteria decision aid

Since different objectives, principles and expectations are necessary to take into account; the Multicriteria Decision Aid (MCDA) is used as a scientific framework. Moreover, this research has assessed synergies among the Rio Conventions at forestry project level.

The problem statement was defined together with the decision maker; and thus for assessing synergies, the sorting of international forestry projects into pre-defined categories has been evaluated. Forestry projects, which have been used, are available at the UNFCCC web site, and they are described in a common format called *Project Design Document* (PDD).

Questionnaire

The questionnaire was used for validating the forestry decision criteria used for assessing synergies among the Rio Conventions at project level in a specific decision aiding process. Between September 2006 and January 2007, the questionnaire process was carried out. Participants were contacted based on participant lists (workshops and conferences), databases from the Rio Conventions secretariats and the "*Forest Policy Info Mailing List*." Descriptive statistics and multivariate analysis for elaborating data from the questionnaire were used (Factor Analysis and Multiple Correspondence Analysis).

Database

The author has considered helpful to build a database because of the cross-cutting topics addressed of this research. The thematic databases are: Rio Conventions documents (relevant technical and decision documents produced by the secretariats from the Rio Conventions); the forestry sector and MCDA.

Information from Conventions has been collected from the web sites (see Appendix 7). Furthermore, e-mail information has been received from the *Earth Negotiations Bulletin*, Climate Change *Info Mailing List* and *Multilateral Environmental Agreement List*. For the forestry and MCDA databases, an on-line search of journals and reports was carried out. In particular, for the forestry sector journals such as Forest Ecology and Management, Forest Policy and Economics were consulted. Other journals used were: Climate Policy, Ecological Economics, RECIEL, Water resource management, Biological Conservation, Ecological Modelling, Journal of Environmental Management, Environmental Monitoring and Assessment, Mitigation and Adaptation Strategies for Global Change, etc.

Moreover, documents have also been collected from international institutions such as CIFOR, Forest Trends, FAO, GEF, IUCN, OECD, Pembina, United Nations University, UBA[3], UNEP, World Resources Institute, World Bank, among others. On the other hand, for the MCDA database, the main journal consulted was the European Journal of Operational Research. Besides, an important source for MCDA bibliography was provided by Lamsade[4].

1.5 Structure of the research

The thesis is organised in different chapters. In Chapter 1, objectives, research questions, and approach and methodology are described. In Chapter 2, different levels of implementation of synergies among the Rio Conventions are presented. In Chapter 3, characteristics of the forestry sector and ecosystem services are presented. In Chapter 4 and Chapter 5, concepts, models and application of the multicriteria approach are illustrated. Chapter 6 is devoted to the construction and validation of forestry decision criteria. In Chapter 7, a whole decision aiding process for assessing synergies at forestry project level is described. Each chapter has been structured with an introduction and conclusions; thus giving the possibility to connect the chapters of the thesis. Finally, general conclusions are elaborated.

Theoretical and descriptive sections of the thesis are complemented with concrete applications and interview processes. Chapter 2 gives a detail idea of what synergies among the Rio Conventions are and how initiatives at different levels are being implemented. By looking at the different levels, needs were identified and allowed to give the correct direction to this research. Chapter 3 introduces the forestry sector as an ecosystem with multiple ecosystem services and multiple actors involved. At global level, the forestry sector has been identified and recognised for exploring synergies among the Rio Conventions. Concrete activities of synergies in the forestry sector are described. Technical information in this chapter, is based on global reports, such as the Millennium Ecosystem Assessment (MA, 2005[a-g]), the Global Forest Resources Assessment (FAO, 2006[a]), and the IPCC Fourth Assessment Report (Easterling *et al*., 2007; Barker *et al*., 2007). Chapter 4 attempts to give information on the multicriteria approach which has been identified as scientific framework to deal with synergies. Chapter 5 presents models used for the

[3] UBA, Umweltbundesamt (German Federal Environmental Agency)
[4] MCDA database: www.lamsade.dauphine.fr/mcda/biblio

multicriteria approach, applications in the forestry sector and in the Rio Conventions context. Chapter 6 is devoted to the validation and analysis of forestry decision criteria used in a specific decision aiding process. A questionnaire process with forestry experts is described. Chapter 7 describes a whole decision aiding process which aims to assess synergies among the Rio Conventions at forestry project level.

In the following representation is possible to have an overview of how the thesis has been structured in order to explore synergies among the Rio Conventions (see Figure 1.1):

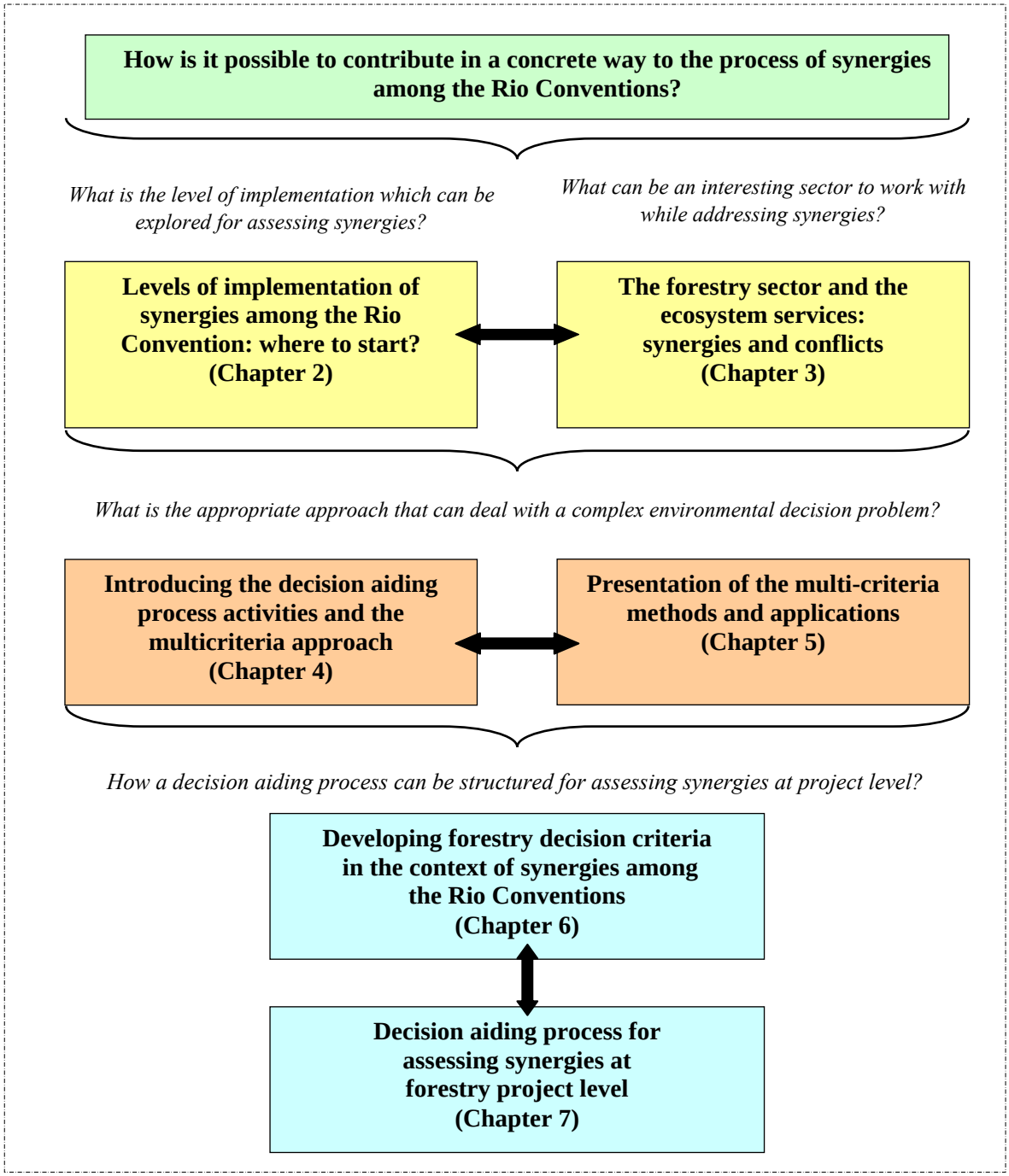

Figure 1.1 Overview of the research questions and chapters of the thesis

CHAPTER 2: SYNERGIES AMONG THE RIO CONVENTIONS

This section attempts to give the background to understand the process of the synergies among the Rio Conventions. The chapter is composed of three main sections, which address the international, national/regional and technical/scientific aspects. For the preparation of this chapter technical documents and reports from the Rio Conventions have been revised.

2.1 Introduction

In recent years, Multilateral Environmental Agreements (MEAs) have been considered and analysed; thus, different perspectives are reported in the literature. For example, Kimball (1997) has analysed the institutional linkages of the CBD and other international conventions, and Kim (2004) has described how biodiversity and climate change **regimes**[5] **interplay**[6] and what effect they might have on operations. Besides, Rosendal (2001) has dealt with **overlapping**[7] regimes, focused on the UNFF, CBD and UNFCCC, and Glowka (2000) has described the **complementarities**[8] between the Convention on Migratory Species and CBD.

From an operational perspective, Zeidler and Mulongoy (2003) have described operational synergies for a specific ecosystem considering CBD and CCD regimes, and Williams (2000) has suggested greater coordination and integration at the national level. Moreover, Beg *et al*. (2002) have proposed to maximise the potential for **synergy**, increasing institutional capacity and awareness building measures, integration across ministries, between the private and public sector, and through international conventions. Caparrós and Jacquemont (2003) have analysed **conflicts** between biodiversity and carbon sequestration programs and suggests that an integrated approach, using the synergy of both regimes at an institutional level, offers an opportunity to enforce biodiversity concerns and greenhouse gas mitigation.

Additionally, examples regarding other MEAs have been described, for instance the inter-linkages[9] between the Montreal and Kyoto Protocols (Oberthür, 2001). Besides, Lasén Díaz (2002) and UNEP-WCMC (2004) have presented an overview of activities to enhance synergies and cooperation among conventions. So synergies between MEAs should not only mean that these instruments are coherent, or that the policy actions are coordinated, but also that the strengths and comparative advantages of each are put together to create a more effective set of laws and policies than currently existing laws (Ecologic, 2001).

Synergies among the MEAs have increasingly become a topic of international discussion since the middle of the 1990s, concentrated mainly on how to improve cooperation. This research deals with **synergies** among the Rio Conventions, including CBD, UNFCCC, and UNCCD. Hence, it is worth to provide a definition of **synergy**:

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[5] Regime, a system or ordered way of doing things (*Oxford dictionary*)
[6] Interplay, the way in which two or more things have an effect on each other (*Oxford dictionary*)
[7] Overlap, cover part of the same area of interest, responsibility (*Oxford dictionary*)
[8] Complementarity, a relationship or situation in which two or more different things improve or emphasize each other's qualities (*Oxford dictionary*)
[9] Interlink, join or connect (two or more things) together; interlinkage(noun) (*Oxford dictionary*)

"the interaction or cooperation of two or more organizations, substances, or other agents to produce a combined effect greater than the sum of their separate effects" (*Oxford Dictionary*).

2.2 International context

2.2.1 Objectives of the MEAs

MEAs address transboundary and global health and environmental problems caused by international trade and other economic activities. Global MEAs were developed in connection with the 1992 Earth Summit in Rio de Janeiro, therefore known as the "Rio Conventions".

The climate change and biodiversity conventions were adopted in 1992, the same year an Intergovernmental negotiating committee for the elaboration of the desertification convention was established, thereafter this convention was adopted in 1994. These conventions entered into force on March 1994, December 1993, and December 1996, respectively. Till now, 189 FCCC, 190 CBD and 191 CCD countries have signed the conventions, all with differentiated responsibilities.

The objectives of climate change, biodiversity and desertification conventions are presented in Box 2.1. In summary, the UNFCCC has as main objective the stabilization of greenhouse gases concentrations. The CBD aims the conservation, sustainable use and fair and equitable share of the benefits arising from genetic resources. The UNCCD make efforts to combat desertification and land degradation, therefore, the core is the development of national, sub regional and regional action programmes. In order to achieve these objectives, Conventions have established principles that guide countries (see Appendix 1).

Eventually, the pillar of the three Conventions is based on a common objective, which is the **sustainable development**, and they are linked since they operate in the same ecosystems and tackle interdependent issues. A specific state of collaboration and cooperation with international organizations can be found in Articles 7.2(l) and 8.2(e) for the UNFCCC, Articles 5 and 24(d) for the CBD and Articles 8.1 and 23(d) for the UNCCD.

2.2.2 Organization

In general, the Rio Conventions have a similar structure, the Conference of the Parties (COP), which is the most important body of the convention, and the Convention Bodies. Then, there is a permanent Secretariat, in charge of making arrangements for COP sessions and the subsidiary bodies, providing them with services as required; for instance, the preparation of documents for the different sessions, known as *Note by the Secretariat*.

The COP of the Rio Conventions is responsible for reviewing the implementation of the Convention and makes decisions necessary to promote an effective implementation (Art. 7 FCCC, Art. 23 CBD, and Art. 22 CCD). The COP convenes annually for the UNFCCC and every two or three years for the CBD and UNCCD. Moreover, the SBSTA (UNFCCC), SBSTTA (CBD) and CST (UNCCD) are the technical Bodies, which have the main objective to provide scientific and technological advice (Art. 9 FCCC, Art. 25 CBD, Art. 24 CCD). Then, technical meetings are held

in preparation and in between the COP. Furthermore, the group of experts or *Ad hoc* groups support technical bodies, following specific themes of interest to the Conventions (Box 2.2).

UNFCCC (Art.2)
"… stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."
CBD (Art. 1)
"…the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding."
UNCCD (Art. 2)
"…to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas." "…long-term integrated strategies that focus simultaneously, in affected areas, on improved productivity of land, and the rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions, in particular at the community level."

Box 2.1 Rio Convention objectives

These Conventions are complemented by the adoption of protocols. Then, the UNFCCC has the Kyoto Protocol signed in 1997, and the CBD has the Cartagena Protocol on Biosafety adopted in 2000, entering into force in 2005 and 2003, respectively.

From the financial point of view, the Global Environment Facility (GEF) is designated as mechanism for the CBD and UNFCCC; and the UNCCD has the Global Mechanism (GM). Xiang and Meehan (2005) have provided an overview of financial cooperation among the Rio Conventions.

A brief introduction of the Rio Convention arrangements has been provided, in the next two sections, the rationality of **synergies** and decisions at international level are described.

2.2.3 Synergies among conventions

The rationale to promote and enhance synergies among the Rio Conventions includes the following facts (UNCCD, 1998): (a) they share a common sustainable development approach and have close linkages with a common global strategy: Agenda 21; (b) the three subjects are intimately related not only on ecological, but also on socio-economic and institutional grounds; several of the policies and measures suggested for achieving the objective of one convention may also contribute to objectives of the others; (c) often decision- and policymakers in charge of implementation of the Conventions belong to the same government ministry or government ministries dealing with closely related portfolios; a pragmatic synergy initiative highlighting intersections among convention objectives could shed light on their deliberations and contribute to cost-effective and more efficient ways to achieve convention and sustainable development objectives at the national and local levels; (d) finally, their small and flexible secretariat arrangements allow for a rapid and effective team effort upon which a long-term-oriented process can be built.

	Convention bodies	Ad hoc group	Group of experts
UNFCCC	Subsidiary body for Scientific and Technological Advice (SBSTA), and the Subsidiary body for Implementation (SBI)	Ad hoc Group on the Berlin Mandate (AGBM), Ad hoc Group on Article 13 (AG13), Ad hoc working group on Annex I commitments (AWG).	Intergovernmental Panel on Climate Change (IPCC) Expert group on: Technology transfer (EGTT), Least Developed Countries (LEG), and Consultative group of experts on Non Annex I National Communications (CGE).
CBD	Subsidiary body on Scientific, Technical and Technological Advice (SBSTTA), and Working groups on: Art.8(j), ABS, Protected Areas Review of Implementation	Ah hoc technical expert group (AHTEG) on: forest biological diversity, biological diversity and climate change, on biodiversity and adaptation to climate change. Ad hoc working group on Biosafety (BSWG)	Panel of experts on Access and benefit-sharing (ABS)
UNCCD	Committee on Science and Technology (CST), and the Committee for the Review of the Implementation of the Convention (CRIC)	Intercessional Intergovernmental Working Group (IIWG) Ad hoc Working Group (AHWG) Ad hoc panel/group of experts	Group of experts (GoE) Roster of independent experts

Box 2.2 Convention bodies and expert groups from the Rio Conventions

Moreover, the benefits of synergies have been identified as the opportunity (UNEP/CBD, 2004[a]): (i) to utilize and share relevant services and information, (ii) to coordinate relevant actions to maximize their impacts, and (iii) to optimize the impacts of both human and financial resources used in the implementation of the instruments. The efforts to exploit synergies should aim at **concrete results**, and the desire for cross-cutting solutions should not lead to a mere re-categorization of existing activities or institutions, but to real efforts at achieving cross-sectoral benefits (Mackenzie, 1997).

However, producing synergy is not easy; it is the culmination of a process in which complementarities between the Conventions are identified and used to further implementation while overlaps are eliminated (or at least conflicts between them reduced). Taking advantage of the complementarities and reducing conflicts requires the ability to design necessary actions and then having the means to take these actions (Jorgensen, 1997).

Besides, SBSTA recommendations have stated that synergies aim to avoid duplication of work, use resources efficiently, capture synergies, and identify potential areas of conflict (UNFCCC, 2003). In theory, cooperation between the Rio Conventions appears to be a logical and meaningful undertaking and should be easy to accomplish. In reality, the different mandates, functions, and implementation approaches of the three conventions create considerable challenges at both the national and international levels (Hoffmann, 2003).

From the point of view of development policy, there are specific reasons for integrating the Rio Conventions (OECD/DAC, 2002): a) addressing global environmental challenges is key to development and poverty reduction, as the development agenda's priority is closely linked to sound management of the local, national, regional and global environment, b) responses to global environmental threats require measures in a variety of sectors, therefore it is necessary to focus on development strategies that respond simultaneously to social and economic development and global environmental concerns.

2.2.4 Activities and decisions

At international level, technical reports and notes from the Secretariats have addressed synergies among the Rio Conventions. This section describes the main decision and recommendations addressed in this field.

Main documents from the UNFCCC in the field of cooperation with relevant international organizations are presented and described in Appendix 2. Different activities and recommendations have been addressed at SBSTA. Probably the most significant decision, at COP level, has been decision **13/COP8**. Moreover, the endorsement for the formation of the **Joint Liaison Group** has been an important step (UNFCCC, 2001[a]). Later, in 2004, the UNFCCC Secretariat has been involved in the preparation of the paper "*Options for enhancing cooperation*" (UNFCCC, 2004[a]). Further, activities such as guidelines for synergies at regional (UNFCCC, 2005[b]) and national level (UNFCCC, 2005[a]) have been developed.

The COP and SBSTTA from CBD have catalysed activities in cooperation with the other Rio Conventions (see Appendix 3). In 1996, the first decision (**III/21**) requested a close relationship with UNFCCC and UNCCD. Also SBSTTA recommendations recognised the importance of synergies among conventions.

In 2000, with decision **V/21**, the CBD Secretariat was asked to strengthen cooperation with UNFCCC in themes such as, dry and sub-humid lands, forest biological diversity, coral reefs, and incentive measures. Later on, through SBSTTA recommendation **VI/7**, the formation of the **Joint Liaison Group** (JLG) was proposed, and the established of an *Ad hoc* technical expert group for assessing the integration of biodiversity considerations into the implementation of the UNFCCC/Kyoto Protocol (*AHTEG on biological diversity and climate change*). Consequently, at SBSTA 14th the JLG was endorsed (UNFCCC, 2001[a]). Moreover, the CBD has also established a liaison group with biodiversity-related conventions.

In 2001, a technical document on addressing interlinkages between CBD and UNFCCC was presented by CBD (UNEP/CBD, 2000) and endorsed by UNFCCC (UNFCCC, 2001[b]). After that a technical document on Inter-linkages on Biological Diversity and Climate Change was published (SCBD, 2003).

In 2005, following the **X/13** SBSTTA recommendation, the *Ad hoc* technical expert group on Biodiversity and Adaptation to Climate Change has prepared a technical paper on climate change, biodiversity, and adaptation (SCBD, 2006). In 2007, a proposal for integrating Climate Change activities within the Programmes of work of CBD, and options for mutually supportive have been presented (CBD/UNEP, 2007[b]). Furthermore, for the coming SBSTTA 13th to be held in 2008, specific supportive actions by parties and relevant organizations to promote synergies among the Rio Conventions have been proposed (CBD/UNEP, 2007[c]).

For the UNCCD, since first COP decisions, cooperation among the Rio Conventions has been requested (see Appendix 4); for instance see decision **13/COP1** (UNCCD, 1997). In addition, during these years, notes prepared by the Secretariat, so called "*Review of activities for the promotion and strengthening of relationships with other relevant conventions and relevant international organizations, institutions and agencies*", have contributed with the discussion on synergies from the institutional and scientific point of view. A deep analysis of the different levels of synergies is described in UNCCD (1999).

This section can be concluded by presenting the documents under which synergies is treated (see Box 2.3). The next section describes the role of the Joint Liaison Group.

Convention	Name under agenda and report documents
FCCC	Cooperation with relevant international organizations (SBSTA agenda item)
CBD	Cooperation with other bodies (SBSTTA agenda item)
CCD	Review of activities for the promotion and strengthening of relationships with other relevant conventions and relevant international organizations, institutions and agencies (Report documents prepared by the secretariat)

Box 2.3 Documents prepared for synergies issues under the Rio Conventions

2.2.5 The Joint Liaison Group

An important step to enhance cooperation among the Rio Conventions Secretariats has been the formation of the Joint Liaison Group (JLG). The proposal of JLG was addressed through decision VI/7 (UNEP/CBD, 2001), endorsed by the UNFCCC, where also the UNCCD was invited.

The main objectives of the JLG are: a) to enhance coordination between the three Conventions, including the exchange of relevant information; and b) to explore options for further cooperation between the three Conventions, including the possibility of a joint work plan and/or a workshop (UNFCCC, 2001[a]).

In 2001, the JLG was requested to collect and share information on the work programmes and operations of each convention including (UNFCCC, 2002[b]): (i) roles and responsibilities of the Secretariats, and any relevant scientific and technical bodies or expert groups; (ii) types of activities under each convention; (iii) potential areas of cooperation, possible joint activities, and any potential conflicts associated with different mandates.

In this context, two international workshops on **synergies** have been organised: a) in 2003, the UNFCCC workshop on synergies and cooperation with other Conventions (Espoo, Finland), and b) in 2004, the CCD workshop on Forests and forest ecosystems: promoting synergy in the implementation of the three Rio Conventions (Viterbo, Italy).

During these years the JLG progress reports on the work between Secretariats have been presented (JLG, 2007; UNFCCC, 2004[b]; JLG, 2003; UNFCCC, 2002[a]), and activities such the preparation of the paper "*Options for enhancing cooperation*" have been agreed (UNFCCC, 2004[a]).

Simultaneously, the JLG has identified **national focal points** as instrument for achieving and implementing synergies among the Rio Conventions. Moreover, in the 7th JLG meeting, the collaboration at the national and local levels has been addressed as essential to enhance synergies. Besides, activities for further consideration and future collaboration were identified (JLG, 2007). Then, in the 8th JLG meeting, four priority activities for implementation were agreed. A summary of the different decision and initiatives from the JLG are available in Box 2.4.

Meeting	Activities or decisions
First (6/12/2001)	(1) to create a common calendar of activities for posting on the respective web sites of the three conventions; (2) to identify high priority events which may require the participation of the staff members of other secretariats; (3) to hold a joint workshop on forests and forestry, an issue of common interest to the three conventions.
Second (30/01/2002)	Exchange information on the work of the subsidiary bodies; consider a draft joint calendar and list of priority events and review progress in the preparations of the joint workshop on forests.
Fourth (19/05//2003)	It was agreed that staff members from each convention would exchange information and explore concrete options initially relating to technology transfer, incentive measures, and observational networks.
Fifth (30/01/2004)	Adaptation, capacity building, and technology transfer were priority issues discussed in this meeting. As general issues, it was realize that synergy is most important at the national level and to achieve this, greater collaboration is needed among the national focal points of the three conventions. It was presented the proposal for the Joint Workshop on Strengthening Synergy among the Rio Conventions through Forests and Forest Ecosystems and agreed that a paper on options for enhanced collaboration should be prepared jointly by the three secretariats.
Sixth (10/2005)	At the sixth meeting of the JLG, the enhance cooperation paper has been considered (FCCC/SBSTA/2004/INF.19).
Seventh (7/06/2007)	Collaboration at the national and local levels was identified as essential. Identification of next steps and main areas for future collaboration: reducing deforestation and adaptation to climate change.
Eighth (12/09/2007)	Activities addressed are: (i) a newsletter on synergies between the Rio conventions; (ii) tools to inform Parties about relevant activities on biodiversity and climate change; (iii) the development of educational materials; and (iv) joint web based communication tools.

Box 2.4 Decision and initiatives from the Joint Liaison Group meetings

From a practical perspective, simple but effective initiatives can be implemented. For instance, specific web sites related to synergies are available for the UNFCCC[10] and CBD[11], and suggested to implement also to the UNCCD (decision **12/COP7**). These are ongoing mechanisms that support dissemination of information. Moreover, the circulation of technical documents, notes

[10] http://unfccc.int/cooperation_and_support/cooperation_with_international_organisations/items/2970.php
[11] http://www.biodiv.org/cooperation/default.shtml

by the Secretariats and reports from expert groups can provide appropriate information and guidance to national focal points of available tools and instruments to implement synergies among the Rio Conventions.

2.3 National and Regional context

In this section, challenges, barriers, complementarities, and past and present initiatives for implementing synergies at national and regional levels are described.

2.3.1 Challenges and barriers

Activities that promote synergy at the *national* and *local* levels are of particular importance, since this is the level in which Conventions are implemented and concrete benefits can be achieved. Given that the responsibility for each Convention does not necessarily belong to the same institution and focal point of a country, coordination and collaboration are needed at the *national level* (Hoffmann, 2003).

SBSTA and SBSTTA have reiterated the importance of promoting synergy at the national and local levels, where implementation occur, recognizing that this can lead to an increased efficiency and an effective cooperation and help to avoid duplication (CBD/UNEP, 2007[b]; UNFCCC, 2006, 2004[c]).

On the way for achieving synergies, barriers can be *technical* (lack of understanding of cross-sectoral issues, information, impact assessments etc.), *political* (inter-departmental conflicts, issues of 'territoriality', lack of guiding principles and understanding at policy making level) and *cultural* (thoughts of not overstepping boundaries and lack of insight to working at local or ground levels). In some cases synergies and integrated approaches exist and can be built upon, and in some cases efforts are needed to stimulate collaboration, cooperation and harmonization (IUCN, 2003).

At the national level, implementing synergies have different drivers and limitations; and this has to be clearly recognised. Probably, synergies have to be selective and not create more work to focal points, which for example, have as limitation the number of people working with a certain number of Conventions. It is up to countries to implement synergies both at process and field level; therefore, is important that the process starts at the national level [12].

2.3.2 Conventions and complementarities

Articles of the Rio Conventions give the legal and operational framework to these MEAs. Moreover, different complementarities among Rio Conventions can be addressed (UNEP/CBD, 2004[a]). For example, all three agreements contain provisions on research, exchange of information, training, public education, capacity building, participation and awareness (Table 2.1).

Besides, other requirements shared by the Conventions include national and regional plans and action programmes, legislation and reporting. Consequently, it is important to identify and develop opportunities for synergy, but it is even more important to **coordinate** activities, which can

ensure the implementation of the Rio Conventions, especially at the **national level** (UNEP/CBD, 2004[a]).

For example, a practical application is to identify complementarities between reporting documents from the Rio Conventions, such as NBSAPS, NAPS, national communications, and NAPAs. Burke (1997) has addressed some recommendations for streamlining the reporting process.

On one hand, legal and operational complementarities are present, and on the other hand, the thematic complementarities have also been addressed (UNEP/CBD, 2004[a]) (see Table 2.2).

Sectors	UNFCCC	CBD	UNCCD
National Inventories/Identification and Monitoring	Article 4.1(a)	Article 7	Article 16
National & Regional Plans	Article 4.1(b)	Article 6(a)(b)	Article 9,10
Legislation	Preamble	Article 8(k)	Article 5(e)
Research	Article 5	Article 12(b)	Article 17,19 (b)
Public Education	Article 6	Article 13	Article 5(d),19,6
Environmental Impact Assessment	Article 4.2(d)	Article 14	
Clearinghouse exchange of technical information	Article 7	Article 17, 18	Article 16
Public Participation	Article 6 (a)(iii)	Article 14.1 (a)	Article 19(3)
COP/ assess implementation	Article 7	Article 23	Article 22
Training	Article 6	Article 12(a)	Article 19
Reporting	Article 12	Article 26	Article 26
Examine obligations-assess implementation	Article 7 (e)	Article 23	
Financial resources and financial mechanism	Article 11	Article 20, 21	Article 20
Technology transfer and cooperation	Article 4	Article 16, 18	Article 12, 18

Table 2.1 Complementarities among the Rio Conventions

Sectors	CBD	UNCCD	UNFCCC
Conservation, sustainable use and sharing of benefits of biodiversity	Article 1	Annex I- Regional Implementation Annex for Africa, Article 8.3b(i) NAPs must sustainable management	Article 4.1(d), promote sustainable management, and promote and cooperate in the conservation and enhancement of sinks and reservoirs.
Land degradation	Decision VII/2 Par 1	Article 2	Decision IX/13 Good Practise Guidance and Other Information on Land use, Land use change and Forestry
Water management	Decision V/23 Decision VII/2 PoW Activity 7(e)	Decision VI/1 Art. 8	IPCC Report: Climate Change 2001: Impacts, Adaptation and Vulnerability Hydrology and Water Resources
Sustainable forest management	Decision VI/22	Decision VI/12 Art 5	Article 4.1 (d); Decision IX/19: Modalities and Procedures for Afforestation and Reforestation Project Activities under CDM
Poverty alleviation	Decision II/2 Par 6; POW Activity 4,5 and 9	Decision VI/2 Art 5 Decision VI/4 Art 3	Prologue Par. 21 ; Decision VIII/1 par 7; Decision IX/5.1(b)
Ecosystem approach	Decision V/6	Decision VI/12	SBI and SBSTA Espoo Workshops recognized ecosystem approach to achieve synergy between MEAs
Restoration and rehabilitation	Decision VII/2 par 5 PoW activity 7(b)	Decision VI/1(par8-12)	Art 4.1(e), Kyoto Protocol Art 2.1 (a)(ii)
Soil conservation	Decision VI/5 (soil biodiversity)	Article 4.1 (f and g)	Decision IX/13

Table 2.2 Thematic complementarities among the Rio Conventions

The following sections describe past and present initiatives that are supporting the implementation of **synergies** at different levels.

[12] Velasquez J. 2005. Personal interview expert synergies. Division of Environmental Law and Conventions, UNEP. Nairobi. October 2005.

2.3.3 Inter-linkages initiative

The United Nations University (UNU) has been pursuing the Inter-linkages approach for several years through a series of workshops and policy reports. In 1999, the UNU developed the *Inter-linkages Initiative*[13] through a 3 year programme that aim to identify practical ways to promote a more integrated and comprehensive approach to the negotiation, ratification, and implementation of MEAs (Velasquez *et al*., 2002). On a practical level, the initiative is based on the assumption that improving the implementation of existing environmental mechanisms does not necessarily require new instruments but, rather, a greater level of coherence among the tools already available (Velasquez and Piest, 2003).

In 2000, UNU administered a questionnaire to address key issues related to the management of the Rio-Agreements within the region of the Economic Social Commission for Asia and the Pacific. Van Toen (2003) has reported findings from this study. Later, Velasquez *et al*. (2002) have reported case studies on interlinkages conducted with the UNU and the South Pacific Regional Environment Programme (SPREP). Some of the common themes which emerge from this study are: a) the negotiation and signature of protocols requires substantial internal coordination; b) the speed and efficacy of the ratification and implementation processes depend on the constitutional requirements of countries; and c) the implementation of many MEAs requires the coordination of activities at the national, provincial, municipal, and rural community levels.

In 2003, through a workshop organised in Brazil, a case study for wetland management has been developed (UNU-IAS, 2004). Recommendations call for an integrated sustainable management of the Pantanal through the creation of an effective **regional framework** (Brazil, Bolivia, and Paraguay) for managing transboundary ecosystems. Therefore, steps to coordinate between the five MEAs (UNFCCC, CBD, Ramsar, WHC and CMS), to work together more closely to reduce duplication of efforts, and to streamline the reporting and monitoring procedures, have been addressed.

2.3.4 National Capacity Self Assessments

An important initiative, which involves developing countries, is the global project on *National Capacity Self Assessments* (NCSA). This project is financed by GEF and implemented by World Bank, UNEP, and UNDP. The aim of NCSA is to conduct a thorough self-assessment and analysis of national capacity needs, priorities, and constraints with respect to its efforts at meeting global environmental management objectives. Approximately, 140 countries have requested GEF assistance for conducting the NCSA. The focus of the NCSA might consider existing reports, and develop a coherent and integrated national framework for global environmental management. In general, coordination between governmental agencies has often been quoted as a challenge in many countries. However, the cross sectoral thematic assessments and multi-stakeholder approach, has

[13] http://www.geic.or.jp/interlinkages/

made a mark in proving the point that the effectiveness and efficiency of efforts to implement the synergies can be improved by creating conditions that are conducive for exchanging cross-sectoral information (IUCN, 2005[a]).

An example of results from **NCSA-Peru** was obtained through an interview with the manager of the project[14]. The NCSA-Peru has been implemented in two phases.

In the first phase, a thematic diagnosis, identification of the level of implementation of the conventions, evaluation of existing needs and capacities, and a matrix analysis of common thematic among Conventions was carried out. The outputs from this first phase were Action Directives.

The second phase consisted in the preparation of the Peruvian Regional Thematic Profiles for the regions of *Pasco*, *Junin*, *Tacna*, *Arequipa*, *Moquegua*, *Cuzco*, *Puno*, *Loreto*, *San Martin*, *Tumbes,* and *Piura*. Therefore, regional experts were involved as well as stakeholders, including public and private institutions. Outputs from this phase were linked to the preparation of Regional Action Plans and the incorporation of the synergies thematic in regional agendas; whereas, at national level, focal points from CBD, UNFCCC, and UNCCD were strengthened. In conclusion, the NCSA-Peru obtained two main products at national and regional level.

2.3.5 Synergies workshops

At the national level, international workshops have contributed with the process of synergies among the Rio Conventions. In Table 2.3, a list of workshops are presented (UNEP/CBD, 2004[b]). Main aspects which have been addressed are coordination, information exchange, and harmonization of information systems, financial and technical support, participation of stakeholders and programme integration.

Countries are part of a wider context, which is the region they belong to; therefore, it is possible to link national level initiatives to a regional level of implementation. Then, countries that share similar ecosystems, environmental priorities or socio-economic situations, can benefit from exchange of information. Besides, coordination among countries' policies and initiatives can maximize results of activities undertaken. However, it is important for regional initiatives to avoid duplication of international initiatives while also avoiding additional administrative burden on countries (UNEP/CBD, 2004[a]).

Furthermore, in the last years, **regional** initiatives in Africa and Latin America have been developed (see UNEP/CBD, 2007[a]; UNEP/CBD, 2004[a]). For instance, the *Sub-Regional Workshop on Agro biodiversity in West Africa* (Bamako, Mali, 15-19 December 2003); the *Regional Workshop for Africa on synergy among the Rio Conventions and other biodiversity-related conventions in implementing the programmes of work on dry and sub-humid lands and agricultural biodiversity* (Gaborone, Botswana, 13-17 September 2004); and the Regional synergy workshop for *Latin America and the Caribbean on the Biological Diversity of Dry and Sub-humid Lands and agricultural biodiversity* (Antigua and Barbuda, 20-23 November 2006).

[14] Gonzales A.M. 2006. Personal communication. Interview with the manager of the NCSA project in Peru. September 2006

Other initiatives for supporting the implementation of synergies at **national** and **regional** level are linked to the preparation of technical guidance. The CBD has prepared the "*Guidance for promoting synergy among activities addressing biological diversity, desertification, land degradation and climate change*" (UNEP/CBD, 2005[a]). But also the UNFCCC has presented two technical documents: "*Synergy among multilateral environmental agreements in the context of national adaptation programmes of action*" (UNFCCC, 2005[a]) and the "*Regional synergy in the context of national adaptation programmes of action*" (UNFCCC, 2005[b]). In section 2.4.2, further description is provided.

Workshop	Organized	Main outcomes
Export meeting on synergies among the Rio Conventions Sede Boquer, Israel: 17-20 March 1997	UNDP-SEED initiative	Financial and technical support; effective strategies to address synergy vary from one country; communication and coordination among government bodies responsible for implementation; stakeholders should participate in the planning process; joint capacity-building and strengthening.
UNU international conference on inter-linkages: synergies and coordination between MEAs Tokyo, Japan: 14-16 July 1999	UNU and UNEP	Harmonization of information systems; mechanisms which can help promote cooperation between scientific endeavours on inter-linkages should be put in place; capacity building should be thematic and institutional to help raise awareness on inter-linkages; cross-cutting issues may serve as useful tools for enhancing and developing synergies between the MEAs; funding initiatives have potential to catalyse synergetic initiatives; national planning processes for MEAs implementation should be incorporated into national development strategies.
Desertification, climate change, biodiversity and forest: synergies for an inter-regional agenda between northern and southern Mediterranean countries 18th February 2000	FAO and Italian National Committee to Combat Drought and Desertification	Improve information exchange; link scientific knowledge with policy making, make use of existing financial resources to achieve synergies; identify appropriate ways to promote on the ground implementation of the UNCCD in synergy with other conventions; integrated pilot projects should be promoted; promote the participatory approach and involvement of all stakeholders.
Workshop for focal points consultation on synergies between Rio Conventions Marrakech, Morocco: 27-31 January 2003	Agence Intergouvernmentale de la Francophonie et L'Institut de l'Energie et de l'Environnement de la Francophonie	Secretariats are encouraged to organize synergy-building workshops; identify and implement pilot projects taking into account the three conventions'; harmonize information mechanisms into one common mechanism; open and flexible coordination framework for the three conventions; capacity-building needs at national and local levels need to be assessed.
UNFCCC workshops on synergies and cooperation with other conventions Espoo, Finland: 2-4 July 2003	UNFCCC	For achieving national level synergy: involvement of high-level politician and stakeholders; balance of bottom-up and top-down approaches; incorporation of Rio conventions' synergies into national strategies; facilitation communication between national focal points; use of the ecosystem approach at the national level.
Workshop on forests and forest ecosystems: promoting synergy in the implementation of the three Rio conventions Viterbo, Italy: 5-7 April 2004	CBD and UNCCD, in collaboration with UNFCCC	Suggested the use of existing tools and mechanisms at local, national, regional and international levels for fostering synergism in the implementation of the Rio conventions; development of indicators for success of synergy work; collection and dissemination of success stories and lessons learned; strengthening information exchange mechanisms on synergy, including clearing-house mechanisms; and better coordination and communication among national focal points and GEF and UNFF focal points.

Table 2.3 Workshops on synergies in the last 10 years

2.4 Technical and scientific context

This last section presents the scientific basis for enhancing synergies among the Rio Conventions, and describes tools and instruments, which have been proposed for assessment.

2.4.1 Scientific linkages

In the Desertification synthesis of the Millennium Ecosystem Assessment (MA, 2005[a]), linkages among the three thematic: climate change, desertification and biodiversity are described (Figure 2.1).

Dryland soils contain over a quarter of all of the organic carbon stores and nearly all inorganic carbon in the world. Therefore unimpeded desertification may release carbon to the atmosphere, with consequences to the global climate system. Besides, **climate change** may adversely affect **biodiversity** and exacerbate **desertification** due to increase in evapotranspiration and a likely decrease in rainfall in drylands. However, since carbon dioxide is also a major resource for plant productivity, water use efficiency will significantly improve for some dryland species that can favourably respond to its increase. These contrasting responses of different dryland plants to the increasing carbon dioxide and temperatures may lead to changes in species composition and abundances. Therefore, although climate change may increase aridity and desertification risk in many areas (medium certainty), the consequent effects on services driven by biodiversity loss, hence, on desertification are difficult to predict (MA, 2005[a]).

Biodiversity affects key ecosystem processes in terrestrial ecosystems such as biomass production, nutrient and water cycling, and soil formation and retention. Moreover, biodiversity influences climate at local, regional, and global scales, thus changes in land use and land cover that affect biodiversity can affect **climate**. Some components of biodiversity affect carbon sequestration and thus are important in carbon-based climate change mitigation when afforestation, reforestation, reduced deforestation, and biofuel plantations are involved (MA, 2005[b]).

Environmental management approaches for combating desertification, conserving biodiversity, and mitigating climate change are linked in numerous ways. Thus joint implementation and further strengthening of ongoing collaborations and partnership can increase **synergies** and effectiveness (MA, 2005[a], [b]). On the other hand, the author of this research claims that the categorization of ecosystem services (provisioning, supporting, regulating and cultural), as presented in the *Millennium Ecosystem Assessment*, can be useful when addressing **synergies** among the Rio Conventions. Therefore, further analysis of this issue and definitions are provided in Chapter 3.

The Intergovernmental Panel on Climate Change (IPCC) and the CBD Secretariat have also studied linkages on climate and biodiversity issues. For instance, the IPCC has described, the observed changes in terrestrial and marine ecosystems associated with climate change; the projected impacts of changes in mean climate and extreme climate events on terrestrial and marine

ecosystems; the potential impacts on biodiversity of activities undertaken to mitigate climate change; and adaptation activities and biodiversity. Also, aspects related to **synergies** between conservation and sustainable use of biodiversity and climate change has been addressed (IPCC, 2002). On the other hand, the CBD has reported climate change mitigation and adaptation options linked to biodiversity, and main conclusions are that (SCBD, 2003):

- the terrestrial and oceanic ecosystems play a significant role in the global carbon cycle,
- the **ecosystem approach (**CBD) provides a flexible management framework to address climate change mitigation and adaptation activities;
- **LULUCF** activities can play an important role in reducing net GHG emissions to the atmosphere;
- afforestation and reforestation can have positive, neutral, or negative impacts on biodiversity; and
- slowing deforestation and forest degradation can provide substantial biodiversity benefits in addition to mitigating GHG emissions and preserving ecological services

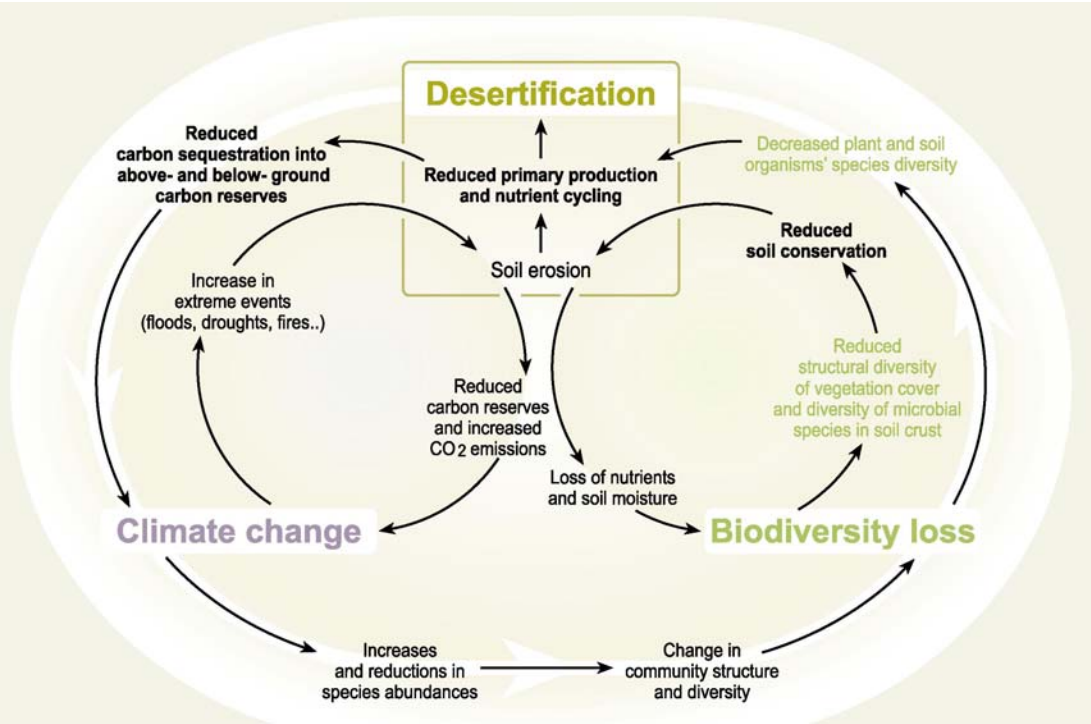


Figure 2.1 Linkages and feedback loops among desertification, global change and biodiversity loss

In the next section, some basic instruments and tools, which have been proposed for assessing synergies among the Rio Conventions, are described.

2.4.2 Guidelines and tools

Different technical documents have suggested the development of appropriate methodologies for assessing synergies. For example, the IPCC (2002) has addressed the necessity to further develop assessment methodologies, criteria and indicators, which can assess climate change mitigation and adaptation activities on the biological diversity and other aspects of sustainable development.

The UNFCCC has recognised the need for cooperation in the development of methodologies and tools in order to act upon synergies (UNFCCC, 2004[a], 2005[a]). Besides, in the 11th SBSTTA (CBD) meeting was addressed that (UNEP/CBD, 2005[a]): "*There is a need to refine and further develop tools and methods for incorporating and evaluating synergy among biodiversity, climate change, desertification and land degradation into national and local planning, including relevant outcome-oriented indicators, while addressing the objectives of the three Rio Conventions and other relevant multilateral agreements*".

Regional and national level

According to initiatives and needs, guidance on synergies has been developed (see Box 2.5). For instance, the UNFCCC technical guidance is focused on providing information related to adaptation to climate change for creating synergy among MEAs, useful in the preparation and implementation of NAPAs (UNFCCC, 2005[a]). There are two interesting elements, the first one, a cross-cutting topic, such as the preparation of national programmes/plans (NAPAs, NAPs, and NBSAP). The second element is actor-oriented; therefore, outputs could provide support to the Least Developed Countries (LDC), through the consideration of the Least Developed Countries Expert Group (LEG).

In addition, UNFCCC has analysed opportunities and barriers of implementing synergies at a regional level, also related to national programmes/plans from the Rio Conventions (UNFCCC, 2005[b]). In summary, linkages between levels of implementation are addressed. At a national level, the NAPs and NBSAP should be considered during the preparation of the NAPAs. Then, the regional level can support the development and efficiency of activities at a national level.

Furthermore, the *Ad Hoc* Technical Expert Group (AHTEG) on Biodiversity and Adaptation to Climate Change has given advice and guidance on synergies for mitigation and adaptation activities (UNEP/CBD, 2005[b]).

Convention	Description
CBD	Guidance for promoting synergy among activities addressing biological diversity, desertification, land degradation and climate change (UNEP/CBD, 2005[b])
UNFCCC	Synergy among multilateral environmental agreements in the context of national adaptation programmes of action (UNFCCC, 2005[a])
UNFCCC	Regional synergy in the context of national adaptation programmes of action (UNFCCC, 2005[b])

Box 2.5 National and regional guidance on synergies among the Rio Conventions

Another initiative is the *UNEP Issue based modules project*, which proposes the coherent implementation of biodiversity related conventions through a voluntary guiding tool for **national focal points**. Modules have been developed based on the analysis and identification of the relationship of articles, decisions, resolutions and recommendations relevant to the specific issues under various agreements, to highlight overlaps and synergies, potential conflicts and possible gaps (UNEP, 2005).

Finally, it is worth to mention the OECD-DAC initiative, which has proposed the **Rio markers** for the identification of activities that target the objectives of the three Rio Conventions. Therefore, the integration of markers in the regular creditor reporting system facilitate the identification of official development assistance (ODA), which allocates funds for the implementation of each Convention (OECD/DAC, 2002).

A first study has been presented in 2002, after the Rio markers have been incorporated in the regular statistical data collection from 2004 for a trial period of three years[15]. Nowadays, a database[16] gives a descriptive indication on ODA targeting the objectives of the different Rio Conventions[17].

Local level

Some initiatives have proposed tools for incorporating objectives from the different Rio Conventions. For instance, the Scientific and Technical Advisory Panel from the Global Environment Facility (GEF) has developed a conceptual design **tool** to help incorporate **inter-linkages** into project design and implementation. The tool takes into consideration biodiversity, climate change, land degradation, and desertification, and aims at capturing synergy among focal areas of the GEF while minimizing potential negative impacts of a given project into other focal areas (GEF, 2004).

Furthermore, the German Federal Ministry for the Environment, Nature Conservation and Nuclear safety (UBA) has presented a **tool kit** for integrating biodiversity concerns in climate change mitigation activities. Besides, available evaluation methodologies are described such as the EIA, SEA and guidelines for the use of indicator (UBA, 2004[a]).

In summary, these tools are proposed for different activities and ecosystems. On one hand, GEF proposes a checklist of questions, and on the other hand, UBA proposes a flowchart of questions.

[15] Benn, J. 2005. Personal communication Information on the state of the art of Rio Markers initiative. Organisation for Economic Co-operation and Development - Development Assistance Committee (e-mail: 18/01/2005).
[16] ODA database: http://www.oecd.org/dac/stats/idsonline/.
[17] Sangaré C. 2007. Personal communication, information on the state of the art of Rio Markers initiative. Organisation for Economic Co-operation and Development. Development Cooperation Directorate. Statistics and Monitoring Division (e-mail: 01/03/2007)

2.5 Conclusions

In Chapter 2, the author of this research has attempted to describe and present different aspects of synergies among the Rio Conventions; for instance the objectives, arrangements, decisions and initiatives. Moreover, the international, regional, and national levels of implementation have been explored, all playing a role in the process.

The author believes that initiatives at international level facilitate and encourage national level implementation; consequently, this last level influences the development of appropriate tools/instruments at local level. Furthermore, the role of national focal points is crucial for coordinating and implementing synergies, since they interact directly with the international level, and can also work locally.

On one hand, UNEP/CBD (2007[c]) has addressed the importance of national level activities in the implementation of mutually supportive activities, especially with regards to mainstreaming. On the other hand, Saint-Laurent (2005) has described, that at national level, taking action based on achieving cross-convention synergies and involving key stakeholders as partners in such activities, can provide countries with good implementation value.

According to the needs identified at different levels, synergies among the Rio Conventions are being implemented. For instance, at international level, the creation of a *Joint Liaison Group* or at national level, the NCSA project. However, now attention should also be given to the assessment of synergies at **local level**. Thus, additional efforts to explore appropriate methodologies are needed. In this sense, this chapter has provided the background and justification to explore an appropriate scientific framework which allows the assessment of synergies among the Rio Conventions.

On the other hand, from the scientific level, interlinkages among the Rio Convention objectives have been recognised. However, from the practical point of view, the author claims that considering ecosystem services can be useful for addressing **synergies**. Therefore, the author has proposed to focus and characterized the forestry sector together with its ecosystem services before presenting the scientific framework of this research.

CHAPTER 3: THE FORESTRY SECTOR AND THE RIO CONVENTIONS

In order to assess synergies among the Rio Conventions, the forestry sector was studied in depth. Therefore, this chapter aims to describe the characteristics and role of this sector.

3.1 Introduction

The 1992 U.N. Forest Principles identified the multi-functional and multi-service purpose of the world's forests: ''*Forest resources use and forest lands shall be managed and used sustainably to fulfil social, economic, ecological, cultural and spiritual needs of present and future generations*'' (Forest Principles 1992).

Forests serve ecological functions and provide wood and numerous other products that contribute significantly to human well being at local, national, and global levels. They provide different services such as the conservation of soil and water resources, the conservation of biological diversity, the protection of natural and cultural heritage, the generation of employment, and recreational opportunities. Furthermore, the debate about forestry is intensifying, particularly in regards to the contradictory goals of conserving forests and biodiversity, meeting fast-growing market demand and promoting sustainable development.

Forests, forest communities, and forest markets are changing in fundamental ways. Therefore, the manner in which society values and manages forests is being seriously revisited (Scherr *et al.*, 2002). Moreover, the importance of forests has been recognised by international environmental processes such as the UNFCCC, CBD, UNCCD, and United Nations Forum on Forests (UNFF). In this context, the link between the global/international and local level in the forestry sector is important to be addressed.

This chapter aims to introduce the forestry sector and illustrates the potential for addressing synergies among the Rio Conventions while taking into consideration forestry ecosystem services. On the other hand, forestry expert interviews are included, thus concrete activities on synergies at different levels of implementation are described. Moreover, also information on stakeholder characterization at national level is presented. Finally, focused is given to the project level; therefore, international forestry projects are described.

3.2 Forests and forest ecosystems

3.2.1 Forest resources

The Global Forest Resources Assessment has reported that the total forest area in 2005 is just less than **4 billion hectares,** not uniformly distributed (FAO, 2006[a]). For example, the 10 most forest-rich countries account for two-thirds of the total forest area (Russian Federation, Brazil, Canada, United States, China, Australia, Democratic Republic of Congo, Indonesia, Peru, and India). Besides, primary forests account for 36% of forest area, but 6 million hectares are lost or modified

each year, and plantation forests are increasing, however still account for less than 5% of total forest area.

One-third of the world's forests are primarily used for production of wood and non-wood products, nevertheless, the value of wood removals is decreasing, while the value of non wood forest products (NWFP) is increasing and underestimated (FAO, 2006[a]). Likewise, the IPCC Fourth Assessment Report has described that the change in the output of global forest products ranges from a modest increase to a slight decrease, although regional and local changes will be large. Besides, production increase will shift from low-latitude regions in the short-term, to high latitude regions in the long-term (Easterling *et al.*, 2007). In Box 3. 1, products from forest ecosystems as described in the MA (2005[f], [g]) are shown.

In addition, more than 300 million hectares of forests are designated for soil and water conservation, and the use of forests for recreation and education is increasing, but difficult to quantify. For the world as a whole, carbon stocks in forest biomass decreased by 1.1 Gt of carbon annually, because of deforestation and forest degradation partly offset by forest expansion (including planting) and an increase in growing stock per hectare in some regions (FAO, 2006[a]).

Deforestation, mainly conversion of **forests** to **agricultural land**, continues at a high rate (about 13 million hectares per year). Moreover, logging and conversion to various forms of land, grazing and road construction are considered the greatest threats to Forest Biological Diversity – FBD (UNEP/CBD/AHTEG-BDCC, 2001). However, forest planting, landscape restoration and natural expansion of forests have significantly reduced the net loss of forest area (FAO, 2006[a]).

Consequently, the growing understanding of the complexity of the effects of **land-surface change** on the climate system shows the importance of considering the role of surface albedo, the fluxes of sensible and latent heat, evaporation, and other factors in formulating policy for climate change mitigation in the forest sector (Barker *et al.*, 2007). More information on the impact of climate change on FBD at genotype, species, ecosystems and biomes level is found in UNEP/CBD/AHTEG-BDCC (2001).

Categories	Products	
Timber and related products	❖ Industrial roundwood ❖ Wood pulp	❖ Craft wood
Non wood forest products (NWFP)	❖ Bamboos ❖ Rattans ❖ Foods ❖ Medicinal products	❖ Dyes ❖ Minerals ❖ Latex ❖ Ornamentals
Fuel	❖ Fuelwood ❖ Charcoal	❖ Industrial wood residues ❖ Biomass energy
Fiber	❖ Wood fiber	❖ Wildlife

Box 3. 1 Products from forest ecosystems

3.2.2 Forest ecosystem services or environmental services?

In general, **ecosystem services** are defined as benefits people obtain from ecosystems (MA, 2005[c]), and they are outcomes from ecosystem functions (GEF, 2002). Moreover, these services are the result of complex relationships and processes of the components of biodiversity – genes, species and ecosystems – working together (IUCN, 2005[b]). The Millennium Ecosystem Assessment has described the **supporting** (services that maintain the conditions for Life on Earth), **provisioning** (goods produced or provided by ecosystems), **regulating** (benefits obtained from regulation of ecosystem processes), and **cultural** (non material) services (MA, 2005[c]). Besides, a similar classification has been reported in a CBD technical document (UNEP/CBD, 2005[c]). Therefore, a comparative list of ecosystem services has been prepared and shown in Box 3.2.

Service		UNEP/CBD (2005[c])	MA (2005[c],[d])
Supporting necessary for the production of all other ecosystem services		- soil formation - nutrients cycling - primary production. - evolutionary processes	- soil formation - photosynthesis - primary production. - nutrients cycling - water cycling
Provisioning harvestable goods	*Natural production*	- timber - firewood - genetic material	- food: capture fisheries, wild plants. - wood: timber, wood fuel - genetic resources - natural medicines - ornamental resources - fresh water
	Nature-based human production	- tree plantations productivity - managed forest productivity	- food: crop, livestock, aquaculture and animal products - fiber: cotton, hemp, silk - genetic resources - biochemical, pharmaceuticals
Regulating responsible for maintaining natural processes and dynamics	*Biodiversity-related regulating services*	- maintenance of genetic, species and ecosystem composition - maintenance of ecosystem structure - maintenance of key ecosystem processes for creating or maintaining biodiversity	- invasion resistance
	Land-based regulating services	- decomposition of organic material - biological control mechanisms - seasonal cleansing of soils - soil water storage capacity - soil protection - suitability for leisure and tourism activities - suitability for nature conservation	- erosion regulation - disease regulation - pest regulation - natural hazard regulation - pollination and seed dispersal
	Water related regulating services	- water filtering - bio-chemical/physical purification of water - storage of pollutants - flow regulation for flood control - river base flow regulation - water storage capacity - regulation of water balance	- water regulation - water purification and waste treatment
	Air-related regulating services	- filtering of air - photo-chemical air processing (smog) - wind breaks - carbon sequestration	- air quality regulation - climate regulation: global, regional, local
Cultural services		providing a source of artistic, aesthetic, spiritual, religious, recreational or scientific enrichment, or nonmaterial benefits.	cultural diversity, spiritual and religious values , knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, and recreational and ecotourism values.

Box 3.2 Ecosystem goods and services from forest ecosystems

On the other hand, Powell *et al*. (2002) have defined **environmental services** of forests as those ecological processes from which humans directly benefit. Rojas and Aylward (2003) have described that environmental services can be taken to refer to the overall concept of natural systems providing a continuous flow of valuable goods and services to society. But environmental services can also refer to positive externalities – affecting a consumer good – associated with particular environmental conditions, e.g. a certain land use (FAO, 2004[a]). Moreover, forest services have been divided into (FAO, 2005[a]): *environmental* (water system regulation, microclimate regulation, carbon fixation and storage, biological diversity conservation, and soil protection) and *social* services (conservation of scenic beauty, the cultural habitat and religious heritage).

In conclusion, the author has found that the concept of **forest services** is constructed in many different ways, using indistinctly ecosystem or environmental services. Therefore, for the purpose of this research, the ecosystem services definition including forest products (timber and non-timber) and services from forest ecosystems have been considered (GEF, 2002). Instead environmental services will include only services, such carbon sequestration, biodiversity protection, etc. In this sense, Katila and Puustjärvi (2004) have defined that markets for forest environmental services in the strict sense cover only the service flows from forest ecosystems and do not include markets for forest goods (non-wood forest products and wood), irrespective of the end use.

Services provided by forests and woodlands are numerous and diverse on all spatial and temporal levels, and they are related to each other in many different ways, ranging from synergistic to tolerant, conflicting, and mutually exclusive. The multi-service paradigm of forest management is therefore quite clear in theory but is often very difficult to implement, as it frequently requires difficult choices and **trade-offs** [18] (MA, 2005[g]). In the last 10 years, forest services which have been reported in literature are shown in Box 3.3.

Nowadays, biodiversity, carbon sequestration, watershed protection and forest landscape are services with the most market potential (Grieg-Gran *et al*., 2005; Katila and Puustjärvi, 2004; Landell-Mills and Porras, 2002). The different commodities, which are used for the same forest environmental services of forests, are shown in Table 3.1.

Furthermore, types of market and payment schemes reported are (Scherr *et al*., 2004): (a) public payment schemes to private forest owners to maintain or enhance ecosystem services; (b) open trading under a regulatory cap or floor; (c) self-organized private deals; and (d) eco-labeling of forest or farm products, an indirect form of payment for ecosystem services.

[18] trade off is defined as the act of balancing two things that you need or want but which are opposed to each other (oxford dictionary)

Source	Forest ecosystem services	
FAO, 1992 (Role of forests in our lives)	❖ Ecological improvement: genetic resources conservation and improvement, climatic and micro climatic influence ❖ Soil and water conservation: nutrient cycle, water storage, soil stabilization ❖ Habitat: wildlife, fish, other flora and fauna ❖ Recreation and aesthetics: national parks, local recreation areas, urban forestry	❖ Forest based industries: wood based and non wood based ❖ Energy utilization: fuel wood and charcoal ❖ Agro-forestry: on-farm multiple use ❖ Range restoration and improvement: fodder, cover, soil protection
Daily 1997 in Scherr *et al*., 2004 (Forest ecosystem services)	❖ Purification of air and water ❖ Regulation of water flow ❖ Detoxification and decomposition of wastes ❖ Generation and renewal of soil and soil fertility ❖ Pollination of crops and natural vegetation ❖ Dispersion of seeds and translocations of nutrients	❖ Maintenance of biodiversity ❖ Partial climatic stabilization ❖ Moderation of temperature extremes ❖ Wind breaks ❖ Support for diverse human cultures ❖ Aesthetic beauty and landscape enrichment ❖ Control of agricultural pests
ICUN et al., 2005 (Ecosystem services)	❖ Fresh water ❖ Food ❖ Timber, fuel and fiber ❖ Novel products ❖ Biodiversity regulation ❖ Nutrient cycling	❖ Air quality and climate change ❖ Human health ❖ Detoxification ❖ Natural hazard regulation ❖ Cultural and amenity
MA, 2005[g] (Ecosystem services)	❖ Industrial wood, fuelwood ❖ Non- wood forest products ❖ Water protection ❖ Soil protection ❖ Health protection ❖ Biodiversity	❖ Climate regulation ❖ Eco-tourism ❖ Recreation ❖ Sport, fishing/hunting ❖ Spiritual ❖ Cultural and historical

Box 3.3 Forest ecosystem services

Payment for Environmental Services (PES) schemes for forest services may be foreseen as part of forest management implementation, providing new incentives to change to more sustainable decision patterns (Nabuurs *et al*., 2007). The central principles of PES are, that those who provide environmental services should be compensated for doing so and that those who receive the services should pay for their provision (Pagiola and Platais, 2002).

Under these circumstances, payments for services can potentially benefit forest owners and producers by increasing forest income, encouraging sustainable production, increasing the scale and value of forest assets, and providing non-income livelihood and community social benefits. Although, there are also potential risks, for example, where payments are dependent upon the delivery of specific ecosystem outcomes, factors outside producers' control may result in a failure to achieve contractual obligations and in non-payment (Scherr *et al*., 2004).

PES has become an important topic in the context of economic development and poverty reduction (Zilberman *et al*., 2006; Grieg-Gran *et al*., 2005). However, experience is concentrated in few countries, mainly in Latin America with mixed results, with smallholders having favoured access in some schemes and being hampered in others (Grieg-Gran *et al*., 2005; Wunder, 2004). For example, Rojas and Aylward (2003) have described initiatives from Costa Rica PES and Gouyon

(2003) has done a review of rewarding the upland poor for environmental services in developed countries.

Environmental service	Commodity
Watershed protection (e.g. reduced flooding; increased dry season flows; improved water quality; maintained aquatic habitat; soil contaminant control; reduced downstream sedimentation)	Watershed management contracts; water quality credits; water rights; land acquisition/lease; salinity credits; transpiration credits; conservation easements; certified watershed-friendly products; stream flow reduction licenses; salmon habitat credits; reforestation contracts; protected areas
Landscape beauty (e.g. protection of scenic "viewscapes" for recreation or local residents)	Entrance rights; long-term access permits; package tourism services; natural resource management agreements; eco-tourism concessions; photographic permits; land acquisition; land lease
Biodiversity conservation (e.g. role in maintaining ecosystem functioning, maintaining options for future use, insurance against shocks, improved choice, existence values)	Protected areas; bio-prospecting rights; biodiversity-friendly products; biodiversity company shares; Debt-for-nature swaps; biodiversity credits; conservation concession; land acquisition; biodiversity management contracts; logging rights acquisition; tradable development rights; conservation easements
Carbon sequestration (e.g. absorption and storage of carbon in forest vegetation and soils)	Assigned Amount Units, Certified Emission Reductions, Emission Reduction Units, Removal Units; carbon offsets/credits, tradable development rights, conservation easements

Table 3.1 Commodities identified for different environmental services of forest

An analysis of the importance and role of environmental markets can be found in Bayon (2004), Landell-Mills and Porras (2002) and Scherr *et al*. (2002). For case studies on water services protection from forest see Perrot-Maître and Davis (2001), Johnson *et al*. (2001) and Cavatassi (2004), for biodiversity services see Jenkins *et al*. (2004), for market evolution of forestry-based carbon offsets see FAO (2001). Besides, the state of ecosystem service market from tropical forests can be revised in Scherr *et al*. (2004). Global review of market for forest environment services and their impact on poor can be found in Landell-Mills and Porras (2002) and for further bibliography see (WI, 2005).

3.3 Synergies in the forest sector

3.3.1 Forest-related MEAs

Different MEAs tackle forests and forests ecosystems as thematic. Therefore, in this context, synergies has been defined as follows: "*synergy could be said to exist when the combined provisions and implementation of all forest-related MEAs is such that conservation, sustainable management and sustainable development of forests is furthered more than would be the case through the sum total of the individual instruments on their own"* (Ecologic, 2001).

Moreover, a significant finding of a project on synergies between MEAs in relation to the conservation and sustainable management of forests is that achieving synergy of forest-related MEAs is a long-term process and is not immediately attainable, but should be seen as resulting from an **iterative** process (Ecologic, 2001).

On the other hand, Kimball (2001) has described that the goal of synergy among forest-related agreements is sustainable forest management (SFM), meaning the sustainable harvest of forest products and ensuring sustained environmental services; the implications for management are actions on an ecosystems basis, which in turn calls for greater reliance on institutional arrangements at the regional level. Within this context, forest ecological **linkages** that are global and regional in scale with the Conventions designated to address these problems are shown in Table 3.2.

Linkages	Scale	Description
Forest-Related Ecological Linkages	*Global Scale*	- climate change - energy supply and sinks - habitat for species that migrate between regions
	Regional Scale	- deforestation - land degradation and desertification - over harvesting/removal of mangrove forests - effects on wetlands function and habitat - adverse effects of forest management on habitat and corridors for migratory species - deforestation in watersheds - sedimentation in rivers and coastal areas, habitat degradation - use of pesticides in forest plantations - river/coastal pollution
Convention Linkages Based on Scale of Problem	*Global Scale Problems*	- Climate Convention - Convention on Migratory Species (habitat/inter-regional migration)
	Regional Scale Problems	- Desertification Convention, Biodiversity Convention, Ramsar Convention on Wetlands - World Heritage Convention, CITES - habitat for listed species - Convention on Migratory Species - habitat/intra-regional migration - Central American Regional Convention for Management and Conservation of Forest Natural - Ecosystems and the Development of Forestry Plantations (1993) - Convention for the Conservation of the Biodiversity and the Protection of Wilderness Areas in Central America (1992) - Alpine Convention - River Basin Conventions - erosion/habitat, migration corridors - Regional Seas Protocols on Land-Based Pollution and Protected Areas/Species - respectively, sedimentation and pesticide pollution; habitat/intra-regional migration - Regional protected areas and species conventions – habitat/intra-regional migration (ASEAN, South Pacific/Apia, Western Hemisphere, Africa/Algiers) - Long-Range Transboundary Air Pollution Convention (1979), Climate Convention - impacts on forests due to transboundary air pollution
Other Linkages		- ITTA – international trade in forest products - WTO – international trade in forest products - CITES - international trade in endangered forest species/products - POPs, PIC Conventions - pesticide use and trade - Biodiversity Convention/Biosafety Protocol – alien plant control - ILO Conventions 107 and 169 - indigenous peoples

Table 3.2 Conventions related to the forest sector

3.3.2 Synergies among the Rio Conventions

Forests and forest ecosystems have been identified as a common topic to UNFCCC, CBD and UNFCCC, enabling Conventions to fully participate and benefit from the exchanges and findings (UNEP/CBD, 2007[c]; UNCCD/CBD, 2004; UNEP/CBD, 2004[c]; UNFCCC, 2002[c]). Moreover, projects related to **forest ecosystems** have a privileged position within GEF's activities owing to the importance of these systems for the focal areas of climate change, biodiversity, soil degradation, and the integrated management of continental waters (FAO, 2005[a]).

From a **scientific** perspective, forests are instrumental in mitigating climate change, promoting biodiversity, and forestalling desertification because of their effect on soil and water. Moreover, forest ecosystems perform hydrological, climate and soil stabilizing functions. Therefore, widespread deforestation may dry up local climates and increase evapotranspiration, accelerates desertification via its effect on biodiversity. Alusa (1997) has analysed the scientific linkages and complementaries between the Rio Conventions and Forest principles.

From a **practical** perspective, Greenspan Bell (1997) has described that UNCCD and forests address aspects of the impacts of unsustainable and detrimental practices, and drought on forest, eco-system, or habitat management. Then, the CBD preserves habitats and ecosystems to maintain biological diversity and the UNFCCC is not specifically directed at the problem of threats to forests, habitats, or ecosystems, and in fact is directed toward a much wider range of human activities.

From a **global** perspective, natural forest protection is a priority, for mitigating the negative impacts of climate change, protecting biodiversity, and combating desertification (OECD/DAC, 2002; UNCCD, 1999). Moreover, forests can make a very significant contribution to a low-cost global mitigation portfolio that provides synergies with adaptation and sustainable development (Nabuurs *et al*., 2007; SCBD, 2003; Totten, 1999). Besides, Mc Ginley and Finegan (2003) have stated that is necessary to promote synergy in planning and implementation of forestry mitigation and adaptation projects to get maximum benefit for the global environment, local communities or economies. However, Tol (2006) has described that there are difficulties in enhancing synergies while analysing the adaptation and mitigation activities.

3.3.3 Conflicts among the Rio Conventions

Both synergies and conflicts between the objectives and instruments of international climate policy and the goal of sustainable forest management appear to be possible as described in Tarasofsky and Oberthuer (2001). Therefore, is necessary to establish an international **framework** to encourage synergistic actions that capture multiple benefits while avoiding negative trade-offs (Totten *et al*., 2003).

In literature, mainly conflicts between activities under the UNFCCC and CBD have been analysed. For instance, Walsh (1999) and Caparrós and Jacquemont (2003) have described positives and negative impacts between the different environmental services of the forest, such as carbon sequestration through afforestation and reforestation and biodiversity. However, Totten *et al*. (2003) have suggested that by establishing appropriate accounting methods, mitigation frameworks, and definitions, Kyoto policymakers have the opportunity to foster actions that could tap the **synergies** that exist between climate and biodiversity protection.

Furthermore, the potential conflict between CBD and UNFCCC appears when trying to **maximise** carbon uptake by forest ecosystems, fast growing monoculture tree plantations promise the maximum short-term removal of carbon dioxide. Then, this could lead to the creation of "high yielding mono-culture tree-plantations" that "resemble fields of crops as opposed to natural forest". Climate policies and measures leading to such results would clearly be at odds with the objectives of sustainable forest management and biodiversity conservation (Tarasofsky and Oberthuer, 2001).

Moreover, whether impact of activities on climate change mitigation and biodiversity conservation are beneficial or adverse depend on: a) the selection of practices within the activity; b) the management options related to the activity; c) biological and physical conditions of the area; and d) the socio-economic conditions of the region (UBA, 2004[b], 2001). In Table 3.3, the beneficial and adverse impacts from different land use activities are shown (UBA, 2004[b], 2000).

After, these sections, where synergies and conflicts have been addressed, the author has found useful to further analyse forest ecosystem services. While describing synergies, different environmental services such as climate regulation or soil stabilization were referred. Moreover, while describing conflicts environmental services such as carbon sequestration or biodiversity protection were illustrated.

Land use activities	Circumstance for potential beneficial on biodiversity	Circumstance for potential adverse impacts on biodiversity
Conservation natural forests	General positive	Priority areas for conservation could be different under both conventions
Afforestation and reforestation	• If natural regeneration and native species are used that reflect structural properties of surrounding forest • If mixed age-classes stands are established • If clearing of pre-existing vegetation and thinning is minimised • If chemical use is minimised/excluded • If areas for habitats for different species are considered • If rotation length is extended • If tree density respects biodiversity needs • If low impact harvesting methods are used • If activity improves connectivity between habitat patches or fragments • If activity takes place on degraded pasture and agricultural site • If biological conservation or restoration of ecosystems is an integral part of the management scheme	• On areas where natural ecosystems are destroyed for the activities (e.g. plantations on • recently cleared tropical forests) • If monoculture of exotic species are used on large areas • If single age-class stands are established • If other vegetation is completely cleared before and during the activity • If chemicals are used • If no habitats are created • If short rotation periods are used • If tree density is very high • If harvesting operations clear complete vegetation • If sites with special significance for the in-situ conservation for agrobiodiversity are afforested • If drainages are used
Restoration of degraded lands/ ecosystems	• Often positive because restoration increases species richness • Positive effect will depend on the definition of degraded	• If habitats of species that are adapted to extreme conditions are destroyed. • Possible increase on N2O emissions because of fertilizer
Forest management	• If natural forest regeneration occurs • If use of chemicals is excluded/ minimised • If fire management respects natural fire regeneration cycles • If low-impact harvesting and extended rotation periods occur • If natural disturbances regimes are permitted resp. emulated (Biodiversity of young and premature stages and open areas benefit) • If used local and side adapted species for planting • If forest stands have different ages and structures • If important microstructures such as old growth forest as well as dead and decaying wood are maintained • If important key habitats are protected • If biological conservation or restoration of ecosystems is an integral part of the management scheme.	• If natural and semi-natural forests are replaced by mono-specific and even-aged plantations • If abundant chemical use occurs • If fire management disrupts natural fie regeneration cycles • If non-site adapted species are planted, e.g. invasive alien species and genotypes or genetically modified organisms (GMOs) • If natural regeneration is suppressed • If poor logging practices (high-impact harvesting) occur, e.g. use of damaging machinery. • If large scale clear-cuttings occurs in areas without natural large scale disturbances • If important forest structures such as dead and decaying wood are removed • If drainages are used
Agroforestry	Mainly positive if not established on areas of natural ecosystems	Negative if natural forests of other natural ecosystems are replaced.
Introduction of species	If species are known as non-invasive in the affected ecosystem, restore natural ecosystems and provide habitat for other native species	Mainly negative
Revegetation	• If measure increases richness of native plant species over time • If measure prevents further degradation and protects neighbouring habitats	• If measure destroys endemic species • If exotic species for revegetation invade native habitats • Possible increase on N2O emissions because of fertilizer use

Table 3.3 Beneficial and adverse impacts from land use activities

3.3.4 Matrix of forest ecosystem services

In this section, the author wants to associate the multiple forestry services with the Rio Conventions. Therefore, ecosystem services can be used as a tool for further analysing interlinkages.

For this purpose, a comparative matrix, with the aim to identify ecosystem services (provisioning, supporting, regulating, and cultural) relevant at local and global level, has been used (see Table 3.4).

Ecosystem services		Local	Global		
			UNFCCC	UNCCD	CBD
Supporting	Soil formation			√	√
	Photosynthesis		√	√	√
	Primary production		√	√	√
	Nutrient cycling		√		√
	Water cycling			√	
Provisioning	Food:				
	Wild plants and animal products	√		√	√
	Wood:				
	timber	√	√	√	
	wood fuel	√	√	√	
	Genetic resources	√			√
	Biochemical, natural medicines, pharmaceuticals	√			√
	Ornamental resources	√			√
	Fresh water	√			
Regulating	Air quality regulation	√			
	Climate regulation:				
	Global		√	√	√
	Regional			√	√
	Local	√		√	√
	Water regulation			√	
	Erosion regulation			√	
	Water purification and waste treatment			√	
	Disease regulation	√		√	√
	Pest regulation	√		√	√
	Pollination and seed dispersal	√		√	√
	Natural hazard regulation	√			
Cultural	Cultural diversity	√			
	Spiritual and religious values	√		√	
	Knowledge systems	√		√	
	Educational values	√			
	Inspiration	√			
	Aesthetic values	√			
	Social relations	√			
	Sense of place	√			
	Cultural heritage values	√			
	Recreational and eco-tourism values	√			√

Table 3.4 Forestry ecosystem services relevant at a local and global level

On the contrary, for valuation purposes, Hein *et al*. (2006) have not included the provisioning services because their value is reflected in the other three types of services and the inclusion in valuation may lead to double counting.

Most **supporting** services, as for example primary production and photosynthesis are relevant to the Rio Conventions. Then, **provisioning** services, such as timber and wood fuel are linked to local interests. But, also UNCCD can be interest on the supply of goods such as timber and wood fuel, and the CBD in the protection of genetic resources, biochemical, natural medicines, pharmaceuticals, and ornamental resources. Moreover, **regulating** services, such as disease regulation, pest regulation, and pollination and seed dispersal can be of indirect interest for the UNCCD activities and also of local interest. The CBD is directly linked to protect these ecosystem services, while climate regulation could adversely influence biodiversity. Finally, **cultural** services are mainly important at a local level, but some of them are being considered under the UNCCD, such as spiritual and religious values and knowledge systems. Indirectly, CBD is linked to the recreational and eco-tourism values. At the end, for the UNFCCC the timber, wood fuel and climate regulation services can be considered of interest.

Through this comparative matrix two aspects can be evidenced. The first one deals with the direct and indirect interests of the Rio Conventions (global level). The second identifies the importance of ecosystem services at local level. In this sense, Kimball (2001) has stated that the UNFCCC is linked to global scale problem and the UNCCD and CBD to a regional scale problem.

On the other hand, forest ecosystem services are *internalised* at local level by owners and managers of the forests (e.g. biological control of plagues) versus *external* benefits (Nasi *et al*., 2002). These last benefits include regional (use of water for irrigation downstream), national (a hydroelectric downstream) and global (carbon sequestration). Many studies have demonstrated that the valuation of external services is higher than internal (local). Besides, Castro *et al*. (2002) have presented the experience in Costa Rica with the internalisation of forestry services, identifying the services and the level of benefit. For instance at global level, carbon sequestration, biodiversity and scenic beauty, and at national level including also hydropower production potential, water supply and watershed protection.

Last but not the least, this initial exercise which recognises local and global interests has been useful when selecting forestry decision criteria (see section 6.3).

3.4 Forestry expert interviews

To connect theory with real-world, an interview process has provided concrete examples in the forestry sector. This section describes the initial interview process which was held in 2005 with international forestry experts and in September 2006 during a field visit in Peru. The first section describes activities for implementing synergies in the forestry sector, at global, regional, and national level. In the second section, the role and interests of forestry stakeholders at national level in Peru are described. The contributions of experts and recommendations have been useful while exploring synergies in the forestry sector.

3.4.1 International forestry experts

The main objective of this interview was to learn about current institutional activities regarding synergies among the Rio Conventions in the forestry sector. Meetings took place on January 24, 2005 and February 09, 2005. Dr. Schoene had organized and contacted experts from FAO working at different levels of implementation (international, regional and national). Other local experts working in the field of Climate Change in Italy were also consulted (APAT and Ministry for the Environment, Land and Sea).

The list of experts that were interviewed is shown in Appendix 5. Moreover, in preparation to FAO meetings, technical documents were reviewed (UNEP/CBD, 2004[b]; UNCCD/CBD, 2004).

In summary, through the interview process the dimension and role of the different implementation levels were understood. Activities and examples are reported in the following paragraphs.

National level

The Rio Conventions have a strong support from the afforestation and reforestation sectors, and some activities developed to support synergies at a national level are: a) Code of Best Practices (Best Available technologies), for planting, standards within ecological zones; b) Forest Resource Assessment (FRA), collection information, report performance of countries on planting; and c) Integrate Databases, considering data related to insect, diseases, fire, illegal logging, yield, rotation, aspects that can cause the lowering of the performance.

Furthermore, the importance of data collection for the Rio Conventions and reporting process was also highlighted by the expert. In this context, Greenspan Bell (1997) has suggested that some attention should be given to the subject of eliminating redundancy and overlap in reporting and related obligations, and thereby capturing some efficiency.

Another perspective of synergies can be focused on the functions from forests; probably each Convention has a different interest (see section 3.3.4). A final recommendation from the expert was to look for the international (UN level) and national levels because of the links among them.

Regional level

At regional level, the need for monitoring the Rio Conventions was addressed (framework of *Silva Mediterranean* project). Therefore, the importance of considering the different conventions has been recognised. The expert has provided an example of sand dune shift. Therefore, if introducing new specie in a sand dune, it is necessary to take into consideration the biodiversity and invasiveness of the introduced specie. Then, desertification and biodiversity issues are considered. This specie introduction can help the restoration of carbon sequestration, thus there is also the contribution in the climate field. At the end, a single intervention has considered desertification and biodiversity aspects, and indirectly also climate change issues.

International level

An international/global initiative on synergies is the Collaborative Partnership on Forests (CPF), created in 2001, with 14 forestry related participants, including the Secretariats of the Rio Conventions. In 1995, before the creation of the CPF, there was the Inter-agencies Task force.

The main goal of CPF is to enhance cooperation in the forestry sector and support the UNFF. The CPF is considered one of the unique partnerships, which make possible to collaborate in the **forestry sector.** The CPF is a voluntary approach, neither official nor mandatory, which has not been formalised under the UN. The main characteristics from CPF are the flexibility and informality, because there is a real commitment from the agencies that are participating to the partnership. In different contexts, the CPF has been emphasized as an important platform for addressing common forest-related topics and **synergies,** because involves all key organizations involved in activities relating to sustainable forest management (UNCCD/CBD, 2004; Tarasofsky and Oberthuer, 2001).

On the other hand, probably the forestry sector is the only one, which has been able to have a partnership and collaboration between agencies. Some concrete activities are the CPF Portal on Forest Reporting which has the challenge to improve information of forest management, provision of information and coordinate information requested to countries. Also, the CPF Sourcebook on funding for sustainable forest management, which has identified more than 500 different potential funds for forestry management.

3.4.2 National forestry experts

During a field visit in Peru, an interview process was held in September 2006 with national forestry experts. Dr. Eduardo Garcia from the *Instituto Nacional de Recursos Naturales* (INRENA), Ministry of Agriculture from Peru had organized the interviews.

The main objective was to identify the different stakeholders participating at the national level in Peru with a specific role in the forestry sector. A questionnaire was also sent to these participants and initial results are presented in this section.

Stakeholder interview

During the field visit to Peru, most relevant stakeholders from the private and public sector in the forestry sector were contacted (see Appendix 5). At the national level, two main institutions were contacted: the National Environmental Council (CONAM), main political body on environmental policy issues, and the National Institute of Natural Resources (INRENA) from the Ministry of Agriculture, in charge as governmental agency of the conservation of forest ecosystems. Different experts from INRENA in charge of forest concessions for different purposes, use of wood, conservation of biodiversity and ecotourism were interviewed. Besides, international cooperation present in Peru was also contacted. For example, the Sustainable Rural Development Program - PDRS from GTZ (German cooperation) is focused on rural issues (irrigation management, production chain and conservation of natural resources).

Non governmental organizations (NGOs) are playing an important role in the forestry sector in Peru. For instance, BSD is implementing reforestation/afforestation projects in Cajamarca, Cuzco, and Ucayali. Then, AIDER is contributing in the North region of Peru with projects on Dry forests, where the aim is to improve livelihoods of local communities through community forestry activities. Another experience comes from TNC Peru, which has as objective for the coming 10 years, the conservation of at least 10% of the main habitats in the world. Therefore, there is priority for intervention activities in Peru (coast area, dry forest, highlands, north dry forest, and yunga). Some projects that have been implemented by TNC are the Pacaya-Samiria Conservation project including community management activities and Selva Central project with community management for strengthening capacities among others. Besides, there is PRONATURALEZA, which includes in project implementation the conservation and management of resources, and environmental educational issues. Besides, projects aim to manage natural resources at local and communal level, capacity building, and organization of communities. Moreover, focus is also given to forest environmental services.

The Agrarian University (*Universidad Nacional Agraria La Molina*) has followed different forestry processes in Peru. They have participated in activities related to protected areas, and protection and conservation of wildlife in Peru, such as *Pacaya-Samiria* in the jungle, *Porcon* in the highlands of Cajamarca, and *El angolo* in the coastal region of Peru.

Finally, there are the environmental funds in Peru, two of them were contacted. FONDEBOSQUES is a forestry fund, which aims to promote sustainable business in productive

areas, where clients are forestry producers with concessions (wood, ecotourism, conservation). FONAM, the national environmental fund, which is promoting the development of Clean Development Mechanism (CDM) projects in the energy and forestry sector in Peru.

In general, the main problems faced in the forestry sector in Peru are the deforestation and the illegal traffic of wood products. More information on the country profile is found in FAO (2004[b]) and World Bank (2007).

Questionnaire

For the questionnaire process, different institutions have participated, such the national environmental authority, ministry of agriculture, ONGs, international cooperation, environmental funds, research institutions and university,

A list of the stakeholders participating and a description of their role in Peru is presented in Appendix 6. For the purpose of this section, only results on macro criteria importance (weight expressed in percentage, %) given by experts when evaluating forestry projects are presented (see Figure 3.1). Further, information on the questionnaire process is described in Chapter 6.

Governmental institutions such as CONAM and IRENA gave highest importance to the social criteria compared with other participants; instead PRONAMACHCS gave a balance importance to the three criteria. Then, environmental funds, such as FONDEBOSQUES gave highest importance to the economic criteria, FONAM gave equal importance to social and economic, instead FONDAM to the social criteria. In general, NGOs (PRONATURALEZA, AIDER, TNC, and AEDES) have assigned importance in a balance way, however social and environmental criteria were more important. Research institutions and university, such CIFOR and UPDAI have given similar importance to the environmental and social criteria; instead ICRAF Peru has given greater importance to the environmental criteria. Last, the international cooperation institution, SNV Peru gave equal importance to the social and economic criteria.

The questionnaire has obtained direct information on the importance (weight) which is given to the social, economic, and environmental criteria, while evaluating forestry projects. Assignment of importance can initially been attributed to the objective of each institution and the type of actor (policymaker or scientist) participating in the questionnaire. An in deep analysis of forestry criteria and the different factors affecting the assignment of weights is given in Chapter 6. Theoretically, for achieving sustainable development, criteria should have similar importance, but practically stakeholder's importance on social, economic and environmental criteria are different.

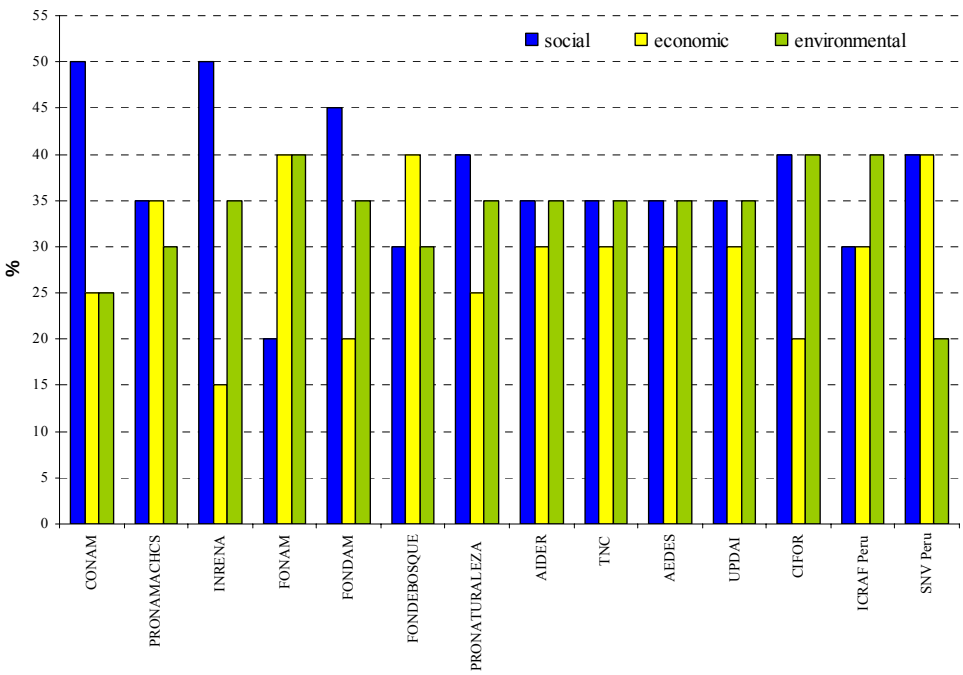


Figure 3.1 Importance of forestry macro criteria for project evaluation

3.5 Assessment of forestry projects

In this section focus is given to international forestry projects as they will be considered for assessing synergies among the Rio Conventions in Chapter 6 and Chapter 7.

3.5.1 International forestry projects

Forestry international projects can be developed and implemented with different objectives. For instance, for the UNFCCC Afforestation/Reforestation (AR) projects seek carbon sequestration among other benefits, the CBD can be interested to the conservation, protection, and sustainable use of forestry resources and the UNCCD can focus efforts on rehabilitation and restoration activities to fight against land degradation. However, forestry projects can promote convergent solutions, which address climate change, biodiversity loss, and combat desertification, since actions could foster problems simultaneously. Benefits, which can be achieved with forestry projects are various and are linked to forest ecosystem services (see section 3.2). A list of benefits from forestry projects is shown in Box 3.4.

On the other hand, implementing projects in different regions call for specific interventions. For example, natural resource management projects in certain parts of Europe and Central Asia region may largely involve arable soils conservation and water salinity management for irrigation, however in the Latin America and Caribbean region projects may involve preserving areas of high endemism in protected areas (World Bank, 2005).

Benefits from forestry projects (Smith and Scherr, 2002)	
• Sustainable management of genetic, biotic and ecosystem resources • Incorporation of genetic resources, identified through bioprospecting, into agricultural production • Control of soil erosion and sedimentation in bodies of water • Sustainability of hydroelectric facilities and irrigation districts • Prevention of floods and landslides • Permanent supply of potable water • Reduction of pressure on natural forests • Reduction in the expansion of extensive and steep lands farming • Reduction of poverty among rural people • Reduction in migration and displacement of rural people	• Reduction of poverty among rural producers by improving their average monthly income and capital accumulation • Increase in social investment at municipal and regional levels • Reduction in armed confrontation and increased political stability • Continuous energy service, of improved quality and at lower cost • Improved local, regional and national commercial balances • Organisation of new businesses and diversification of rural production • Opening of new markets and improved positioning of agricultural land forest products in internal and external markets • Development of social organisation and citizen participation

Box 3.4 Benefits of forestry projects

In the last few years, different activities under the Kyoto Protocol framework have involved forestry projects, where only AR activities are authorised, excluding categories such as soil carbon storage, sustainable forest management, and avoided deforestation. Eyre (1999) has demonstrated how significant is the effect of the Kyoto Protocol on the forestry sector's development and how the Kyoto Protocol provides a catalyst to capture the economic rent of other environmental values.

Some aspects on forestry projects and the Kyoto Protocol are highlighted in the following paragraphs. Update information on the Kyoto Protocol mechanisms is found in the following web sites: UNFCCC/CDM [19], Institute for Global Environmental Strategies [20] and UNEP Riso Centre[21]. Information on baseline and monitoring methodologies guidelines for AR projects under the Kyoto Protocol can be found in the UNFCCC/CDM web site[22], FAO (2005[b]) and Pearson *et al*. (2005[a], [b]).

In this context, several official submissions regarding LULUCF have been made from Africa, Asia, and Latin America regarding the sustainable development benefits associated with making such assets more attractive to the market (Capoor and Ambrosi, 2006). So far LULUCF remains at 1% of volumes transacted. Their regulatory complexity and limited market access to the EU is likely to limit their demand (at least from private compliance buyers and their intermediaries). However, the proven community benefits and competitive cost may result in some additional demand from public buyers, including European governments (Capoor and Ambrosi, 2007).

Some scenarios on carbon sequestration have also been reported by different authors. For instance, Sathaye *et al*. (2001) have presented the potential for carbon sequestration and emissions

[19] http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php
[20] http://www.iges.or.jp/en/cdm/report.html
[21] http://cd4cdm.org/publications.htm
[22] http://cdm.unfccc.int/methodologies/index.html

reduction in the forestry sector for seven developing countries (Brazil, China, India, Indonesia, Philippines, Mexico, and Tanzania). Besides, at a global level, Benitez *et al*. (2007) have reported a framework for identifying least-cost sites for AR and deriving carbon sequestration cost curves in a scenario of limited information. Results have shown that within 20 years and considering a carbon price of US$50/tC, tree-planting activities could offset 1 year of global carbon emissions in the energy sector. However, if considering country risk, political, economic, and financial risks, carbon sequestration is reduced by approximately 60%.

The sustainability of forestry projects is important to consider during preparation and implementation phases. The sustainability of the LULUCF projects consists on the economic, environmental, social and institutional dimensions. Madlener *et al*. (2006) have stated that at this level, the complexity of sustainability is understood as a multiple objective optimisation exercise. Such an exercise aims to simultaneously maximize the stability of both nature and human society by optimising and harmonizing among the social, economic, environmental, and institutional dimensions, irrespective of whether they are in line with each other or diametrically opposed (Madlener *et al*., 2006). Nevertheless, the author of this research claims that for achieving sustainability through **optimisation** exercises is not anymore appropriate, but identifying compromise solutions. Further discussion on sustainable development and multiple objectives is provided in Chapter 4 (see section 4.4.5).

3.5.2 Project classification

Davis (2000) and Totten (1999) have described that existing carbon forestry projects include: preserving and protecting frontier forests, buying back logging concessions in biologically rich areas, reduced impact logging methods, sustainable forest management, managing wildfire threats, bringing degraded lands into plantation production, afforestation of pasture and marginal agricultural land, use of sustainably grown biomass to displace fossil fuels, agro-forestry on farms, and urban forestry.

Besides, Brown *et al*. (1996, 2000) have grouped forestry mitigation activities in three categories: a) activities that avoid the release of emissions from C stock, such as forest conservation and protection, b) activities that store C, for example afforestation, reforestation and agroforestry, and c) involves substituting the use of C-intensive products and fuels with sustainably harvested wood products and wood fuel, for example wood substituting for concrete or steel and bioelectricity substituting for fossil fuel electricity.

Furthermore, Smith and Scherr (2002) have addressed two major strategies, afforestation/reforestation by establishing additional forest cover, and through averted deforestation, protecting standing forest seeking to remove threats such as unsustainable logging, agriculture, or state crops.

For this research, the classification of forestry projects as reported in Smith and Scherr (2002, 2003) has been considered (see Table 3.5).

Forest project type	Approach
Large-scale industrial pulp or timber plantations	Establish plantations of fast-growing trees for industrial use in deforested and degraded areas
Agroforestry, community forest plantations	Increase tree-growing and forest cover on farms associated non-farmed Lands to supply tree products or ecosystem services (wind breaks, filter strips, fodder banks, border plating, woodlots, stream bank plantings)
Agroforests (forest gardens), secondary forest fallows	Convert land under annual crops or pasture to multi-species agroforests and secondary forest fallows
Forest rehabilitation and regeneration	Rehabilitate and regenerate severely degraded natural forests on community land or farms, to supply products and ecosystem services; Once regenerated, develop sustainable forest management system with local communities
Strictly protected forest areas	Remover potential threats of deforestation, and manage area so as to minimise human impacts
Multiple- use community forestry within protected areas	Remove potential threats of deforestation and develop sustainable forest management systems with local communities (timber, NTFPs, hunting, ecotourism) within protected forest

Table 3.5 Classification of forest projects

Different type of project can contribute at local level while addressing the Rio Conventions objectives. For example, projects focusing on rehabilitation of forests on degraded land can be of particular interest for desertification control and rural development, as well as restore biodiversity and sequestrate carbon, among other benefits (Aune, 2003).

In this context, Appanah (2003) has described different rehabilitation methods. The **secondary/degraded** forests management, logging using crawler-tractor systems has without exception caused much damage to the young regeneration and pole growth. The **monocultures**, the vast majority of afforestation and reforestation work used single species, plantation concepts (fast-growing exotics). The **multi-species plantations**, planting mixtures of species, either upper-storey timber species or mix of species in various canopy levels, and meeting a variety of products, from timber, food, medicines, spices, etc. have been tried out, however, this last method is complicated to establish.

3.5.3 Project evaluation

In the context of the UNFCCC/Kyoto projects, standards and tools have already been developed for evaluating the **sustainability** of projects in the energy sector (Gold standard, 2006; UNEP, 2004 [b]; Sutter, 2003; Halsnaes and Markandya, 2002; SSN, 1999). Also for the forestry sector tools and standards have been proposed (Carbon fix, 2007; Encofor, 2007; CCBA, 2005). In this section focus is given to the evaluation of forestry projects.

The Climate, Community and Biodiversity (CCB) Standards, have been created to foster the development of projects that deliver benefits in an integrated and sustainable manner, primarily designed for climate change mitigation projects. The CCB Standards evaluate projects in the planning or early stage of project implementation. Information about the proposed project is used to determine whether the project satisfies indicators associated with given criterion (23 criteria). For the CCB Standards approval, projects must satisfy all fifteen required criteria, if projects go beyond the

basic approval, it is possible to earn Silver or Gold rating, depending on the number of points scored (CCBA, 2005).

The Encofor, an EU-funded project for the design of sustainable CDM forestry projects, has developed tools and links to manuals, checklists, and spreadsheets. They are organised in 3 modules: pre-feasibility, feasibility and documentation stages. Tools and manuals are available such as, Encofor Financial DSS, Encofor Economic Analysis Tool, Encofor Environmental Impact Assessment Tool, Encofor Social Impact Assessment Tool, and Encofor Institutional Assessment Tool, among others (Encofor, 2007).

The CarbonFix Standards (CFS) are practical standards for forest climate projects on the voluntary market. In particular, CFS tackles crucial aspects of forest climate projects ensuring high quality CO_2-certificates for the buyer. At the end of October a process of public review took place (Carbon fix, 2007).

In general, criteria, which have been used for the standards and tools, are linked to the UNFCCC/Kyoto Protocol requirements and CBD principles, which is the case for the Encofor project and CCBA standards, respectively.

3.6 Conclusions

The characteristics of forest and forests ecosystems have been briefly introduced; therefore their role and importance have been highlighted. Besides, while addressing synergies and conflicts in the forestry sector, ecosystem services have been identified as key element for further analysis.

The author of this research believes that trying to implement synergies is important if aiming to achieve sustainable development. Besides, the need for synergies involves more than looking for **complementarities** among conventions, but not to underestimate or overestimate single objectives when implementing programmes, plans, or projects. On the other hand, the author wants to remark that forest ecosystem services are multiple and different interests are also evident, such as the global, regional, national, and local level.

Since, this research is exploring synergies in the forestry sector, the local and global (UNFCCC, CBD, and UNCCD) levels have been analysed through a matrix, identifying forestry ecosystem services which can be relevant. At the end, in the forestry sector context, it should not be underestimated or overestimated a single ecosystem services but the challenge should be to consider the different interests. Consequently, the author thinks that it has been crucial to have a clear picture of the different ecosystem services which characterised forests and at the same time recognise the levels of interest. Afterwards, in order to assess and aggregate all this information, an appropriate scientific framework which can provide a **compromise** solution should be used.

To connect theory with practical-world and to explore synergies in the forestry sector, an interview process with international and national forestry experts was carried out. On one hand, the different implementation levels of synergies in the forestry sector have been addressed. On the other hand, at national level, stakeholders who have a role and a particular interest in the forestry sector have been described. Through the interviews a **learning process** has been initially established and has been useful for the purpose of the research.

Forestry projects have a central role not only at local level, but also at global level while addressing the implementation of synergies among the Rio Conventions. Thus, it is crucial to assess forest ecosystem services while considering options/actions/alternatives that aim to achieve sustainable development. Andrasko (1997) has described that most forest management activities are organized at the project scale, while environmental conventions recognizes the nation as the party to the agreement. Hence, measurement and monitoring issues are emerging at the intersection of the project and national scales.

For this research, focus for assessing synergies among the Rio Conventions is given to the forestry project level. Later on, the scientific framework of the research is presented (Chapter 4 and Chapter 5), forestry decision criteria are analysed (Chapter 6) and a decision aiding process for assessing synergies at forestry project level is described (Chapter 7).

CHAPTER 4: MULTICRITERIA DECISION AID (MCDA)

This chapter presents the characteristics of the Multicriteria Decision Aid (MCDA) approach and also the decision aiding process activities are described. Definitions, characteristics, and methods are presented. Afterwards, a link between the multicriteria approach and sustainable development is addressed.

4.1 Introduction

At different levels of analysis, the challenge in decision making has been the use of evaluation methodologies, which can be called **decision support tools**.

At *global level*, different integrated assessments implemented in decision analytical frameworks between adaptation and mitigation, have been reported by the IPCC Fourth Assessment Report (Klein *et al*., 2007), such as the Cost-Benefit Analysis (CBA), the Multi-Criteria analysis (MCA) common for adaptation activities (e.g., NAPA), the Tolerable Windows Approach (TWA) and the Cost-Effectiveness Analysis (CEA).

At *ecosystem level*, graphical depictions of the trade-offs in ecosystem services associated with alternative policy options (spider diagrams), multicriteria analysis, which provides a framework to assess choices in the presence of multiple, perhaps contradictory, objectives, and the CBA have been addressed (MA, 2005[e]).

At *policy evaluation level*, Halsnaes and Markandya (2002) have described the use of CBA, CEA and MCA.

At *project level*, for assessing sustainability of Clean Development Mechanism[23] (CDM) projects, the most common referred to checklists and multicriteria assessments, or a combination of the two. Other approaches are CEA, CBA, ranking methodologies, guidelines, and negotiated targets (Olsen, 2005). In general, a particular characteristic of this decision support tools is that they attempt to evaluate different objectives.

Probably, the most well-known evaluation method is the CBA, a formal method of decision/evaluation and a mono-criterion approach, which can rely on more than 50 years of theoretical and practical investigations. CBA may involve highly complex models; the underlying logic of the method is simple and easily understandable (Bouyssou *et al*., 2000). However, supporting decision/evaluation processes involves more activities than just "evaluation" and is far from exhausting the activity of supporting decision/evaluation processes (Watson 1981 in Bouyssou *et al*., 2000).

Within the broader context of **sustainable development**, a range of tools and processes to assess the economic, environmental, and social implications are available. These include, but are not limited to, environmental impact assessments (EIAs), strategic environmental assessments (SEAs), decision analytical frameworks, valuation techniques, and criteria and indicators (SCBD, 2003).

[23] A global carbon market developing as a response of Kyoto response towards mitigation of global warming (Olsen, 2005)

Moreover, decision-analytic frameworks are tools to evaluate the economic, social and environmental impacts which can be used, and include for example, decision analysis, CBA, CEA, the policy exercise approach, to cultural prescriptive rules (UNEP/CBD, 2003[a]; SCBD, 2003).

Another aspect of decision supports tools is the scale of application. Within this perspective, for designing and implementing adaptation activities under the UNFCCC, the sustainable livelihood approach at national and local level can be used or the CBD ecosystem approach at local, sub-national and regional are described (UNEP/CBD, 2005[d]).

In many cases, participatory/multi-stakeholder approaches and cooperation between stakeholders are an essential component (UNEP/CBD, 2005[d]). Afterwards, the amalgamation of these approaches, methods, and tools provide concrete opportunities for exploiting and addressing the synergies between the objectives of multiple environmental conventions and sustainable development goals (UNEP/CBD, 2005[b], [d]).

In this chapter, the Multicriteria Decision Aid (MCDA) is explored as a tool for assessing synergies among the Rio Conventions. Furthermore, activities from a decision aiding process are described.

4.2 Decision aid

4.2.1 Basic terms

MCDA is part of a larger framework that is the Operational Research. Therefore, definitions useful for the subsequent sections are provided.

There is no "official definition" of **Operational Research** - OR[24] ("Operations Research" in the US), but it can be described as a scientific approach to the solution of problems in the management of complex systems. In a rapidly changing environment an understanding is sought which will facilitate the choice and the implementation of more effective solutions that, typically, may involve complex interactions among people, materials and money. Many new analytical methods have evolved, such as: mathematical programming, simulation, game theory, queuing theory, network analysis, decision analysis, multicriteria analysis, etc., which have powerful application to practical problems with the appropriate logical structure.

Decision maker (DM), this may be viewed either as a real person for whom or in the name of whom decision aid is provided, or as a mythical person whose preferences can be used to enlighten the decision aid problem (Roy, 1990).

[24] http://www.euro-online.org/display.php?page=what_or (04/09/2007)

Actor, a person involved in the decision process, playing any role as decision maker (having the authority to make the decision), an expert, or a stakeholder (Omann, 2004).

Analyst, the person, who is responsible for the decision-aid process, could be a facilitator or researcher (Omann, 2004).

Decision, is presented like the fact of an isolated individual (the "decision maker") exerting freely a choice between several possibilities of actions at one time given in time (Roy and Bouyssou, 1993).

Decision process, a sequence of interactions amongst persons and/or organisations characterising one or more objects or concerns (the "problems") (Bouyssou *et al*., 2000)

4.2.2 Decision aiding and decision making

Decision aid is the activity of one who uses explicit, but not necessarily completely formalized, models to obtain elements of answers to questions raised by an actor involved in a decision process. These elements tend to clarify the decision and, usually, to prescribe or simply to encourage behaviour that will increase the coherence between the evolution of the process and the objectives supported by this actor (Roy and Bouyssou, 1991; 1993).

Decision aid, founded on appropriate concepts and procedures, can and does play an important and beneficial role in decision processes (Roy and Bouyssou, 1991). Moreover, decision aid can contribute to (Roy, 1999): the analysis of the decision problem and its context; the organisation and structure of the process and can thus increase coherence among the values underlying the objectives and the final decision; the creation of understanding between stakeholders; the use of different models and the available information to reach recommendations; and increased legitimisation of the decision.

On the other hand, Tsoukiàs (2007) has defined that a **decision aiding process** is a particular type of **decision process**, and this last concept concerns the cognitive[25] activities of an individual facing a question for which non-automatic reply pattern is available (*set of activities*). **Decision aiding** situations appears an interaction space, for at least two actors such as the client and analyst, characterised by a meta-object, which is the consensual construction of a client's concern representation. In other words, the decision aiding process are efforts undertaken by the actors (e.g. client-analyst) to influence "positively" the decision process in which they are involved.

Furthermore, Bouyssou *et al*. (2000) have described that the decision/evaluation aid process is conditioned by factors outside a formal method such as the quality of the structuring of the problem, of communication with stakeholders, the availability of user-friendly software, the timing

[25] Cognitive, connected with mental processes of understanding (*Oxford dictionary*)

and costs of the study, etc. all elements of importance in the quality of a decision/evaluation aid process.

In this context, the difference between **decision making** and **decision aiding process** are important to be defined. For the first concept the situation concerns a decion maker who, having a concern might use a theoretical tool in order to establish a potential action to undertake, and theoretically, there is no distinction between the decision maker and the analyst. On the contrary, decision aiding exists when at least two actors (DM and analyst) playing different roles with respect to the concern of the client are present (Tsoukiàs, 2007).

Furthermore, in a **decision aiding process** different products are obtained. Then, 4 cognitive artefacts: the representation of a problem, a problem formulation, an evaluation model, and final recommendation have been described (Tsoukiàs, 2007). The content of these cognitive artefacts is not the result of a straightforward process, but the reasoned result of the interactions between the client and the analyst (Bouyssou *et al*., 2006).

In addition, in decision aiding references to four type of approaches are found (Tsoukiàs, 2007; Bouyssou *et al*., 2006): *normative*, derive rationality models from norms established a priori; *descriptive*, derive rational models from observing how decion makers make decisions; *prescriptive*, discover rationality models from a given client from his/her answers to preference related-questions; and *constructive,* expected to help a client to build his/her own rationality models from his/her answers to preference related questions.

The differences among approaches start from dividing them in 2 groups (Bouyssou *et al*., 2006). Normative and descriptive approaches use general models of rationality, established independently from the client and the decision process, intending to model the rationality of decision makers. But, prescriptive and constructive approaches derive a model for the rationality of the contingent client, and only that particular client. Then, Tsoukiàs (2007) has described that different approaches diverge in the meaning attached to the client's rationality model, the process of obtaining this model, and the interpretation of the answers that are provided to the client based on the model (see Box 4.1; Bouyssou *et al*., 2006). In general, approaches represent general directions on how a decision aiding process is conducted and therefore represent a key part of a decision aiding methodology (Bouyssou *et al*., 2006).

Approach	Characteristics	Process to obtain the model
Normative	Exogenous rationality, ideal economic behaviour	To postulate
Descriptive	Exogenous rationality, empirical behaviour models	To observe
Prescriptive	Endogenous rationality, coherence with the decision situation	To unveil
Constructive	Endogenous rationality, coherence with the decision process	To reach a consensus

Box 4.1 Differences between approaches

To conclude this section, the author remarks that the **decision aiding process** are useful to understand activities of decision aid, which can also follow a **monocriterion** or a **multicriteria** approach. These approaches are useful for the evaluation model and are helpful to construct a coherent decision aid model. Therefore, evaluating the different concepts for this research, the author has identified as appropriate the decision aiding process concept. Three actors have been identified: *the analyst,* the author of this thesis (researcher); *decision maker,* the actor who has a problem to solve; and *experts,* participants involved in the questionnaire and interviews processes (see Chapter 7). Theoretical information on decision aiding process is found in section 4.3.

4.2.3 Monocriterion or multicriteria?

In a *monocriterion analysis* one must be able to define a point of view taking all consequences into account and having a more or less concrete meaning: benefits, rate of return, utility. In other words, the **criterion** needs to capture all the aspects relevant to the problem (Scarelli, 1997). It should be emphasized that such analysis implies that it is possible to measure all consequences on a common scale. But, when consequences are heterogeneous that the preceding difficulties cannot be avoided, it is preferable to proceed with a *multicriteria analysis*.

In the multicriteria approach, different points of view are transformed into a set of criteria, which represent the way in which the actors of a decision process justify, transform, and defend their preferences (Scarelli, 1997). Therefore, a family of several criteria is built, each one apprehending a homogeneous category of consequences, and which can be seen as an intermediate step in the decision aid process. These criteria may be aggregated into a single one at a later stage of the study, but such aggregation into a single criterion, which should not be confused with monocriterion analysis (Roy and Bouyssou, 1991).

In this context, the author has considered appropriate, to work with a multiple criteria approach, which main concepts and definitions are described in the following sections.

4.2.4 Decision problems

While considering a discrete set of alternatives/options described by some criteria, there are four different kinds of analysis that can be performed in order to provide significant support to DM (Roy, 1985): (1) to identify the best alternative or select a limited set of the best alternatives, (2) to classify/sort the alternatives into predefined homogenous groups, (3) to construct a rank-ordering of the alternatives from the best to the worst ones, and (4) to identify the major distinguishing features of the alternatives and perform their description based on these features. The former three approaches (choice, ranking, classification/sorting) lead to a specific evaluation outcome. Roy and Bouyssou (1991) have described in detail the objective and results of decision problems (Table 4.1).

Decision problem	Objective	Result
P.α	Clarify the decision through the choice of a subset, as restricted as possible, for the final choice of a single action. This subset should contain the "best" actions ("optimums") or, failing that, "satisfactory" actions.	a choice or a selection procedure
P.β	Clarify the decision through a sorting consisting in an affectation of each action to a category, these categories being defined a priori (e.g. accepted, rejected, sent back for more information).	a sorting or an assignment procedure
P.γ	Clarify the decision through a sorting consisting in an affectation of each action to a category, these categories being defined a priori (e.g. accepted, rejected, sent back for more information).	a ranking or a classifying procedure.
P.δ	Clarify the decision through a description of the actions and their consequences.	a description or a cognitive procedure

Table 4.1 Type of decision problems

4.3 Decision aiding process

In this section, the decision aiding process products are described. For this purpose, the author of this research has revised Tsoukiàs (2007, 2003) and Bouyssou *et al*. (2006). Initially, some definitions are given, and then activities of a decision aiding process, which involve the definition of the problem situation, problem formulation, evaluation model, and final recommendations, are described.

Bouyssou *et al*. (2006) has addressed that the model of **decision aiding process** is *descriptive*, which not only shows how the process gets structured, but also *constructive*, because it suggests a path for the process concerning both the client and the analyst. Besides, it allows controlling the conduction of the process since it fixes the cognitive artefacts that are expected to be constructed during the process.

Some other definitions are provided:

Action, or "alternative", to designate anything which appears to be a possible contribution to making a decision and which can either be represented by a set of coordinates or as an item in a list. Depending on the situation an action may appear either as a plan or a program (e.g. production planning, scheduling) or as a variant of a project (e.g. sitting, launching of a new product) (Roy and Bouyssou, 1991).

Criterion, is a function that associates each action with a number indicating its desirability according to consequences related to the same "point of view" (Roy and Bouyssou, 1991). Actions/options are evaluated according to a criterion, which results in performance levels shown in an evaluation matrix. To show the performance level, it is wise to use indicators (Omann, 2004).

Indicator, an instrument that synthesizes in quantitative or qualitative form information that lays the foundation for a judgement about certain effects of options. Indicators definition is a

difficult process, requiring careful calculation, use of models, surveys, or expert advice (Roy and Bouyssou 1991).

Aggregation procedure, is merely a matter of algorithmic and mathematical skills and it can considered a synthesizing criterion, outranking or interactive approach (Guitouni and Martel, 1998).

4.3.1 Problem situation

The representation of a problem situation is constructed to improve the communication between actors (e.g. client-analyst). By this the client, who asked for support, will be able to understand his/her position in the decision process and the analyst will understand his/her role in the decision process (Tsoukiàs, 2007). Formally, the representation of the problem has a descriptive objective and three elements are considered (Tsoukiàs, 2007; Stamelos and Tsoukiàs, 2003):

(i) the participants involved,

(ii) the objects (problems, interests, opportunities) introduced by each participant, and

(iii) the resources allocated by each participant on their stakes and the other participants stakes.

4.3.2 Problem formulation

For a problem situation, and for a given time and decision maker (client), **one or more** problem formulations can be defined (Stamelos and Tsoukiàs, 2003). The problem formulation can be considered a formal and abstract representation of the problem for which the client asked the analyst to support him (Bouyssou *et al*., 2000). Consequently, the client's concern are transformed in formal problems and is possible to apply techniques such as statistics, measurements, operational research, simulation, etc (Tsoukiàs, 2007; Stamelos and Tsoukiàs, 2003). To obtain the client's consensus it is important to show the different problem statements and the different outputs to which they lead, thus it will be possible to establish the appropriate method or procedure.

The problem formulation considers a (Tsoukiàs, 2007; Bouyssou *et al*., 2000):

(i) set of potential actions/alternatives to consider

(ii) set of points of view under which alternatives are evaluated

(iii) the problem statement which can include, but are not limited to choice, ranking, description, etc. (see section 4.2.4 or 4.4.2)

It is crucial to know whether the desired evaluation is **absolute** as in the sorting problem statement (modelling of norms) or **relative** as in the choosing and ranking problem statement (Bouyssou *et al*., 2006). On the other hand, the problem formulation is important for the evaluation model phase, it is said that: *half of a problem is deciding what to decide* (Tsoukiàs, 2007). Besides, Guitouni and Martel (1998) have stated that the formulation of the problem is often more essential than its solution.

4.3.3. Evaluation model

After establishing the problem formulation the evaluation model can be built, and this is because the information provided previously can lead the elaboration of a formal model. Different elements are needed in this phase (Tsoukiàs, 2007):

(i) A set of alternatives on which the model applies,

(ii) A set of dimensions (attributes) under which alternatives are observed, described, measured, etc, then the precise scale type of such a measure should be established,

(iii) A set of criteria under which alternatives are evaluated in order to consider the client's preferences. The set of criteria has to fulfil a number of conditions depending on the type of procedure. This is a **central** activity in the decision aiding process. A complete chapter has been dedicated to the construction of decision criteria (see Chapter 6),

(iv) Uncertainty have to be considered, and it can be *exogenous* (e.g. hesitation or inconsistency of the client, poor information as far as criteria are concerned) and *endogenous* (e.g. difficult to discriminate alternatives on a dimension or on a criterion due to its ambiguous definition or linguistic nature), and

(v) Precise method to elaborate the solution to a model (see section 4.4.2). Moreover, the method requires other information which can be called parameters, such as the coefficient of importance, thresholds, cutting level, etc.

The consequence of a decision aiding process can lead to the selection of a method, this means after defining the problem situation and problem formulation, and not to select first the method. Two criteria for choosing the method have been proposed (Tsoukiàs, 2007): (a) *theoretical meaningfulness*, which means that the method should be sound with respect to the information used, and (b) *operational meaningfulness*, which means that the client should be able to understand and use the result within the decision process (see section 5.2.2).

Furthermore, Munda (2005, 2001) has described that the construction of a decision model of a real world system depends on very strong assumptions, such as: (1) the *purpose* of this construction, e.g. to evaluate the sustainability of a given city, (2) the *scale* of analysis, e.g. a block inside a city, the administrative unit constituting a Commune or the whole metropolitan area and (3) the set of dimensions (economic, social, environmental etc.), objectives and indicators used for the evaluation process.

Some ideas to keep in mind while working with evaluation models are (Bouyssou *et al*., 2000):

- building an evaluation model is a complex task even in simple situations. Actors are most likely to modify their behaviour in response to the implementation of the model;
- "evaluation operations" are complex and should not be confused with "measurement operations" in Physics. When they result in numbers, the properties of these numbers should be

examined with care; using "numbers" may be only a matter of convenience and does not imply that any operation can be meaningfully performed on these numbers.

- the aggregation of the result of several evaluation models should take the nature of these models into account. The information to be aggregated may itself be the result of more or less complex aggregation operations and may be affected by imprecision, uncertainty and/or inaccurate determination.
- aggregation models should be analysed with care. Even the simplest and most familiar ones may in some cases lead to surprising and undesirable conclusions.

4.3.4 Final recommendation

The evaluation model produces a result that needs to be translated, from an abstract to a formal language, which can be understood by the client.

Then three precautions are suggested before formulating final recommendations (Tsoukiàs, 2007): (a) sensitivity analysis, which evaluate how the solution can vary when the parameters of the model are changed; (b) robustness analysis, which evaluate how good the solution will be under different scenarios; and (c) legitimating, which means how legitimate is the foreseeable recommendation with respect to the organisational context of the decision process.

Furthermore, recommendations described above are useful to guarantee the theoretical soundness of the result (meaningfulness), the operational completeness of the result (usefulness) and the legimitation of the results within the client's decision process (Bouyssou *et al*., 2006).

In summary, a decision aiding process have to establish a set of representations which include the representation of the problem situation; one or more problem formulations (formal anticipation of the model to construct, in which the client's concerns); one or more evaluation models enabling to elaborate the problem formulation and to establish a conclusion; and a final recommendation, where conclusions of the decision aiding process are summarised (Bouyssou *et al*., 2006). Afterwards, in Chapter 7, a real decision aiding process is described.

4.4 Multicriteria Decision Aid (MCDA)

4.4.1 What is MCDA?

Multicriteria approaches have been developed basically in two schools, the European Multicriteria Decision Aid (MCDA) and the American Multi-Criteria Decision Making (MCDM). The former differs from the latter because seeks to give recommendations, whereas the American MCDM school tries to approach an ideal solution, derived from a set of axioms (Roy and Vanderpotten 1996).

Vincke (1992) has described that MCDA aims to give the decision makers some tools in order to enable to advance in solving a decision problem where several - often contradictory- points of view must be taken into account. Roy (1990) has described that the aim of MCDA is not to discover a solution, but to construct or create something which is viewed as liable to help ''an actor

taking part in a decision process either to shape, and/or to argue, and/or to transform his preferences, or to make a decision in conformity with his goals''. Then different multiple conflicting criteria can be incorporated in the process.

Furthermore, Munda (2004) has concluded that multicriteria methods supply a powerful **framework** for policy analysis since it accomplishes the goals of being **inter/multi-disciplinary** (with respect to the research team), **participatory** (with respect to the local community) and **transparent** (since all criteria are presented in their original form without any transformations in money, energy or whatever common measurement). Besides, Kangas and Kangas (2005) have described that MCDA is typically used for dealing with planning situations in which decision alternatives need to be holistically evacuated, especially by multiple decision criteria that are difficult to compare, and by conflicting interests affecting the decision making process.

The multicriteria approach[26] can be usefully used not only for specific multicriteria methods, but also as: either a soft tool allowing, for instance, different elements of representation to be arranged in to formal schemes, so as to create a link between conceptual and formal models, or even a framework, suitable to outline logics of connection between development and other kind of activities and thus to control the modelling process evolution within the decision aid process (Bana e Costa and Vincke, 1990). A description of the different methods is provided in the following section.

4.4.2 Which are the MCDA methods?

Three types of operational research approaches or methods for MCDA can be distinguished: multiple attribute utility theory, outranking methods, and interactive methods (Vincke, 1992; Bana e Costa and Vincke, 1990). Roy (1985) and Mousseau *et al*. (1999) call these categories: (i) unique synthesis criterion approach evacuating any incomparability; (ii) outranking synthesis approach, accepting incomparability; and (iii) interactive local judgement approach with trial error iterations.

The first family of methods has an American inspiration, and the second French inspiration. In addition, while the first two approaches embody a clear mathematical structure, the third one is not linked to any formalised or automatic procedure but uses dialogue between the decision maker and the analyst (Omann, 2004). Detail information on MCDA methods is presented in Chapter 5.

4.4.3 Which multicriteria decision problems exist?

A **multicriteria decision problem** is a situation in which, having defined a set A of actions and a consistent family F of criteria on A, one wishes (Vincke, 1992): (a) to determine a subset of actions considered to be the best with respect to F (choice problem), (b) to divide A into subsets according to some norms (sorting problem), or (c) to rank the actions of A from best to worst (ranking problem).

[26] approach, a way of dealing with something; a way of doing or thinking about something such as a problem or a task (*Oxford dictionary*)

In Table 4.2, examples of decision problems are shown (Bouyssou *et al*., 2006; Mousseau *et al*., 2000). Moreover, a graphical representation of the different decision problematic can be found in Mousseau and Slowinski (1998).

Choosing problems	Ranking problems	Sorting problems
• a recruiter wants to select a unique applicant • an engineer wants to select the best possible technical device, • a patient wants to choose the best possible treatment among those offered in an hospital, • a manager wants to optimise the supply policy of a factory, • a consultant wants to screen a large number of possible sites to set up a new factory.	• a sports league wants to rank order the teams at the end of the season, • an academic programme has to select a number of applicants. Applicants are then selected by decreasing order of their average grade till the constraint on the size of the programme is reached, • an R&D department rank ordered and financed research projects till the budget constraint is binding.	Suppose that you want to sort a set of alternatives between two ordered categories C1 and C2, the elements of C1 being more desirable than the elements of C2. Examples: evaluation of applicants for loans or grants, business failure risk assessment, screening methods prior to project selection, satellite shot planning, medical diagnosis.

Table 4.2 Example of the decision problems

4.4.4 Which is the procedure?

The procedure to undertake a **multicriteria analysis** has been described by different authors. For instance, Guitouni and Martel (1998) have described 4 steps, which included: (i) structuring the decision problem, (ii) articulating and modelling the preferences, (iii) aggregating the alternative evaluations (preferences) and (iv) making recommendations.

Scarelli (1997) has described that the solution to a multicriteria problem consists in: defining the problem though its motivation; the type of question from the decision maker or from the group involved in the decision (passive and active actors); defining the actions or strategies; defining the points of view or specific objectives; requested problematic; constructing the criteria; and choosing the appropriate aggregation procedure.

Besides, Vincke (1992) has described that MCDA is not only a family of aggregating techniques but consists in: (a) defining criteria; (b) modelling preference; (c) stating the problem; and (d) choosing the decision aid method.

Finally, Munda (1995) has described that for a multicriteria evaluation steps such: (a) defining and structuring the problem; (b) defining a set of evaluation criteria; (c) choosing between methods; (d) identifying of the preference system of decision maker, and (e) choosing the aggregation procedure are needed.

In summary, the procedure that follows a **multicriteria** approach, mainly defines the structure of the problem, defines criteria, models preferences and chooses the appropriate method. However, the author of this research considers useful and complete, the model of **decision aiding process,** where the problem situation, problem formulation, evaluation model and final

recommendation are defined. Therefore, for this research efforts were concentrated not only in the evaluation part, but in the whole decision aiding process (see Chapter 7).

4.4.5 Why considering a multicriteria approach?

While dealing with synergies among the Rio Conventions (see Chapter 2) in the forestry sector (see Chapter 3), different objectives, and sectorial characteristics need to be considered. In addition, different levels of interests such as the global, regional, national, and local are in play. Therefore, when dealing with a complex environmental situation, the multiple- or multicriteria approach is appropriate to be explored. Romero (1996) has claimed that in many real environmental contexts multicriteria and multiple decision makers are involved in the process.

The main advantage of multicriteria methods is that a large number of data, relations and objectives, generally present in a specific real-world decision problem, can be studied from multiple angles or multidimensional fashion (MA, 2005[e]; Martinez-Alier *et al*., 1998; Munda, 1995).

On the other hand, in MCDA, there does not exist, in general, any decision (solution, action) which is the best simultaneously from all points of view. Therefore, it is not possible to **optimise** all the objectives at the same time; in contrast to the classical techniques of Operations Research, multicriteria method does not yield 'objectively best' solutions (Munda, 2004; Vinke, 1992).

Then, solving a multicriteria decision problem aims to help the decision maker to master the (often complex) data involved in his problem and advance toward a solution, therefore, it will be a '**compromise solution**'. But it must be emphasized that it depends strongly in the DM's personality, on the circumstances in which the decision aiding process takes place, on the way in which the problem is presented and on the methods which is used (Martinez-Alier *et al*., 1998; Vincke, 1992).

Besides, Munda (2005) has stated that the overall quality of multicriteria study depends crucially on the way this mathematical model is embedded in the social, political, and technical structuring process. This is the reason why in MCDA it is claimed that what is really important is the **decision process** and not the final solution (Roy, 1996; Roy 1985).

4.4.6 Which are the advantages and difficulties?

The multicriteria approach has many **advantages** over <u>informal</u> judgement unsupported by analysis (Omann, 2004; Beccali *et al*., 2003; Dodgson *et al*.; 2000; Bouyssou, 2000):

- Formal methods, which relies on an explicit mathematical model of the DMs preferences.
- The decision process is structured. This promotes systematic thinking, definition of options, identification of criteria and impact assessment with respect to the various actors involved.
- Provision of a framework for the exploration of the objectives, interests, and concerns of stakeholders. Different positions of different actors are considered and identified at an early stage of the process.
- It can provide an important means of communication, within the decision making body and sometimes, later, between that body and the wider community. In the course of the decision

process, the construction of the model requires that pieces of information, knowledge and priorities that are usually implicit or hidden, be brought into light and taken into account; also, the choice of the model reflects the type of available information (more or less certain, precise, quantitative).

- The integration of stakeholders is supported and fostered (different approaches emphasise this integration, e.g. participative multicriteria evaluation, stakeholder MCDA).
- The choice of objectives and criteria that any decision making group may make are open to analysis and to change if they are felt to be inappropriate.
- They offer more explicit reflection on value judgements concerning the alternatives, the criteria, and the trade-offs.
- Documentation of decision making process aids transparency for every actor. Subjectivity, which is present in any evaluation, is made explicit.
- The set of criteria can be very heterogeneous; costs and benefits of the option under analysis, environmental quality impact in physical and qualitative terms, social impact in non-monetary terms, verbal descriptions of aesthetics to name but a few.
- Scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values, and amended if necessary.
- Multicriteria approach makes a decisional process more flexible and transparent.

The main difficulty in a multicriteria problem lies in the fact that it is an **ill-defined mathematical** problem, e.g. it does have an objective solution (Vincke, 1992). Besides, the application of the different methods can lead to different solutions. Furthermore, Omann (2004) has listed some **weaknesses** of MCDA:

- There might be too much information for the stakeholders, which might reduce their motivation to participate.
- The results of an MCDA are hard to verify or repeat, as they largely depend on the specific process and the interactions of the actors. These are never exactly the same on different occasions.
- In general all kinds of problems related to participation can occur.
- There is the danger of wrong or improper application.

4.5 MCDA and sustainable development

Sustainable development carries the ideal harmonisation or simultaneous realisation of economic growth and environmental concerns; therefore, is a **multidimensional** concept (Munda, 2005). In this framework, there is a need to support **sustainable development** [27] policy evaluations with technical approaches that can facilitate a systematic assessment of multiple objectives (Halsnaes and Markandya, 2002).

The multicriteria approach constitutes a powerful tool that is able to take into account several concerns and to foster participation and learning processes among politicians and citizens. Besides, MCDA has proved to be a useful tool for decision making processes in the context of sustainability (De Montis *et al*., 2004; Munda, 2001; Munda, 1995). Furthermore, the management of environmental issues involves many layers and kinds of decisions, and requires the construction of a dialogue process among many stakeholders, individual and collective, formal and informal, local and not (De Marchi *et al*., 2000).

Multicriteria evaluation is a good tool for the assessment of sustainability, and according to the aggregation procedure chosen; a **weak** or **strong** sustainability concepts can be operational. This depends on the degree of compensation allowed by the aggregation procedure. Where compensation refers to the existence of **trade-offs**. Hence a preference relation is **non-compensatory** if no trade-off occurs, otherwise is compensatory (Martinez-Alier *et al*., 1998). An important consequence of non-compensation is that it is possible to make operative the concept of *strong sustainability* (Munda, 1997).

For example, CBA is based on the compensation model, and then only definition of sustainable development that can be operative is the *weak sustainability* concept, the same applies for the utility-based compensatory multicriteria methods (Martinez-Alier *et al*., 1998; Munda, 1995). However, strong sustainability can be found with the ELECTRE family methods, which are non-compensatory, implying that minorities represented by criteria with smaller weights can still be very influent (use of discordance index) (Munda, 2005) or it means that a really bad score of any alternative with respect to any one criterion cannot necessarily be compensated for by good scores in other criteria (Kangas *et al*., 2001). The compensatory concept is further analysed in section 5.2.5.

Generally, ecosystems are used in different ways at the same time by different users; this situation leads to conflict of interest. Then, many natural resources are subject to multiple uses by multiple users with overlapping and contested claims, evoking a plethora of social, institutional, and governance issues (World Bank, 2005).

From an operational point of view, the major strength of multicriteria methods is their ability to address problems marked by various conflicting interests, providing insight into the nature of the

[27] Sustainable development is defined as paths of human compromising the ability of future generations to meet their needs. Definition provided on the Report by the World Commission on Environment and Development, 1987, "Our common future", known as "Brundtland report"

conflicts by providing systematic information into ways to arrive to a **compromise**. Multicriteria methods provide a flexible way of dealing with qualitative multi-dimensional environmental effects of decisions (Munda, 1995). Moreover, as a tool for conflict management, multicriteria evaluation has demonstrated its usefulness in many sustainability policy and management problems (Munda, 2005; Martinez-Alier *et al*., 1998).

Another characteristic of multicriteria approaches is the variety of **scales** needed to measure criteria (Omann, 2004). Some criteria can be transformed into quantitative indicators, like m^3/hectare of wood, others use qualitative, like life quality (using linguistic terms such as good, moderate, bad). On the other hand, the information contained in the criteria and concerning the effects of the decision can be uncertain and highly qualitative (Munda, 1995; Munda *et al*., 1995). In this context, incommensurability should be considered, which implies that there is clear need for methods that are able to take into consideration both qualitative and quantitative criterion scores (Munda, 2005).

In summary, the **multicriteria approach** allows to tackle conflicts, multidimensional, incomparable, or incommensurable multiple criteria, different scales, and uncertain information (Omann, 2004; Martinez-Alier *et al*., 1998). In theory, the multicriteria approach is appropriate for supporting decision which promote sustainable development and can be a very efficient tool to implement a multi/inter-disciplinary approach (Munda, 2005; 2003). Therefore, the multicriteria approach can be used as an approach for assessing synergies among the Rio Conventions (see Chapter 7).

On the other hand, examples of environmental problems and multicriteria methods are shown in Table 4.3. Bloemhof-Ruwaard *et al*. (1995) have described that Operational Research method, which were applied for the first time to environmental problems, appeared in the mid seventies in journals of environmental issues (e.g. Environment and Planning, Water Resources Research). Later also application of OR to environmental management appeared in OR journals (e.g. Operations Research, European Journal of Operational Research). In the coming chapter multicriteria methods are further described (Chapter 5).

Method	Application
PROMETHEE	**Multi-criterion decision-making in irrigation planning,** Agricultural Systems, Volume 62, Issue 2, November 1999, Pages 117-129 by K. S Raju and D. N Kumar **Environmental impact assessment and ranking the environmental projects in Jordan,** European Journal of Operational Research, Volume 118, Issue 1, 1 October 1999, Pages 30-45 by D. Al-Rashdan, B. Al-Kloub, A. Dean and T. Al-Shemmeri **Comparing multi-criteria methods in the context of environmental problems,** European Journal of Operational Research, Volume 104, Issue 3, 1 February 1998, Pages 485-496 by Hokkanen J., Salminen **Analysing Water Resources Alternatives and Handling Criteria by Multi Criterion Decision Techniques,** Journal of Environmental Management, Volume 48, Issue 1, September 1996, Pages 69-96 by E. C. Özelkan and L.Duckstei **Environmental site evaluation of waste management facilities embedded into EUG ENE model: A multicriteria approach,** European Journal of Operational Research 139 (2002) 436–448 by K. Vaillancourt, J.P. Waaub **Water resources planning in the Middle East: application of the PROMETHEE V multicriteria method,** European Journal on Operational research 81(1995): 500-511 by M.F.Abu-Taleb and B. Mareschal **The role of weights in multicriteria decision aid, and the ranking of water projects in Jordan,** European Journal of Operational Research 99(1997): 278-288 by B.A. Akash, O.R. Al-Jayyousi, M.S. Mohsen
AHP	**Multicriteria analysis of environmental quality in Taipei: public preferences and improvement strategies,** *Jour*nal of Environmental Management (2002) 65, 109–120 by G.H.Tzeng, S.H.Tsaur, Y.D. Laiw and S. Opricovic **Multi-criteria approach for the selection of alternative options for environmentally sustainable transport system in Delhi,** Transportation Research Part A37 (2003) 717–729 by S.Yedla , R.M. Shrestha **Multicriteria analysis of non conventional energy technologies for water desalinisation in Jordan,** Desalinisation 114 (1997) 1-12 by B.A. Akash, O.R. Al-Jayyousi, M.S. Mohsen **Pre-feasibility MCDM tools to aid communities in prioritizing local viable renewable energy sources,** Renewable Energy 29 (2004) 1775–1791 by K. Nigim, N. Munier, J. Green **The use of the Analytical Hierarchy Process to incorportate stakeholder preferences into regional forest planning,** Forest Poliy and Economics 5 (2003) 13-26 by J. Ananda and G. Herath
ELECTRE III	**Comparing multi-criteria methods in the context of environmental problems,** European Journal of Operational Research, Volume 104, Issue 3, 1 February 1998, Pages 485-496 by P. Hokkanen, J. Salminen **Choosing a solid waste management system using multi-criteria decision analysis,** European Journal of Operational Research, Volume 98, Issue 1, 1 April 1997, Pages 19-36 by J. Hokkanen and P. Salminen **Application of ELECTRE III for the integrated management of municipal solid wastes in the Greater Athens Area,** European Journal of Operational Research, Volume 97, Issue 3, 16 March 1997, Pages 439-449 by A. Karagiannidis and N. Moussiopoulos **Decision making in energy planning: the electre multicriteria analysis approach compared to a fuzzy-sets methodology,** Energy Convers. Mgmt Vol. 39, No. 16-18, pp. 1869-1881, 1998 by M. Beccali, M. Cellura and D. Ardente **Improving petroleum contaminated land remediation decision-making through the MCA weighting process, Chemosphere** 66 (2007) 791–798 by A. Balasubramaniam, A. Rohan Boyle, N.Voulvoulis **Urban storm water drainage management: The development of a multicriteria decision aid approach for best management practices,** European Journal of Operational Research 181 (2007) 338–349 by C. Martin, Y. Ruperd, M. Legret
NAIADE	**Multi-criteria evaluation in a fuzzy environment. Theory and applications in ecological economics**, Physica-Verslag, Berlin, 1995 by G. Munda **STEEDS: A strategic transport¯energy¯environment decision support,** European Journal of Operational Research, Volume 139, Issue 2, 1 June 2002, Pages 416-435 by C. Brand, M. Mattarelli, D. Moon, and R. Wolfler Calvo **Environmental management and sustainable development: an application of multi-criteria methodologies to urban solid waste management,** Institute for Systems, Informatics and Safety, Ispra, 2000 by A. Lucia **SIWA, A Decision Support System for the Management of Urban Wastes**, European Commission, Institute for the protection and Security of the Citizen 2001 by F. Rinaldi **Planned Highway in Conflict with Groundwater Resources,** European Commission, Institute for the protection and Security of the Citizen 2001 by F. Rinaldi **Combining participative and institutional approaches with multicriteria evaluation. An empirical study for water issues in Troina, Sicily, Ecological** Economics 34 (2000) 267–282 by B. De Marchi a, S.O. Funtowicz, S. Lo Cascio , G. Munda **Integrated Assessment and Multicriteria Analysis,** Phys. Chem. Earth (B), Vol 26, N 7-8, pp 541-545, 2001 by V. Wenzel
ELECTRE TRI	**Land management with GIS and multicriteria analysis,** Intl. Trans. in Op. Res. 7: 67-78, 2000 by F. Joerin and A. Musy **Multicriterion Analysis for Sustainable Water Resources Planning: A Case Study in Spain,** Water Resources Management 14: 435–456, 2000 by K. Srinivasa Raju, L. Duckstein, and C. Arondel **Sorting cropping systems on the basis of their impact on groundwater quality,** European Journal of Operational Research 127: 467-482, 2000 by C: Arondel and P. Girardin. **Evaluation of environmental performances for an industrial site: a decision aiding methodology for facilitating the dialogue between stakeholders,** Presentation in 22nd European Conference on Operational Research. 9-11 july 2007. Prague, C. Republic by S. Andre
REGIME	**Multi-criteria Assessment for Choosing a Wastewater Treatment Option: The Case of Hammarby Sjöstad, Sweden**, Proceedings National Onsite Wastewater Recycling Association Conference, Kansas City, 2002, by C.Etnier and H. Söderberg. **Multicriteria Decision-making in Wastewater Planning,** Norwegian Agricultural Economics Research Institute, 2001 by K. Refsgaard. Together with other methods: **Environmental quality and sustainability in the province of Reggio Emilia (Italy): using multi-criteria analysis to assess and compare municipal performance** *Journal of Environmental Management* (2001) **63**, 117–131 by A. Ferrarini, A. Bodini and M. Becchi

Table 4.3 MCDA application for environmental situations

4.6 Conclusions

This chapter has described the Multicriteria Decision Aid (MCDA) approach as scientific framework. Besides, activities of the decision aiding process have been presented. Concepts, definitions, and characteristics, useful for the coming chapters of the thesis are provided.

On one hand, the decision aiding process is suitable to understand the activities of decision aid, because it allows to better structure a decision process. For this reason, a whole decision aiding process has been emphasised and not just the evaluation part of the decision process. Besides, the problem formulation can be considered as crucial, since it conditions the evaluation model. However, also the construction of the decision criteria is significant in a decision process (see Chapter 6). On the other hand, in the context of sustainable development, the multicriteria approach can be appropriate for environmental decision situation. The approach can consider conflicts, multidimensional, incomparable, or incommensurable multiple criteria. In other words, MCDA is able to aggregate different expectations, therefore, take into consideration sustainability issues, conflicts among dimensions (social, economic and environmental), different alternatives, etc.

The application of multicriteria methods for environmental decision situations, are becoming more important in different contexts such as transport, energy, water and wastewater, land management sectors among others. Nevertheless, in general, studies are related to multicriteria methods mainly used for evaluation purposes in a decision making context; which means the use of a method to establish a potential action to be undertaken. As a result, the author of this research considers necessary to remark the importance of using a multicriteria method within a specific decision aiding process.

The author of this research believes that an important strength of the multicriteria approach is the possibility to look for a **compromise** solution, thus a suitable concept when dealing with environmental decision problems. Consequently, different alternatives, points of view and actors should be considered. For the purpose of this research, where synergies need to be explored at project level, it should be appropriate to look for a compromise solution and not for an optimal solution. Still further information on MCDA methods are given in Chapter 5. Then, in Chapter 6, forestry decision criteria are validated and analysed, and in Chapter 7, a whole decision aiding process for assessing synergies among the Rio Conventions at forestry project level is presented.

CHAPTER 5: MULTICRITERIA METHODS AND APPLICATIONS

This chapter describes more in detail the different multicriteria methods. Applications are described for the forest sector and in the framework of the Rio Conventions.

5.1 Introduction

At the beginning of this research, a general background and justification to explore an appropriate scientific framework for assessing synergies has been described. In this context, the need for exploring synergies at local level has been identified (Chapter 2). Next, the forestry sector, chosen to further explore synergies has been characterised (Chapter 3).

On the other hand, several tools to evaluate or measure sustainability at different levels have been addressed. For instance, guidelines and checklist at the Convention level (see section 2.4.2), standards and decision support tools at project level in the forestry sector (see section 3.5), and in the context of sustainable development (see section 4.1).

For the purpose of this study, the multicriteria approach has been identified as appropriate to assess synergies. In Chapter 4, the theoretical justification for use of the multicriteria approach has already been given. However, is important to remember that the assessment of synergies is part of a whole decision aiding process and is not only an evaluation procedure.

In order to complement information given in Chapter 4, this chapter provides information on MCDA methods such as AHP, PROMETHEE, and ELECTRE. Moreover, since the ELECTRE TRI method has been identified for the decision aiding process for assessing synergies at the project level, detail description is provided. The last sections are devoted to present some applications of the multicriteria methods. A section describes the application of MCDA in the forest sector, and another section provides information on how MCDA methods are used in the context of the Rio Conventions.

5.2 Multicriteria methods

5.2.1 General information

Multicriteria methods such as the multiple attribute utility theory, outranking and interactive have already been addressed (see section 4.4.2); now some detail information is given. A comprehensive list of methods is reported in Guitouni and Martel (1998) (see Table 5.1). Moreover, Siskos and Spyridakos (1999) have represented graphically the different multicriteria methods.

Multiple attribute utility theory

Multiple attribute utility theory (MAUT/MAVT) consists in aggregating different points of view into a unique function, which must be subsequently optimised (Vincke, 1992). The goal of MAUT/MAVT is to find a simple expression for the DM's preferences. This method transforms diverse criteria into one common dimensionless scale (utility/value), but also relies on the

assumptions that the DM has perfect knowledge and the preferences are transitive (Linkov *et al*., 2004).

Besides, Siskos and Spyridakos (1999) have described the value system approach based on strict assumptions of complete and transitive preference relation. The estimated value system by this approach provides a quantitative way that leads the decision maker to a final decision.

A fundamental notion in this domain is "**compensation**" that is why the Analytical Hierarchy Process (AHP) is included within this operational approach. The multi-attribute utility theory (MAUT) and the multi-attribute value theory (MAVT) are other major methods of the single synthesizing criterion approach (Vincke, 1992).

Outranking

The outranking approach consists first in building, on the set of actions, a relation (called outranking relation) to represent the preferences of the decision maker. This relation is neither necessarily transitive nor complete ("incomparability" is a key outranking concept). The second step is the exploitation of this relation in order to help the decision maker in the choice, or sorting, or ordering problems (Roy, 1990). Besides, Siskos and Spyridakos (1999) have described the outranking approach not to be bound into a mathematical model but providing further exploitation and processes to support the decision maker to conclude to a "good" decision.

Outranking methods are aimed at enabling the user to estimate the order of priority of the alternatives with minimum assumptions as compared to those assumed for the utility function. Moreover, with some outranking methods it is possible to use data on the **ordinal** scale.

Furthermore, the uncertainty associated with measuring or predicting the values of criteria can be taken into consideration when using **threshold**. Finally, these methods involve assigning weighting coefficients to the criteria, which do not depict trade-offs among the criteria, but 'votes' given to the criteria (Kangas and Kangas, 2005). An example, of outranking methods are the ELECTRE family methods.

Interactive method

An interactive method consists of alternating computation steps and dialogue with the decision maker. The first computation step provides an initial solution, which is presented to the decision maker, who acts further by giving additional information about his preferences. Then, adding the latter information into the model allows a new solution to be built (Vincke, 1992).

It is possible to speak of interactivity in multiple objective programming since 1971. In traditional (single objective) mathematical programming, a single objective such as minimizing cost or maximizing profit must be settled. However, frequently multiple objectives are identified (Steuer and Gardiner, 1990).

MCDA methods	Description
Elementary methods	
Weighted sum	The global performance of an alternative is computed as the weighted sum of its evaluations along each criterion. The global performance is used to make a choice among all the alternatives.
Lexicographic method	Based on the logic that in some DMS a single criterion seems to predominate. The procedure consists in comparing all the alternatives with respect to the important criterion, and proceeds with the next one until only one alternative is left.
Conjunctive method	An alternative, which does not meet the minimal acceptable level for all criteria, is rejected. The minimal acceptable levels for each criterion are used to screen out unacceptable alternatives.
Disjunctive method	An alternative is selected on the basis of its extreme score on any one criterion. Desirable levels for each attribute are used to select alternatives, which equal or exceed those levels on any criterion.
Maximin method	The overall performance of an alternative is determined by its weakest or poorest evaluation.
Single synthesizing criterion	
TOPSIS (technique for order by similarity to ideal solution)	The chosen alternative should have the profile, which is the nearest (distance) to the ideal solution and farthest from the negative-ideal solution.
MAVT (multi-attribute value theory)	Aggregation of the values obtained by assessing partial value functions on each criterion to establish a global value function V. Under some conditions, such V can be obtained in an additive, multiplicative, or mixed manner.
UTA (utility theory additive)	Estimate the value functions on each criterion using ordinal regression. The global value function is obtained in an additive manner.
SMART (simple multi-attribute rating technique)	Simple way to implement the multiattribute utility theory by using the weighted linear averages, which give an extremely close approximation to utility functions. There are many improvements like SMARTS, SMARTER.
MAUT (multi-attribute utility theory)	Aggregation of the values obtained by assessing partial utility functions on each criterion to establish a global utility function U. Under some conditions, U can be obtained in an additive, multiplicative, or distributional manner.
AHP (analytic hierarchy process)	Converting subjective assessments of relative importance into a set of weights. This technique applies the decomposition, the comparative judgments on comparative elements and measures of relative importance through pairwise comparison matrices, which are recombined into an overall rating of alternatives.
EVAMIX	Two dominance indexes are calculated: one for ordinal evaluations and the other one for cardinal evaluations. The combination of these two indexes leads to a measure of the dominance between each pair of alternatives
Fuzzy weighted sum	These procedures use α-cut technique. The α level sets are used to derive fuzzy utilities based on the simple additive weighted method.
Fuzzy maximin	This procedure is based on the same principle as the standard maximin procedure. The evaluations of the alternatives are fuzzy numbers.
Outranking methods	
ELECTRE I	The concept of outranking relationship is used. The procedure seeks to reduce the size of non-dominated set of alternatives (kernel). The idea is that an alternative can be eliminated if it is dominated by other alternatives to a specific degree. The procedure is the first one to seek to aggregate the preferences instead of the performances.
ELECTRE IS	This procedure is exactly the same as ELECTRE I, but it introduces the indifference threshold.
ELECTRE II	ELECTRE II uses two outranking relations (strong and weak).
ELECTRE III	The outranking is expressed through a credibility index.
ELECTRE IV	This procedure is like ELECTRE III but did not use weights.
ELECTRE TRI	This procedure is like ELECTRE III and uses the conjunctive and disjunctive techniques to affect the alternatives to the different categories (ordered).
PROMETHEE I	PROMETHEE I is based on the same principles as ELECTRE and introduces six function to describe the decision maker preferences along each criterion. This procedure provides a partial order of the alternatives using entering and leaving flows.
PROMETHEE I	PROMETHEE II is based on the same principles as PROMETHEE I. This procedure provides a total preorder of the alternatives using an aggregation of the entering and leaving flows.
MELCHIOR	MELCHIOR is an extension of ELECTRE IV.
ORESTE	This procedure needs only ordinal evaluations of the alternatives and the ranking of the criteria in term of importance.
REGIME	A pairwise comparison matrix is built using +1 if there is dominance, 0 if the two alternatives are equivalent and - 1 for the negative-dominance. The aggregation of these weighed scores provides a total preorder of the alternatives.
NAIADE (novel approach to imprecise assessment and decision environments)	This procedure uses distance semantics operators to assess the pairwise comparisons among alternatives. The fuzzy evaluation is transformed in probabilities distributions and as PROMETHEE, this procedure compute entering and leaving flows.
Mixed methods	
QUALIFLEX	This procedure uses successive mutations to provide a ranking of the alternative corroborating with the ordinal information.
Fuzzy conjunctive/ disjunctive Method	When data are fuzzy, the match between values and standard levels provided by the DM and the evaluations becomes vague and a matter of degree. The degree of matching is computed using the possibility measure and the necessity measure. The alternatives with the highest degree of matching are considered the best.
Martel and Zaras method	This procedure uses the stochastic dominance to make pairwise comparison. These comparisons are used as partial preferences and an outranking relation is built based on a concordance index and discordance index.

Table 5.1 List of methods used in MCDA

On the other hand, Siskos and Spyridakos (1999) have considered four theoretical trends on multicriteria analysis the value system, outranking, disaggregation-aggregation, and multiobjective optimisation approaches. The disaggregation-aggregation aims to analyse the DM behaviour and cognitive style. Special iterative interactive procedures are used, where the components of the problem and DM's global judgement policy are analysed and aggregated into a value system.

The multiobjective optimisation approach is an extension of the Mathematical Programming one, aiming to solve problems where there are **no discrete** alternative actions and the objectives are more than one. The solution is estimated through iterative procedures which lead to: (a) achieving the satisfaction levels of the DM on the criteria or; (b) constructing a utility model of the DM that is used for the selection of the solutions that are assessed from a utility maximization procedure; or (c) a combination of the above two described methods

Other classifications have also been reported. For example, Hwang and Yoon (1981) have suggested: (a) methods which solve problems with a **discrete** set of options (e.g. ELECTRE, PROMETHEE, NAIADE, Regime, AHP, MAUT, Evamix, or MACBETH), and (b) those for solving problems which require selection from **continuous** sets of options (e.g. Goal Programming and Multiple Objective Programming). Besides, Janssen and Munda (1999) have divided the methods into (a) **quantitative** (e.g. Weighted Sum, MAUT, MACBETH, outranking methods and AHP) and (b) **qualitative** (e.g. Regime and Evamix). The first group requires quantitative information about scores of each criterion, whereas the second group is used if only qualitative or mixed information is available.

5.2.2 How to choose an appropriate method?

There is no method that is universally best or even applicable for all situations (Kangas and Kangas, 2005). Different attempts to choose the appropriate MCDA method have been addressed. However, is important to keep in mind that the construction of a model <u>is not all of the decision process</u> (Bouyssou *et al*., 2000). Moreover, the evaluation model used for the decision aid is linked to the problem situation and problem formulation, thus to a whole **decision aiding process**.

In the following paragraphs, different criteria and recommendations for choosing the method are presented. For example, Moffett and Sarkar (2006) have proposed taxonomy of methods. Then, Guitouni and Martel (1998) have suggested that a comparative study of different MCDA methods might help to identify the most appropriate method for a given situation.

In the context of sustainable development, De Montis *et al*. (2004) have proposed criteria for the quality assessment of methods, such as: (1) operational components of MCDA methods, (2) applicability of MCDA methods in the user context, and (3) applicability of MCDA methods considering the problem structure. However, also criteria for the selection of MCDA methods have

been proposed such as internal consistency and logical soundness; transparency; ease of use; data requirements not inconsistent with the importance of the issue being considered in realistic time and manpower resource requirements for the analysis process; ability to provide an audit trail; and software availability (Dodgson *et al*., 2000).

Different comparisons among multicriteria methods have been reported in literature (Wolfslehner, 2006; Moffett and Sarkar, 2006; Omann, 2004; Pohekar and Ramachandran, 2004; De Montis *et al*., 2004; Söderberg and Kärrman, 2003; Zopounidis and Doumpos, 2002; Olso, 2001; Dodgson *et al*., 2000; Salminen *et al*., 1998; Beccali *et al*., 1998; van Huylenbroeck, 1995).

However, also synergies among methodologies have been proposed. For instance, methods such as AHP and PROMETHEE (Macharis *et al*., 2004) or hybrids of outranking, MAUT, and numerical optimisation (Kangas *et al*., 2001) have been studied. Furthermore, even the combination of multicriteria methods with other methods has been proposed. For instance, Bojórquez-Tapia *et al*. (2004) have proposed a land sustainability assessment (LSA) approach consisting in the combination multivariate statistics, multicriteria modelling, and mathematical programming procedures. Besides, van Huylenbroeck (1995, 1997) has proposed the use of the Conflict Analysis Method (CAM) combined with ORESTE, ELECTRE and PROMETHEE methods.

In addition, Mendoza and Prabhu (2005) have combined participatory modelling and multicriteria analysis for community-based forest management. Curtis (2004) has proposed for the valuation of ecosystem services the use of surrogate market and combination of multicriteria analysis and a Delphi panel. Goletsis *et al*. (2003) have proposed for the ranking of projects an hybrid of ELECTRE III and PROMETHEE (MURAME) method.

Furthermore, De Montis *et al*. (2004) have described some rough guidelines which can be given for the comparison of methods:

1. If the respective decision problem is such that relying upon social welfare theory and its assumptions is possible and if the data to build utility functions is available (risk and qualitative data are possible) then MAUT is a good choice.
2. If working with different conflicting interest groups is important for the case, NAIADE [28] and AHP provide the best performance.
3. If the involved DMs should primarily learn from the application of the MCDA tool, it is advisable to use MAUT or AHP.
4. If thresholds and constraints are central for the problem under investigation, which means that there is non-substitutability of some criteria, ELECTRE III or GP/MOP should be chosen.
5. If the problem is a continuous one, e.g. there is not a discrete number of alternatives, which comes out of the specific situation, Goal Programming (GP), or Multi-Objective Programming (MOP) should be chosen.

[28] NAIADE, Novel Approach to Imprecise Assessment and Decision Environments

6. If a complete ranking of the given alternatives as result of the analysis is indispensable MAUT, AHP, Evamix, or Regime should be applied.

While MCDA offers demonstrable advantages, choosing among MCDA methods is a complex task. Each method has strengths and weaknesses; while some methods are better grounded in mathematical theory, others may be easier to implement.

Data availability may also act as a constraint on applicable methods. It is therefore unavoidable that the decision maker will have to choose, on a case-by-case basis, the most suitable MCDA technique applicable to each situation (Linkov *et al*., 2004; Haralambopoulos and Polatidis, 2003; Bouyssou *et al*., 2000), and as mentioned before, the method should be choose and linked to a whole **decision aiding process**.

Furthermore, Bouyssou *et al*. (2000) have addressed that the choice of a particular method or approach as a result of an evaluation, in a given decision situation, is the chances of being able to elicit the **parameters** of the corresponding model in a reliable way. These "chances" obviously depend on several factors such as the available data, the way of thinking of the decision maker, the knowledge of the problem.

Moreover, there are also **internal** and **external** consistency criteria that a method should fulfil. Internal consistency implies making explicit the hypotheses under which data form an acceptable input for a method. Then the method should perform operations on the input that are compatible with the supposed properties of the input; this in turn induces an output which enjoys particular properties. External consistency consists in checking whether the available information matches the requirements of acceptable inputs and whether the output may help in the decision process (Bouyssou *et al*., 2000).

For the purpose of this research, the author has considered important to further describe AHP, PROMETHEE, and ELECTRE methods. These methods have been used during the **decision aiding process** (see section 7.2.1). AHP is classified as unique synthesis criterion approach, and PROMETHEE and ELECTRE in the outranking approach. In the context of decision problems, AHP and PROMETHEE are used mainly for ranking problem; instead ELECTRE family methods can be used for choosing, ranking, and sorting problems.

Siskos and Spyridakos (1999) have described Expert Choice (AHP), ELECTRE methods and PROMETHEE as the most powerful multicriteria decision support systems according to their methodology and software capabilities.

5.2.3 AHP

Analytic Hierarchy Process (AHP) is a multiple criteria decision-making tool (Saaty, 1980). AHP is an eigenvalue approach to the pairwise comparisons. Besides, it provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances.

Moreover, AHP helps to incorporate a group consensus and generally this consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution (Vaidya and Kumar, 2006). AHP is based on three principles (Macharis *et al*., 2004): construction of a hierarchy, priority setting, and logical consistency.

Construction of the hierarchy

AHP requires the decision maker to describe up to four different components: the objective, the relevant criteria, the relevant sub-criteria if any, and the alternatives to be evaluated (Handfield *et al*., 2002; Tzeng *et al*., 2002).

Priority setting

AHP begins by asking the decision maker to consider each of the criteria pairwise and assign a relative importance to the criteria, often on a nine-point scale ("1" represents equal importance and "9" represents much more importance). Then, the relative importance is used to construct a preference matrix, from which the weights for each criterion will be extracted (Saaty, 1980).

These subjective estimates of relative importance are used to generate the weights assigned to each of the criteria. Later on, AHP evaluates the performance of the alternatives relative to these weighted criteria. The same method is followed to describe the relative performance of each alternative for each of the criteria. For each criterion, a reciprocal preference matrix is generated that shows the trade-offs between each alternative on that one criterion.

Then, this matrix is used to calculate a vector of weights that denote the performance of the alternatives on that one criterion. When this is done for all criteria, the result is an **nxm** matrix of performance weights (**n=** number of criteria; **m=** number of alternatives). In Box 5.1, an example of a possible pairwaise comparison matrix is shown.

To calculate the overall score for each alternative, the matrix of performance multiplies the matrix of criteria weights (Handfield *et al*., 2002). As a result, the overall relative priority to be given to the lowest level elements (e.g., the alternatives) is obtained, indicating the degree to which the alternatives contribute to the focus (Macharis *et al*., 2004).

		C1	C2	C3	C4
Criterion 1	**C1**		2	2	1
Criterion 2	**C2**			3	1
Criterion 3	**C3**				2
Criterion 4	**C4**	**Inco:0.04**			

Box 5.1 Matrix of performance

Logical consistency

AHP provides a measure of the evaluator's inconsistency. It is based on the fact that the participants perform pairwise comparisons in a circle (Sutter, 2003). In each pairwise comparison matrix, a number of comparisons are redundant (see Box 5.1). When the pairwise comparison matrices are completely consistent, the priority (or weight) vector is given by the right eigenvector (W) corresponding with the highest eigenvalue (λmax). Building on this information Saaty (1980) uses the largest eigenvalue λmax to define a consistency index (λmax-n)/(n-1), where n is the number of criteria. The consistency index is divided by the random index of the order of the matrix considered to compute the final inconsistency measure referred to as *consistency ratio*. A consistency ratio of 0.10 or less is considered acceptable (Saaty, 1980).

Vaidya and Kumar (2006) have classified the applications of AHP in three groups: (a) applications based on a theme, (b) specific applications, and (c) applications combined with some other methodology. They concluded that most of the papers on AHP fall in the combination of engineering and selection, social and selection, and personal and decision making. This highlights the utility of AHP as a decision making tool in engineering as well as in social sector.

Furthermore, Vaidya and Kumar (2006) have listed different **themes** for AHP such as selection, evaluation, benefit-cost, allocation, planning and development, priority and ranking, decision making, forecasting, medicine and QFD[29], and also **application areas** such as social, manufacturing, political, engineering, education, industry, government among others. It is observed that AHP is being predominantly used in the theme area of selection and evaluation.

Moreover, it was found that as the confidence of researches grew with the use of AHP, the combination of AHP with other techniques has been experimented. Besides, Vaidya and Kumar (2006) have concluded that AHP is a flexible multicriteria decision-making tool.

AHP has several **advantages** from the viewpoints of multiple-use and participatory planning, since expert knowledge, and subjective preferences can be considered together. Besides, qualitative criteria can be considered in the evaluation of alternatives (Kangas and Kangas, 2005).

One major **weakness** of the application-oriented AHP studies is that it tends to focus on the mechanics of AHP, instead of on the theoretical and practical results associated with implementing AHP. However, one major advantage of AHP is that the construction of the hierarchy diagram forces the decision maker to structure the problem. Therefore, the objective and relevant criteria needs to be defined and assigning numerical values for their relative importance forces to consider trade-offs in some detail (Handfield *et al*., 2002).

Moreover, other problems with the application of AHP are that the original comparison scale does not allow for the expression of any hesitation regarding the comparisons, the AHP itself does not provide tools for in-depth analyses of the comparisons, particularly of the uncertainty inherent in

[29] QFD, Quality Function Deployment

the data and the number of comparisons increases rapidly as the number of alternatives and criteria increases (Kangas and Kangas, 2005). However, different proposals have been made to extend AHP to a fuzzy environment (Buckley, 1985).

Furthermore, AHP suffers from the **rank reversal** problem, which means that the ranking of the alternatives is reversed. Thus it violates the independence of irrelevant alternatives axiom of decision theory (Arrow and Raynaud, 1986).

The use of AHP is implemented as decision support system with the **Expert Choice** software.

5.2.4 PROMETHEE

The Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) is based on a principle of pairwise comparisons (Geldermann and Zhang, 2001; Brans, 1982; Brans and Vincke, 1985; Mareschal, 1986, 1988; Brans *et al*., 1984, 1986). PROMETHEE has the following principles (Macharis *et al*., 2004): evaluation table, relative importance, and information on decion maker preference. Some of the information used for preparing this section was taken from an article prepared by Brans and Mareschal[30].

Evaluation table

In the evaluation table provide by PROMETHEE, alternatives are evaluated on the different decision criteria, and these evaluations involve essentially numerical data.

Relative importance

PROMETHEE does not provided specific guidelines for determining these weights, but assumes that the decion maker is able to weigh the criteria appropriately, at least when the number of criteria is not too large (Macharis *et al*., 2004). Decision problem are required in a decision matrix (see Table 5.2), including ***m*** evaluation criteria, ***n*** alternatives and **nxm** evaluation.

For example, there are five alternatives (sites) with the following evaluation criteria: investment, operations, employment, transportation, environment, and social (see Table 5.2). The matrix often must be evolutive and achieved progressively, which means that additional alternatives may be considered according to the gain in information during the progress of the decision procedure. New evaluation criteria could be considered, some others temporarily deleted.

Information on decision maker preference

For each criterion a specific preference function must be defined and there are corresponding parameters and thresholds. This function is used to compute the degree of preference associated to

[30] Brans J.P. and Mareschal B. How to Decide with PROMETHEE.
Available: http://www.visualdecision.com/Pdf/How%20to%20use%20PROMETHEE.pdf

the best action in case of pairwise comparisons. Then, six possible shapes of preference functions are available and described in Brans *et al*. (1986).

Parameters	**Criteria**					
	Investment	*Operations*	*Employment*	*Transportation*	*Environment*	*Social*
Min/Max	Minimize	Minimize	Minimize	Maximize	Minimize	Minimize
Weight	20	10	22	22	13	13
Preference function	Linear	Linear	Linear	Level	Level	Level
Indifference threshold	5%	5%	5%	0,50	0,50	0,50
Preference threshold	25%	25%	10%	1,50	1,50	1,50
Unit	M$	M$	workers	5-points	impact	impact
Alternative	**Alternative evaluation**					
Site1	73	11	176	Average	High	Low
Site2	85	9	171	Good	Low	Very low
Site3	88	8	146	Very good	Very low	Moderate
Site4	114	10	96	Bad	Low	High
Site5	127	11	111	Good	Moderate	Very low

Table 5.2 Matrix used for PROMETHEE methods

Individual stakeholder analysis

PROMETHEE permits the computation of the following quantities for each stakeholder *r* (r= 1. . , R) and alternatives *a* and *b*: $\pi_r(a,b)$, $\Phi_r^+(a)$, $\Phi_r^-(a)$ and $\Phi_r(a)$.

For each alternative *a*, belonging to the set *A* of alternatives, $\pi_r(a,b)$ is an overall preference index of *a* over *b*, taking into account all the criteria, $\Phi_r^+(a)$ and $\Phi_r^-(a)$. These measure respectively the strength and the weakness of a vis-a-vis the other alternatives. $\Phi_r(a)$ represents a value function, whereby a higher value reflects a higher attractiveness of alternative *a*. $\Phi_r(a)$ is the net flow of alternative *a* for stakeholder *k*. Then, three main tools can be used to analyse the evaluation problem: PROMETHEE I partial ranking; PROMETHEE II complete ranking; and GAIA plane.

PROMETHEE calculates positive and negative preference flows for each alternative. The positive flow is expressing how much an alternative is dominating (power) the other ones, and the negative flow how much it is dominated (weakness) by the other ones. Based on these flows, the PROMETHEE I partial ranking is obtained.

The PROMETHEE I partial ranking provides a ranking of alternatives. In some cases, this ranking may be incomplete. This means that some alternatives cannot be compared and, therefore, cannot be included in a complete ranking. This occurs when the first alternative obtains high scores on particular criteria for which the second alternative obtains low scores and the opposite occurs for other criteria. The use of PROMETHEE I then suggests that the decision maker should engage in additional evaluation efforts (Macharis *et al*., 2004).

PROMETHEE II provides a complete ranking of the alternatives from the best to the worst one. It is based on the balance of the two preference flows, and the net flow is used to rank the alternatives. The information looks stronger but some parts of it get lost in the process. Obviously the PROMETHEE I and II rankings are influenced by the weights allocated to the criteria (Macharis *et al*., 2004).

Furthermore, De Keyser and Peeters (1996) have listed considerations to take into account when applying PROMETHEE methods:

- the DM can express his/her preferences between two actions/alternatives on all the criteria on ratio scales.
- the DM can express the importance he/she attaches to the criteria on a ratio scale.
- the DM wants to take all criteria into account and is aware of the fact that the weights are representing trade-offs.
- for all criteria the difference between evaluations must be meaningful.
- none of the possible differences on any of the criteria can give rise to discordance.
- the DM knows exactly what can happen if one or more actions are added or deleted and is fully aware of the influence on the final decision.

A special feature of the software is the *Walking Weights*, which allows to modify the weights and to observe the resulting modifications of the PROMETHEE II ranking. Such a **sensitivity analysis** tool is particularly valuable when the decision maker has no predetermined weights in mind.

Moreover, the **GAIA plane** is obtained by projection of this information on a plane such that as few information as possible get lost. Alternatives are represented by points and, criteria by axes, then, criteria expressing similar preferences on the data are oriented in the same direction, conflicting criteria are pointing in opposite directions.

In addition, the projection of the weights vector in the GAIA plane corresponds to another axis (π, the PROMETHEE decision axis) that shows the direction of the compromise resulting from the weights allocated to the criteria. Thus, the decision maker is invited to consider the alternatives located in that direction.

Finally, visual elements in PROMETHEE are under development and aims for new specific displays to better visualize single criteria performance and to uncover incomparability in the PROMETHEE ranking, and the use of a three-dimensional representation is proposed to increase the amount of information displayed by GAIA (Mareschal *et al*., 2007).

Among the **advantages** of PROMETHEE methods: the efficiency and easy applicability. Nevertheless, a **critical** aspect of PROMETHEE is the problem of the rank reversal as described for AHP. Geldermann and Zhang (2001) have provided a list of **advantages**:

- The basic decision information requested from the decision maker is limited to a number of key parameters that can be easily and precisely fixed. This ensures a higher quality of results.
- The thresholds in the preference functions, that control the compensatory effects, are well explicable to any decision maker.
- Besides ranking of the actions, additional tools of statistics are available, such as GAIA, allowing users to experiment with different hypotheses and to learn more about the key features of the decision problem.
- Furthermore, extensive sensitivity analysis as well as visual representations of the data is available to the decision maker.

The use of PROMETHEE methods (PROMETHEE I and PROMETHEE II) is implemented as decision support system with the **Decision Lab 2000** software.

5.2.5 ELECTRE methods

Bernard Roy (1968) has originally developed the *Elimination Et Choix Traduisant la Realité* (ELECTRE [31]) methods and the origins go back to 1965. Several versions of the ELECTRE method have been presented. **ELECTRE I** the first method developed for choosing the best action. A further version known as **ELECTRE IS** was used for modelling situations in which the data was imperfect. This last method is the current version of ELECTRE methods used for choice problematic.

In the late sixties the problem of ranking arose, which led to the birth of **ELECTRE II**, a method that rank from the best to the worst option. A few years later a new ranking method was developed, the **ELECTRE III**, where the notion of pseudo criteria was introduced as well as fuzzy binary outranking relations. Later the **ELECTRE IV** method arose and rank without using the relative criteria importance coefficient and also equipped with an embedded outranking relations framework. The last method, which was proposed, the **ELECTRE TRI** method, which sorts actions into predefined and ordered categories (Figueira *et al*., 2005).

ELECTRE methods are relevant when decision situation have some characteristics, such as that the decision maker wants to include in the model at least three decision criteria. However, aggregation procedures are more adapted in situations when decision models include more than five criteria (up to 12 or 13), and at least one of the following situations must be verified (Figueira *et al*., 2005):

- ❖ Actions are evaluated (for at least one criterion) on an ordinal scale or on a weakly interval scale.
- ❖ A strong heterogeneity related with the nature of evaluations exists among criteria
- ❖ Compensation of the loss on a given criterion by a gain on another one may not be acceptable for the DM. Therefore; such situations require the use of **non-compensatory** aggregation procedures (see also section 4.5; application to sustainable development).

[31] ELECTRE translate into English, *Elimination and Choice Expressing the Reality*

- For at least one criterion, the following holds true: small differences of evaluation are not significant in terms of preferences, while the accumulation of several small difference may become significant. This requires the introduction of discrimination thresholds (indifference and preference).

Preference modelling in ELECTRE methods is done by using **binary outranking relations** ***S***. Then outranking is defined: "*at least as good as*". In other words, an **outranking** relation is a binary relation ***S*** such that ***aSb,*** if given what is known about the decision maker's preferences and given the quality of the valuations of the actions and the nature of the problem, there are enough arguments to decide that ***a*** is at least as good as ***b***, while there is no essential reason to refute that statement (Roy, 1974). If there are two alternatives, ***a*** and ***b***, four situations may occur (Figueira *et al*., 2005):

- *aSb* and not *bSa* (e.g., *aPb*, *a* is strictly preferred to *b*)
- *bSa* and not *aSb* (e.g., *bPa*, *b* is strictly preferred to *a*)
- *aSb* and *bSa* (e.g., *aIb*, *a* is indifferent to *b*)
- Not *aSb* and not *bSa* (e.g., *aRb*, *a* is incomparable to *b*)

In ELECTRE methods the **incomparability** concept has been introduced and is useful when the decision maker is not able to compare two actions/alternatives. Then, the construction of the outranking relation is based on two major concepts (Bouyssou, 2001):

(a) *Concordance*, for an outranking *aSb* to be validated, a sufficient majority of criteria should be in favour of this assertion.

(b) *Non-concordance*, when the concordance conditions holds, none of the criteria in the minority should oppose too strongly to the assertion *aSb* (or *bSa*) in a "too strong way".

An outranking relation is not necessarily transitive. Preference **intransitivity** comes from two situations: Condorcet effect and incomparability between actions. Then, an exploitation procedure is required to derive results from such a relation that fit the problem situation (Figueira *et al*., 2005).

In summary, the ELECTRE method follows two important procedures: (a) the construction of one or several outranking relations, and (b) the exploitation procedure. The first procedure has an objective to compare in a comprehensive way each pair of actions/alternatives. The second procedure is used to elaborate recommendations from the results obtained with the first procedure. The recommendations are linked to the type of situation and method which is used (choose, rank or sort).

In a decision process using these methods, the analyst usually interacts with the DM in order to elicit values for **preference-related parameters**. This can be done either directly or through a disaggregation procedure that infers the values of the parameters from holistic preferences provided by the DM. Inference is usually performed through an optimisation program that accounts for the

aggregation model and minimizes an ‘‘error function’’ (Mousseau and Dias, 2004). Other authors have proposed methods for obtaining preferential information for ELECTRE methods, for instance Rogers and Bruen (1998[a], [b]) and Balasubramaniam *et al*. (2007).

In this section, the author found important to further explore the concept of **compensation** (see section 4.5). There are no unanimous definitions or principles to characterize the degree of compensation. Some authors have addressed mainly compensatory and non-compensatory concepts (Figueira *et al*., 2005; Munda, 2005; Kangas *et al*., 2001; Martinez-Alier *et al*., 1998; Munda, 1997; Bouyssou, 1986). Nevertheless, other authors also use a partially-compensatory concept, providing MCDA methods as examples (Linkov *et al*., 2004; Colson and De Bruyn, 1989 in Guitouni and Martel, 1998):

1. *Compensatory*: in this case, one admits that an absolute compensation between the different evaluations can exist. Hence, a good performance on one criterion can easily counterbalance a poor one on another. There exist many methods that can fall into this category like the weighted sum. Also the MAUT/MAVT and AHP are a compensatory optimisation approaches.
2. *Non-compensatory*: no compensation is accepted between the different dimensions. The DM may state that the dimensions are important enough to refuse any kind of compensation or trade-offs. The lexicographic, maximin, minimax, conjunctive and disjunctive methods are considered as a non-compensatory method;
3. *Partially compensatory*: in this case, some kind of compensation is accepted between the different dimensions or criteria. Most of the MCDA methods fall within this category. The major problem is to evaluate the degree of compensation for each one.

For the purpose of this research, it is particularly important to know that MCDA methods are related to a **compensation** concept, which refers to the existence of **trade-offs**. That is the possibility of offsetting a disadvantage on some attribute by a sufficiently large advantage on another attribute, whereas smaller advantages would not do the same (Bouyssou, 1986).

Furthermore, this concept is related to sustainability issues; therefore, for environmental problems it is rather significant to go for non-compensatory methods (see section 4.5). Another issues is to understand the degree in which a method is compensatory, partially or non-compensatory. Nowadays, these aspects are under development and discussion. For instance, Bouyssou and Marchant (2007[a], [b]) claimed that only the pessimistic version of ELECTRE TRI method fits into the framework of non-compensatory sorting models with veto.

On the other hand, authors have presented some disadvantages of the methods. For instance, Guitouni and Martel (1998) have described that outranking methods make sense practically and are based in different preference structure, but they are lacking on the axiomatic basis However, recent

trend of research aim to give these methods sound theoretical foundations (Bouyssou and Marchant, 2007[a], [b]).

Moreover, difficulties in understanding and interpreting the calculations and their results are, perhaps, the most crucial deficiencies of most outranking methods as addressed in Kangas *et al.* (2001). Furthermore, easiness to use and understand the method, and interpretability of the results are important qualities of planning methods applied particularly in participatory planning, this is a crucial deficiencies of most outranking methods (Kangas *et al.*, 2001). Joerin and Musy (2000) have stated that the drawbacks are significant because outranking methods (like ELECTRE methods) have difficulties in handling large numbers of alternatives, which lead to the conclusion that these methods are impractical for land management.

5.3 ELECTRE TRI

For this research ELECTRE TRI method has been chosen in a specific decision aiding process (see Chapter 7); therefore, a detail description is provided in the following section.

ELECTRE TRI is a Multiple Criteria Sorting Method (MCSM) where an **outranking relation** is used as a preference model. ELECTRE TRI is a method that assigns alternatives to pre-defined categories. In other words, it consists in assigning each alternative to one of the categories pre-defined by some norms corresponding to vectors of scores on criteria, called **profiles** (limit categories). Then, the assignment of an alternative results from the **intrinsic** evaluation of the alternative on all criteria with respect to the profiles (Mousseau and Slowinski, 1998; Mousseau *et al.*, 2000). In order to implement the preference model of the decision maker, the values of preference parameters, like importance coefficients and discrimination thresholds are needed.

On the other hand, when considering a **classification/sorting** the decision maker needs to perform an absolute judgment [32]. While both classification and sorting refer to the assignment of a set of alternatives into predefined groups, they differ with respect to the way that the groups are defined. **Classification** refers to the case where the groups are defined in a **nominal** way. Besides, **sorting** refers to the case where the groups are defined in an **ordinal** way starting from those including the most preferred alternatives to those including the least preferred alternatives (Zopounidis and Doumpos, 2002).

Furthermore, Bouyssou *et al.* (2006) have addressed, when sorting the problem is formulated: a) to partition the set of alternatives into several categories, the definition of these categories being intrinsic; b) to propose a procedure that will generate such a partition. The essential distinctive characteristics of the problem statement lie in the definition of the categories. Then, two cases arise: a) definition of categories may not refer to the desirability of the alternatives (e.g. pattern

[32] absolute judgement - each alternative is considered independently from the others in order to determine its intrinsic value by means of comparisons to norms or references and not on the comparison of an alternative to other alternatives (Mousseau et al., 2000, 2001)

recognition, speech recognition, or diagnosis). This situations call for the use of **classification** techniques. In those situations, a category is often defined to the categories according to their "proximity" to the prototypical elements; and b) evaluation that sought involves the desirability of the alternatives (e.g. a credit manager wants to isolate "good" risks and "bad" risks, an academic programme may wish to enrol only "good" students). Then the problem lies in the definition of the categories, i.e., of the norms defining what is "good" risk, a "good" student.

5.3.1 Outranking relation

Let F denote the set of indices of the criteria $g_1, g_2, \ldots g_m$ ($F=\{1,2,\ldots m\}$) and B the set of indices of the profiles defining $p+1$ categories ($B=\{1,2,\ldots p\}$), b_h being the upper limit of category C_h and the lower limit of category C_{h+1} ($h=1,2,\ldots p$). b_{p+1} and b_0 correspond to the ideal and non ideal alternatives, respectively (see Figure 5.1). ELECTRE TRI builds an outranking relation S, e.g., validates or invalidates the assertion aSb_h and b_hSa, which means "a is at least as good as b_h". Moreover, the assignment of an action $\boldsymbol{a}$ to a specific category does not influence the category, to which another action $\boldsymbol{b}$ should be assigned (Mousseau *et al*., 1999, 2000).

At the comprehensive level of preferences, in order to validate the assertion aSb_h (or b_hSa), two conditions should be verified, as described in section 5.2.5, concordance and non-discordance (Mousseau *et al*., 2001). At this point parameters such as the importance coefficient and veto threshold are used (see 5.3.3). ELECTRE TRI builds an index $\sigma(a,b_h) \in [0,1]$ ($\sigma(b_h,a)$ that represents the degree of credibility of the assertion aSb_h (or b_hSa).

An outranking relation is built in order to enable the comparison of an alternative $\boldsymbol{a}$ to a profile $\boldsymbol{b_h}$. Therefore, determining the credibility index, $\sigma(a,b_h)$, consists in the following steps (Mousseau *et al*., 1999) (see Figure 5.1):

- compute the partial concordance indices $c_j(a,b_h)$ and $c_j(b_h,a)$,
- compute the overall concordance indices $c(a,b_h)$,
- compute the partial discordance indices $d_j(a,b_h)$ and $d_j(b_h,a)$,
- compute the fuzzy outranking relation grounded on the credibility indices $\sigma(a,b_h)$,
- determine a $\boldsymbol{\lambda}$-cut of the fuzzy relation in order to obtain a crisp outranking relation.

After determining the **credibility index**, the translation of the obtained **fuzzy** outranking (defuzzyfied; Mousseau *et al*., 2000) relation into a **crisp** outranking relation is done by the $\boldsymbol{\lambda}$-cutting level. $\boldsymbol{\lambda}$ is considered the smallest value of the credibility index compatible with the assertion aSb_h or determines the preference situation between a and b_h (Figueira *et al*., 2005; Mousseau *et al*., 2000).

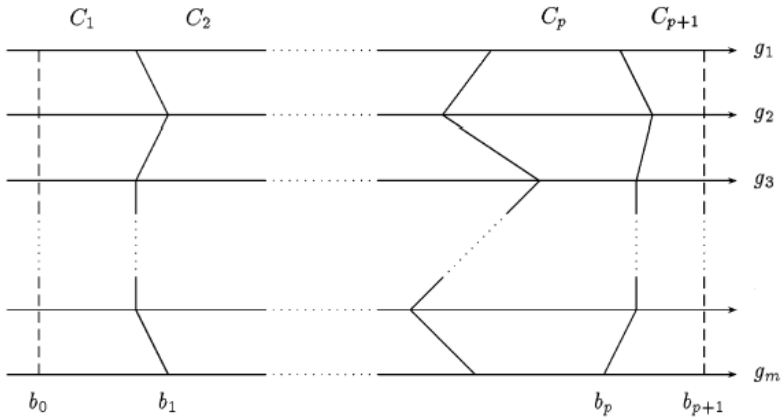


Figure 5.1 Set of criteria, categories and profiles in ELECTRE TRI

The action ***a*** and the profile b_h are related to each other as shown below (where > is preference, I is indifference and R is incomparability):

aIb_h if aSb_n and b_nSa

$a>b_h$ if aSb_n and not b_nSa

$a<b_h$ if not aSb_n and b_nSa

aRb_h if not aSb_n and not b_nSa

5.3.2 Exploitation procedure

After the construction of the outranking relation, then the role of the exploitation procedure is to analyse the way in which an alternative ***a*** compares to the profiles and determine the category to which ***a*** should be assigned. There are two assignment procedures (Mousseau *et al*., 1999, 2000):

- Pessimistic or conjunctive procedure, where an action can be assigned to a category when its evaluation <u>on each criterion</u> is at least as good as the lower limit which has been defined on the criterion to be in this category. Then the action is assigned to the highest category fulfilling this condition.
- Optimistic or disjunctive procedure, where an action can be assigned to a category, if it has, <u>on at least one criterion</u>, an evaluation at least as good as the lower limit which has been defined in the criterion to be in this category. Then the action is assigned to the highest category fulfilling this condition.

For interpreting results with ELECTRE TRI method is important to compare the two assignment procedures. Therefore, when the evaluations of an alternative are between the two profiles of a category on each criterion, then both procedure assign this alternative to this category. Besides, a divergence exist among results of the two assignment procedures only when an alternative is **incomparable** to one or several profiles. In this case the pessimistic assignment rule assigns the alternative to a lower category than the optimistic one (Mousseau *et al*., 1999).

For more details on ELECTRE TRI, see the manual (Mousseau *et al*., 1999) and other publications such as Dias and Mousseau (2006), Mousseau *et al*. (2003), Ngo The and Mousseau (2002), Dias *et al*. (2002), Mousseau *et al*. (2000, 2001), Dias and Climaco, (2000), and Yu (1992).

ELECTRE TRI method has been subjected to new applications (Siskos *et al*., 2007; Andre, 2007; Rousval, 2005), continous development (Bouyssou and Marchant, 2007[a], [b]; Figueira *et al*., 2007; Figueira *et al*., 2005), and variants which supports the task of inferring parameters for ELECTRE TRI (see Tervonen *et al*, 2007, 2005; Dias and Mousseau, 2003; Dias *et al*., 2002).

5.3.3 Criterion preferential information

Roy and Bouyssou (1991) have defined a **criterion** as a function that associates each action with a number indicating its desirability according to consequences related to the same "point of view". This particular point of view permits to give a concrete meaning to the numbers *g(a)*, given the nature of the various consequences taken into account.

Then, the direction of preference on a criterion can be increasing or decreasing (Mousseau *et al*., 1999). In the first case, the higher the evaluation *g(a)*, the better is *a* with respect to the criterion *g* (quality criterion). In the second case, a criterion with a decreasing direction of preference corresponds to a criterion *g* on which the performance of an alternative *a* decreases when *g(a)* increases (cost criterion).

Furthermore, for implementing ELECTRE TRI method, inter and intra-criterial preferential information is needed. For the elicitation of the ELECTRE TRI parameters different publications can be revised (Bouyssou *et al*., 2006, 2000; Dias and Mousseau, 2006; Figueira *et al*., 2005; Mousseau and Dias, 2004; Figueira and Roy, 2002; Dias *et al*., 2002; Mousseau *et al*., 2003, 2001; 2000; Dias and Climaco, 2000, 1999; Mousseau and Slowinski, 1998; Roy *et al*., 1986; Belton, 1986; Mousseau, 1995).

Inter-criterion information

Two types of inter-criteria preference parameters are present in the construction of the outranking relation ***S*** (Mousseau *et al*., 2001):

- set of **weight-importance coefficients** (w_1, w_2,… w_m), which is used in the <u>concordance</u> test when computing the relative importance of the coalitions of criteria being in favor of the assertion aSb_h.
- set of **veto thresholds** ($v_1(b_h)$, … $v_j(b_h)$,… $v_m(b_h)$), which is used in the <u>discordance</u> test; $v_j(b_h)$ represents the smallest difference $g_j(b_h) - g_j(a)$ incompatible with the assertion aSb_h.

The use of weights with intensity of preferences gives rise to **compensatory** multicriteria methods and gives the meaning of trade-offs to the weights. On the contrary, the use of weights with ordinal criterion scores originated **non-compensatory** aggregation procedures and gives the weights the meaning of importance coefficients (Munda, 2005).

Furthermore, the notion of importance of the criteria and its implementation are strongly model dependent. Weights and trade-offs should not be elicited in the same manner depending on the type of model since e.g. they may or may not depend on the scaling of the criteria (Bouyssou *et al*., 2000).

In particular, for ELECTRE methods the weights that describe the relative importance of criteria are typically used additively to measure the importance of coalitions of criteria independently of the evaluations of the alternatives (Bouyssou *et al*., 2000).

Intra-criterion information

In order to account for the imprecision, uncertainty and indetermination of the data, it is common to use discrimination **thresholds** that identify the limits between situations of indifference and strict preference (Roy *et al*., 1986). Two values q and p are introduced and are called **indifference** and **preference** threshold, respectively. In the general case, these thresholds may vary with the evaluations (Mousseau *et al*., 1999).

Roy and Bouyssou (1991) have explained that the criterion $\boldsymbol{g}$ is a real-valued function defined on the set $\boldsymbol{A}$ of potential actions so that the comparison of the two numbers $g(a)$ and $g(b)$ allows us to describe and/or argue the result of the comparison of $\boldsymbol{a}$ and $\boldsymbol{b}$ relative to the point of view underlying the definition of g. More precisely, criterion g is a model whereby:

$g(b) \gneq g(a) \rightarrow bS_g a$

Traditionally, two relations between actions are the indifference between $\boldsymbol{a}$ and $\boldsymbol{b}$ (bIa), and the **strict preference** (bPa), which are described in the following way:

$g(b) = g(a) \leftrightarrow bI_g a$

$g(b) > g(a) \leftrightarrow bP_g a$

But this model is not always very realistic in practice: a small positive difference $g(b)- g(a)$ may not be indicative of a strict preference. A more sophisticated preference modelling is obtained by introducing two thresholds p_g and q_g, with $p_g \gneq q_g$, so that when $g(b) \gneq g(a)$:

$g(b)- g(a) \lneq q_g \leftrightarrow bI_g a$

$p_g < g(b)- g(a) \leftrightarrow bP_g a$

The situation not covered by these two intervals, namely:

$q_g < g(b) - g(a) \lneq p_g$

corresponds to a case of hesitation (indetermination) between indifference and strict preference, called **weak preferences** and denoted as Q_g. Therefore, the following relations exist: $aI_g b$, $aP_g b$, and $aQ_g b$.

In summary, to compare the actions $\boldsymbol{a}$ and $\boldsymbol{b}$, there are three possibilities: preference, indifference and refusal or inability to compare (Vincke, 1992). These relations make up a **preference structure**. A summary of preference modelling is shown in Table 5.3. Specifically, for ELECTRE TRI method a **pseudo-criterion** is used; therefore, preference and indifference thresholds are needed.

Model	Preference structure	Criterion	Characteristic
'Traditional model'	Complete order structure (no ties)	True criterion	No threshold
'Traditional model'	Complete pre-order structure (ties)	True criterion	No threshold
'Threshold model'	Semiorder structure	Semi-criterion	Indifference threshold (constant)
'Variable threshold model'	Interval structure	Interval-criterion	Indifference threshold (variable)
'Double threshold model'	Pseudo order structure	Pseudo-criterion	Indifference and preference thresholds

Table 5.3 Different preference modelling

Linkov *et al*. (2004) have described that preference and indifference thresholds are introduced for each criterion to avoid exaggerating the importance of small differences in performance. The indifference threshold is the difference beneath which a decion maker has no preference, a difference that is too small to be used as a basis of distinction between the two. The preference threshold is the difference above which the decion maker strongly prefers one management alternative to another. Between the indifference and preference threshold, weak (or fuzzy) preferences may be represented by any number of mathematical interpolation functions such as linear, stepwise, or Gaussian.

Furthermore, the indifference threshold can be defined either with respect to the **uncertainty** of the criteria values or as a threshold at which the differences become perceptible to decision makers (Rogers and Bruen 1998[b] in Kangas *et al*. 2001).

Maystre *et al*. (1994) have defined the indifference threshold as the minimum margin of uncertainty, and the preference threshold as the maximum margin of uncertainty with respect to different criteria. Thus, the preference threshold implies that there is no doubt that a certain alternative is better than the other. However, there are no right values for the thresholds, or even a right way to define them.

5.4 MCDA in the forest sector

For many years Operational Research (OR) has supported long, medium, and short term planning in the forest sector (Martell *et al*., 1998). The following paragraphs provide a brief description of different applications. More references on multicriteria methods in the forest sector and natural resource management are found in de Steiguer *et al*. (2002).

Large term planning

Strategic management planning models apply to parcels of land or management units that can be large (thousand of hectares) over planning horizons that can san centuries. Problems are related to land use, development strategies, and regional planning.

For example, Espelta *et al*. (2003) have evaluated with NAIADE reforestation methods in central Catalonia. Kangas *et al*. (2001) have reviewed the use of outranking methods (ELECTRE and PROMETHEE) in Strategic Natural Resources Planning. Besides, Bojórquez-Tapia *et al*. (2004) have presented a land suitability assessment approach for designing the Sierra San Pedro Mártir

National Park, Baja California, Mexico, where AHP has been implemented to facilitate debates among experts.

Medium term planning

Management models for medium term deal with the problems related to a regional management in limited period of time. Here it can be considered: the harvest rotation, management of accessibility to the territory, integration of different productive systems, creation of infrastructure, integration in management of different natural resources.

For example, see Lexer *et al*. (2005), Huth *et al*. (2005), Huth *et al*. (2004), Leskinen *et al*. (2003), Riedl *et al*. (2000), Tecle *et al*. (1988) and Romero *et al*. (1998).

Short term planning

Problems related to short term forest operations of forests and natural resources, which include problems such as the selection and location of harvesting machinery, the selection of units of harvest, the selection of tree stem bucking patterns to use in each unit, the allocation of logs to destinations to satisfy demand, and management of the transportation system. For examples, see Steuer and Schuler (1978), Liu (2001) and Nhantumbo *et al*. (2001).

As described in Martell *et al*. (1998), other issues in which OR have been used is fire management. However, the issues related to massive spatial and temporal hierarchies (considering the social, economic and ecological dimensions with different scales), planning under uncertainty and community forestry needs have also been addressed.

In the last years, one of the fields which has gained importance in the forest sector is assessment of **sustainable forest management** (Wolfslehner *et al*., 2005; Sheppard and Meitner, 2005; Mendoza and Prabhu, 2005, 2003, 2000; Wolfslehner *et al*., 2003; Brang *et al*., 2002; Varma *et al*., 2000). Then, initial efforts in this field have been presented in Prabhu *et al*. (1998, 1999[a], 1999[b]), along with the guidelines for selecting criteria and indicators for sustainable forest management and applying multicriteria analysis. Moreover, Wolfslehner (2006) has analysed the potential and limitation of multicriteria methods in assessing sustainable forest management.

A recent review of multicriteria approach in supporting forest management has been presented in Kangas and Kangas (2005). They have described that the multiple criteria comparisons of alternative forest plans can be divided into three main stages: (a) the production of several alternative plans and selection of a few to be examined; (b) evaluation of the selected alternatives in regard to each individual form of use, function, or criterion of significance in the planning and decision making process; and (c) the comprehensive comparison of the alternative plans considering a criteria set for the forest area. These authors also have concluded that multiple criteria decision methods can not replace traditional forest planning but **complement** each other.

Finally, Diaz-Balteiro and Romero (2007) have compiled an exhaustive list of Multi-Criteria Decision Making (MCDM) applications in the forest sector. They have concluded that there are

areas like harvest scheduling and biodiversity conservation, where Multi-Criteria Decision Making (MCDM) applications have reached a certain level of maturity. However, future developments are expected for the sustainability and group decision-making areas.

5.5 MCDA for the Rio Conventions

This section provides some applications of multicriteria methods in the context of the Rio Conventions. In general, for the Rio Conventions, the multicriteria approach is suggested as tool for developing action plans, such as the NAPA, NAPS, and NBSAPS. For instance, in the context of the UNFCCC, guidelines for the use of the multicriteria approach while developing the NAPA are provided (UNFCCC, 2005[c]; Broersma *et al*., 2004; UNFCCC, 2002[d]).

In the biodiversity field, Moffett and Sarkar (2006) have provided a review of multicriteria decision methods that may potentially be used during systematic conservation planning for the design of conservation area networks (CANs). In this context, most common methods used are the multiple attribute value theory (MAVT) and Analytic Hierarchy Process (AHP). Besides, they have concluded that several methods can potentially be usefully deployed in conservation planning have either never been used (Regime, ELECTRE III, PROMETHE I) or used very rarely (NDS computation, Goal Programming). Furthermore, Reyers *et al*. (2002) have used a multicriteria approach to reserve selection, which brings a step closer to ensure the long-term maintenance of biodiversity within conservation areas. Besides, Wood and Dragicevic (2007) have described how to identify priority locations for future marine protection through the use of a GIS-based multicriteria evaluation framework.

In the climate field, at **international** level, a study of equity in international greenhouse gases abatement scenarios, where PROMETHEE method is used, has been presented (Vaillancourt and Waaub, 2004). They have concluded that multicriterion decision aid approach is suited to compare regions or countries by considering their own characteristics, their perceptions of equity and the different economic, social, and environmental stakes. Besides, the analysis brings a better understanding of the equity issues and leads to relevant conclusions being able to feed the international negotiations in finding **compromise** solutions.

At **national** level, Bell *et al*. (2001) claimed that multicriteria methods are potentially useful for understanding trade-offs and evaluating risks associated with climate policy alternatives. Methods compared in this study included value and utility functions, goal programming, ELECTRE, fuzzy sets, stochastic dominance, min max regret, and several weight selection methods. Moreover, Georgopoulou *et al*. (2003) have used a multiple criteria decision aid approach by investigating ELECTRE TRI through its application in the case study in Greece. This study has defined national

priorities for a National Action Plan for GHG mitigation in the energy sector and formulates a relevant time schedule for actions implementation.

Then, Borges and Villavicencio (2004) have illustrated how the inclusion of MCDA assessment in national greenhouse abatement costing studies can, without departing from the established analysis framework, be a pretext to provide a process which enhances stakeholder participation, validation and ownership of the planning process. Such a process was used in a national study in Peru.

Finally, the Egypt National Strategy Study (NSS) on Clean Development Mechanism (CDM) has also performed a multicriteria analysis based on an initial screening for suitable projects covering all sectors of the economy, but focussing on those with the highest GHG emission reduction potential, e.g. energy generation, renewable energy applications, transportation, energy efficiency in industry, and LULUCF (UNEP, 2004[b]).

At **project** level, in the UNFCCC and CDM contexts, general finding from applying any of the sustainability assessment tools (e.g. multicriteria) to CDM projects is that trade-offs exist between the two objectives of the CDM in favour of cost-effective reductions of GHG (Olsen, 2005). Also, Halsnaes and Markandya (2002) have applied a multicriteria approach for case studies in forestry project options in Brazil and energy options in India.

Moreover, Begg *et al*. (2003) have used a multicriteria decision analysis for assessing the sustainability benefits delivered by the projects in Kenya, Tanzania, and Ghana. In addition, Sutter (2003) has proposed sustainability Check-Up for CDM energy projects through MATA-CDM, which allows compensations between the different criteria and is based on the theoretical frame of **Multi-Attributive Utility Theory** (MAUT). In this work case studies were done in South Africa, India, and Uruguay.

In the forest sector, Brown and Corbera (2003[a], [b]) have proposed a multicriteria exercise to evaluate 16 qualitative and quantitative indicators reflecting carbon sequestration, ecological conservation, and social development criteria using a set of qualitative techniques, ranking, qualitative scales, and percentage weighting. They have found that by discussing criteria and indicators with different stakeholders and seeking their priorities and preferences through scoring and ranking exercises, their interests, views, and roles could be explored.

After, going through different application of MCDA methods in the context of the Rio Conventions, in most cases the attempt is to evaluate social, economic, and environmental issues. However, their definition as well as criteria and indicators and concrete methodologies to address them, for example throughout the project cycle, have turned out to be highly challenging and intensively debated subject matters (Madlener *et al*., 2003).

5.6 Conclusions

In this chapter, focus has been given to the different multicriteria methods used for environmental decision situations. Moreover, the author of this research has considered useful to provide a detail description for methods which are commonly used such as the AHP, PROMETHEE, and ELECTRE methods. Advantages and disadvantages are inherent to the different multicriteria methods. However, a crucial step in a **decision aiding process** is to select a method in a decision situation context. In that case, a decision problem (choice, rank or sort) is clearly defined (problem statement) and a multicriteria method can be selected.

Through the description of the multicriteria methods (AHP, PROMETHEE and ELECTRE), the author of this research has evidenced the type of information which is needed to implement them. On one hand, AHP is a unique synthesis criterion approach, which requires parameters such as criteria and alternative that are assessed with a pairwaise comparison. AHP can become exhausting if many alternatives are evaluated, however a method predominantly used these days. On the other hand, PROMETHEE and ELECTRE are outranking methods, which require also preferential information, such as the weights, thresholds, etc. The advantage of these methods is that they make models realistic. For instance, thresholds are normally used in human decision, hence they should be included in a decision process, even more information is required for the model.

In the forest sector, the author of this research has emphasized the important role of Operational Research in planning at different scales (long, medium and short term). In general, in the last 30 years, the forest sector has been characterised for the use of the unique synthesis criterion (e.g. AHP) and interactive (goal programming) approach. However, new situations are evolving in the forest sector. Therefore multicriteria methods have the challenge to face and solve complex decisions, such as the assessment of forest sustainable development.

In the context of the Rio Conventions, different applications of multicriteria methods are presented. In general, for preparing national action plans under the Rio Conventions, the multicriteria approach has been suggested. However, when gathering for applications of multicriteria methods, most references in the climate field (UNFCCC) were found. Policies, projects, and emission scenarios have been evaluated with different multicriteria methods (ELECTRE, PROMETHEE, MAUT, etc).

Another important issue is the **compensatory** concept of MCDA methods, which refers to the existence of **trade-offs**. There are some MCDA methods such as the ELECTRE family methods that are not totally compensatory between the performance of alternatives on the criteria, and accept incomparabilities, which are managed by proposing pessimistic and optimistic approaches. Besides, for environmental decision situations, the compensatory concept is of interest. Thus, it is rather significant to go for **non-compensatory** MCDA methods, which can make **strong** sustainability operative (section 4.5). For the purpose of this research, ELECTRE TRI method has been chosen in a specific decision aiding process. Further justifications and validation is provided in Chapter 7.

CHAPTER 6: FORESTRY DECISION CRITERIA

This chapter describes how decision criteria, in particular, forestry decision criteria have been constructed. Criteria characteristics and the validation procedure are presented.

6.1 Introduction

Decision criteria are used in different ways. Sometimes criteria are just a set of indicators used as a checklist, in other situations there are well-established set of criteria that institutions use. Finally, decision criteria can also be used together with preferential information with aggregation methods, such as the multicriteria methods.

In a decision aiding process, the construction of decision criteria is one of the expected activities of the process. Constructing criteria represents a crucial stage since it often generates dialog with the decision maker, thus plays a significant communication role in the decision process. Moreover, the effectiveness of the decision process is highly dependent on the way in which this stage is conducted (Azibi and Vaderpooten, 2003).

The first step in constructing criteria is the recognition of the different points of view which are relevant to the decision situation. The following section is devoted to the illustration of criteria characteristics. Furthermore, since only some information which describes the construction of environmental decision criteria was found, the author of this research feels the importance of describing the strategy on how forestry decision criteria were constructed in a specific decision aiding situation (see Chapter 7).

Furthermore, to get a better understanding of decision criteria, in the specific framework of synergies among the Rio Conventions, an analysis of forestry decision criteria was carried out. In order to achieve this goal, a multivariate statistical analysis and an *ad hoc* survey has been carried out. This analysis allows the finding of specific patterns in the obtained answers as it evaluates together information arising from more than one variable, both quantitative and qualitative.

In this chapter, the author aims to describe basic elements, which are needed for the construction of forestry decision criteria. Afterwards, these criteria are used in Chapter 7 for assessing synergies at project level in the forestry sector.

6.2 Criteria characteristics

In the decision aiding process, different points of view are collected when defining the problem formulation. Then a set of criteria (*familiy of criteria*), which highlight these points of views are required during the evaluation model. These points of views represent the different axes along which the various actors of the decision process **justify**, **transform,** and **argue** their preferences (Bana e Costa and Vincke, 1990; Bouyssou, 1990). In particular, the author of this research claims that most environmental problems, if not all of them are multiple criteria decision situations. Hence, the multicriteria approach is a useful tool for the assessment of environmental decision problems.

Criteria construction ***(g)*** relies on the evaluation of consequences generated by the execution of the alternatives, and these consequences are structured according to the different points of view (Azibi and Vaderpooten, 2003). The choice of a particular point of view allows us to give a concrete meaning to the numbers ***g***, given the nature of the various consequences which are considered. Therefore, the definition of the number criteria implies the introduction either of a unit connected to the point of view (dollars spent, time gained, miles covered, etc), or of successive levels on a qualitative scale (a hindrance difficult to bear, a hindrance to which one becomes quickly accustomed, neither good nor bad, rather nice on the whole, exceptionally comfortable) (Roy and Bouyssou, 1991). Furthermore, in order to deal with **imprecision**, **uncertainty** and **inaccurate** determination in the construction of a criterion, discrimination **thresholds** are useful tools (see also section 5.3.3).

For the multicriteria approach a **family of criteria** is needed. However, this family is helpful only if it possesses a number of consistency properties (e.g, exhaustiveness, non-redundancy), is intelligible to the different actors that are involved in the decision process, and accepted by them as the basis of their work.

Furthermore, the family of criteria should have two important qualities (Bouyssou, 1990): *legibility*, which means that the family should contain a sufficiently small number of criteria so as to be a discussion basis allowing the analyst to assess inter-criteria information necessary for the implementation of an aggregation procedure, and *operationality*, which means that the family should be considered by all actors as a sound basis for the continuation of the decision aiding process.

Some of these qualities and properties have also been addressed by Dodgson *et al*. (2000), who have proposed the consideration of the following qualities for the final choice of criteria:

a) *Completeness*, include all important criteria necessary to compare the performance of all the options. Criteria need to capture all the key aspects of the objectives that are the point of the MCDA.

b) *Redundancy*, criteria that have been judged relatively unimportant or to be duplicates should have been removed at a very early stage, but it is good practice to check again.

c) *Operationality*, important that each option can be judged against each criterion. The assessment may be objective, with respect to some commonly shared and understood scale of measurement, like weight or distance.

d) *Mutual independence of preferences*, straightforward applications require that preferences associated with the consequences of the options are independent of each other from one criterion to the next.

e) *Size*, an excessive number of criteria leads to extra analytical effort in assessing input data and can make communication of the analysis more difficult. A final check to ensure that the structure is no lager than it needs to be is useful at this stage.

6.3 Forestry decision criteria

In section 6.2, basic definitions and characteristics of criteria have been presented. Now, attention is given to describe the construction and understanding of the importance of forestry decision criteria.

6.3.1 Construction of criteria

The construction of criteria is crucial problem of which the solution depends on the art and experience (Bouyssou, 1990). Since, a criterion is a model which allows establishing preference relations between alternatives (see also 5.3.3), the quality of the construction of this model is crucial for the **quality** of decision aid.

For the multicriteria approach, the construction of criteria applying sophisticated aggregation procedures is important, but it is of little use if the criteria have been built in an unconvincing way (Bouyssou, 1990). On the other hand, criteria are strategic and should reflect the values and important considerations of both the stakeholder groups and the best scientific knowledge available (Maness, 2005).

For this research, the purpose is to construct a set of forestry decision criteria capable of assessing synergies among the Rio Conventions at project level. Later, in Chapter 7 these criteria which are part of a decision aiding process are used.

6.3.2 Strategy

For this research, a set of forestry decision criteria have been **selected**, taking into account characteristics for assessing synergies at project level. Afterwards, a validation process with forestry experts was implemented. In this section the steps followed to obtain the forestry decision criteria are described.

The author of this research has emphasized on the selection of criteria in this particular context of assessing synergies, and has given experts the task of validating already defined criteria. Then, the work of gathering and processing information related to synergies among the Rio Conventions, sustainable development criteria and forestry projects have been carried out by the analyst (researcher). In other situations, it is possible to let the decision maker to choose criteria, for instance in a local context. Toman *et al*. (1994) have described an iterative process for stakeholder involvement in determining indicators.

Elements for the selection of decision criteria were not only collected from bibliographic and specific research, but have also considered information from the interview processes of this research. Therefore, the author completely agrees with the statement presented in Munda (2005) who describes that the rough material collected during interviews and focus groups could be used as a

source of inspiration but the technical formulation of criteria having properties is job of the researcher.

In particular, for constructing and selecting a set of forestry decision criteria, which could evaluate international forestry projects in the context of synergies among the Rio Conventions, the following items were considered:

ITEM 1. Analysis of ecosystem services in order to learn and recognise crucial elements of the forestry sector (see also Chapter 3). A comparative matrix with the aim to identify ecosystem services relevant at local and global level has been developed as an initial step (see section 3.3.4). After this step, mainly environmental and social aspects have been recognised, but if considering sustainable development as basic for exploring synergies, a detail analysis of the three dimensions (social, economic and environmental) is needed.

ITEM 2. Identification of past and present experience working with sustainable development criteria. During this research different methodologies for assessing sustainability has been found, those mostly used are checklists and guidelines. At this time, the multicriteria approach was also identified (see Chapter 4 and Chapter 5).

ITEM 3. Select appropriate forestry criteria, suitable for a project level assessment in the context of synergies, taking into account already published information (see Box 6.1).

ITEM 4. Complementary information has been used for selecting criteria, such as case studies, experience in forestry projects and objectives/principles from the Rio Conventions. In particular, lack or deficiencies have been identified from case studies.

ITEM 5. Verify the compatibility of forestry criteria which have been selected. This has been done with the different international processes on criteria in the forestry sector (CIFOR, MCPFE, ITTO, Montreal Process, and FSC).

As described in this section, the departure point has considered an analysis of the forestry sector and the multiple ecosystem services. Next, the sustainable development concept apply to the assessment of projects has been studied.

The selection of criteria have been complemented with information coming from case studies and experience in forestry projects. Moreover, the selection is focused at project level and on synergies among the Rio Conventions topic. A final verification of criteria was done with already existing forestry criteria processes, in order to make sure that the selected criteria are compatible with the forestry context. References which have been chosen for this research and which have guided the selection of forestry decision criteria are shown in Box 6.1. All these items, which are listed, represent points of views and aspects that are connected. Therefore, the selection procedure has gone back and forth from one item to the other, before selecting the final decision criteria.

In conclusion, the author of this research has attempted to select the most important aspects needed when assessing synergies at forestry project level. For that reason, forest multiple services,

sustainable development concept and synergies among the Rio Conventions topics were kept in mind. The role of the author in the selection of criteria is to filter information and to converge with a minimum number of criteria, which can give much information in a defined decision situation.

Steps	References
Item 1: Ecosystem services	Zilberman *et al*., 2006; Hein *et al*., 2006; MA, 2005[c],[d]; IUCN, 2005[b]; IUCN *et al*., 2005; Katila and Puustjärvi, 2004; Curtis, 2004; FAO, 2003; Farber *et al*., 2002; De Groot *et al*., 2002; Powell *et al*., 2002; Wilson and Howarth, 2002; Pagiola and Platais, 2002; Johnson *et al*., 2001.
Item 2: Sustainable development	JBIC, 2007; Gold Standard, 2006; CCBA, 2005; Olsen, 2005; Pembina, 2005, 2004, 2003; Omann, 2004; Salgado, 2004; Reid *et al*., 2004; UNEP, 2004[a],[b]; Sutter, 2003; Begg *et al*., 2003; Beg *et al*., 2002; Halsnaes and Markandya, 2002; Kolshus *et al*., 2001; SSN, 1999; GEF, 2000; WRI, 1999; Stork *et al*., 1997.
Item 3: Forestry sector	Sell *et al*., 2006; Madlener *et al*., 2006; FAO, 2006[a],[b]; World Bank, 2005; Both End, 2005; Pearson, 2005 [a],[b]; MA, 2005[f],[g]; FAO, 2005[b]; Grieg-Gran *et al*., 2005; Perugini, 2005; Scherr *et al*., 2004, 2002; FAO, 2004[a]; Cavatassi, 2004; UBA, 2004[b]; Mendoza and Prabhu, 2003, 2000; Smith and Scherr, 2003, 2002; Lamb, 2003; Brown and Corbera, 2003[a],[b]; Corbera and Zepeda, 2003; Gouyon, 2003; Rojas and Aylward, 2003; Madlener *et al*., 2003; Aune, 2003; Appanah, 2003; Whitten *et al*., 2003; Landell-Mills and Porras, 2002; Brang *et al*., 2002; GEF, 2002; Smith and Applegate, 2002; Dykstra, 2002; Pearce, 2001; SCBD, 2001; FAO, 2001; Ecologic, 2001; Muhtaman *et al*., 2000; Davis, 2000; Vine *et al*., 1999; Prabhu *et al*., 1999[a]; Schroeder *et al*., 1993; FAO, 1992; Zimmermann, 1992.
Item 4: Synergies and case studies	SCBD, 2006; Saint-Laurent, 2005; Maness, 2005; Xiang and Meehan, 2005; UNEP/CBD, 2005[b],[c]; Chidiak *et al*., 2004; GEF, 2004; UBA, 2004[a]; UNEP/CBD, 2004[c]; UNFCCC, 2004[a]; UNCCD/CBD, 2004; Kim, 2004; Schlaepfer *et al*., 2004; UNEP/CBD, 2003, [a],[b]; Caparros and Jacquemont, 2003; Totten *et al*., 2003; SCBD, 2003; UNFCCC, 2002[c]; OECD/DAC, 2002; IPCC, 2002; UNEP/CBD/AHTEG-BDCC, 2001; Tarasofsky and Oberthuer, 2001; Kimball, 2001; UBA, 2001; Lal, 2001; Rosendal, 2001; Oberthur, 2001; UBA, 2000; Glowka, 2000; Walsh, 1999; Kimball, 1997; Greenspan Bell, 1997; Jorgensen, 1997.
Item 5: Verification	MCPFE, 2005; FSC, 2004; Ritchie *et al*., 2000; CIFOR, 1999; Prabhu *et al*., 1999 [a],[b]; Prabhu *et al*., 1998.

Box 6.1 References used for selecting forestry decision criteria

6.3.3 Decision criteria

After addressing different items for the selection of forestry decision criteria, two levels of criteria were defined: macro and micro criteria. On one hand, macro criteria have considered the basic dimensions of sustainable development (social, economic and environmental), which is also a common topic for the Rio Conventions. On the other hand, micro criteria have considered specific forestry related-criteria, which have been classified under the macro criteria.

Attention has been given to the selection of micro criteria with the aim to capture crucial elements such as the objectives and principles of the Rio Conventions, and characteristics of the forestry sector, which means considering local and global interests on criteria. Furthermore, the aim of criteria is not only to represent different point of views, but also to make possible the differentiation among the alternatives (e.g. projects) which need to be evaluated.

After the selection procedure, 15 criteria have been identified: 5 social, 4 economic and 6 environmental. The number of criteria for each set of macro criteria is not the same, and it could be attributed to the complex type of situation, where synergies among the Rio Conventions at project level need to be explored (see Table 6.1).

Forestry decision criteria	
Macro	**Micro**
Social	Land tenure Equitably share natural resources/benefits of development Skill development Ensure strong local participation Spiritual value maintenance
Economic	Employment Financial returns to local entities Infrastructure Financial forestry incentives
Environmental	Use of native species being encouraged Conservation and maintenance of soil resource Conservation and maintenance of water resource Biodiversity conservation Flood prevention/protection Average carbon benefit

Table 6.1 Forestry decision criteria

6.3.4 Criteria importance

After establishing a set of criteria it is relevant to establish their importance (also known as weight). In this section, some initial information on the relative importance of criteria is given.

Just to evidence how different users and interests are present in the forestry sector, MA (2005[g]) has presented a matrix giving information on the groups in a tropical forest and the relative importance they attribute to forest services (see Table 6.2).

This matrix shows an analysis that goes further than the one in section 3.3.4, where only local and global interest on ecosystem services have been identified. Moreover, methods to elicit the relative importance of decision criteria vary according to the methods which are used or the different aggregation procedures (Bouyssou *et al.*, 2000). Later on, information and discussion on the elicitation of the weights parameter are described for a specific decision aiding process in Chapter 7 (see section 7.3.2.)

User group	Freshwater yield	Fuel	Timber and pulp	NWFP	Biodiversity	Amenities	Carbon storage
Local communities	5	5	3	4	2	4	2
Loggers	2	4	5	2	1	2	2
Downstream users:							
Cities	4	3	4	3	2	4	2
Agriculture	5	4	3	4	3	3	1
Industry	3	2	5	1	0	1	1
Timber traders	1	3	5	3	0	0	1
National	5	4	4	3	4	4	3
Global	3	4	3	4	5	3	3

5- crucial; 4- very important; 3- important; 2- moderately important; 1-sporadic use; 0-not used

Table 6.2 Services provided by tropical forests and woodlands to various user groups

On the other hand, when dealing with different stakeholders, interests should be considered, but also other information, such as the dependence on forest, use of the forestry, issues of concern, and knowledge/participation.

In Table 6.3, a stakeholder matrix useful for social analysis in natural resource management projects is presented (World Bank, 2005). This matrix evidences the individuals and groups that have an interest or a "stake" in decisions affecting resources management in the project area. From one hand, timber sales can provide valuable revenue for countries. Then, local communities seek to improve their lives and are therefore willing to trade in their forests. Moreover, there is the ecological value that is inherent to forests. In the forestry sector, there are conflicts between those who want to protect native forests and those who cut trees for economic purposes (JBIC, 2007).

Stakeholder group	Dependence on forest	Use of forest	Top issue of concern	Knowledge and participation
General population	Heavy	Wood fuel& sales, food construction	Low income, unemployment, transport	Low
Poorest	Greatest	Fuel wood	Low income, unemployment, transport	Lowest
Middle poor	Heavy	Wood cutting and selling fuel wood	Low income, unemployment, transport	Medium
Least Poor	Least heavy	Buying fuel wood	Electricity and health care	Higher
Loggers	Heavy	Logging		
Environmental organizations	Heavy	Issue cause	Forest degradation	Highest knowledge, some exclusion
Hunters	Light	Hunting		
Government	Heavy	Responsibility budget	Licensing restriction, nature, preserves and privatisation, decentralization and budget enforcement	Mixed
National agencies	Heavy	Responsibility budget		Mixed
Municipal agencies	Heavy	Responsibility		Mixed
Local employees	Heavy	Responsibility brides		Mixed

Table 6.3 Stakeholders interests in the forestry sector

6.4 Criteria validation procedure

After setting forestry decision criteria, a validation process has been carried out. Then, a **questionnaire** (*ad hoc* survey) was used for validation, where forestry experts were involved.

A questionnaire can be used directly to ask experts a set of criteria for a certain decision problem (see Sell *et al*., 2006). The only disadvantage can be the allocation of the large amount of criteria in some criteria, but of course the advantage is that decision makers are directly expressing their preference in designating criteria. Alternatively, a questionnaire can be used to validate already defined criteria. The disadvantage could be that the experts are influenced by the defined criteria, which are proposed to them. The advantage of this procedure for complex situations is that you give the expert the task of validating defined criteria, and the researcher is in charge of studying in depth the problem situation before selecting the criteria.

The process of validation was requested by the decision maker involved in the decision aiding process (see Chapter 7; section 7.2). Therefore, for the purpose of this research, it has been decided together with the decision maker to use the second approach, in which defined criteria are proposed to forestry experts. Then, through this approach the author has tried to find an agreement among experts on the forestry decision criteria used for the assessment of synergies at project level.

Furthermore, since experts from different parts of the world were involved in this validation process, the approach of sending them a questionnaire by e-mail with defined criteria, giving them also the possibility to add a criterion if necessary, was implemented. Once more, each method for validating criteria depends very much on the characteristics of the problem situation, on participants involved, and on the request of the decision maker, thus depends in the decision situation.

6.4.1 Participants

The questionnaire was used for validating forestry decision criteria, involving two groups of active participants who follow the "Rio Conventions" and UNFF process. In this context, policymakers and scientists, which play a significant role in the international processes, have been contacted. Thus, those who make decisions from the government (ministry, agency, etc.) and technicians (University, Centre, or Research institutions) were involved.

After collecting data from experts and preparing a database, different groups of participants were contacted (for analysis purposes a denomination is given to each group of participants):

- Experts or *Ad hoc* groups from the "Rio Conventions", the secretariats from CBD, UNFCCC and UNCCD were contacted. In this group, participants from the AHTEG on biodiversity and climate change, AHTEG in forestry, roster of independent experts on forestry from CCD, experts from afforestation/reforestation from the UNFCCC were identified (*Rio Conventions*).

- A second group consists in participants from the two workshops on synergies (Finland and Viterbo), organised by the "Rio Conventions", and the Workshop on Deforestation organised by FAO in 2006 (*Workshops*).
- A third group was represented by forestry institutions, experts from institutions such as CIFOR, ICRAF among others were contacted (*Forestry institutions*).
- A fourth group of forestry experts was contacted after the field interview in Peru. This last group includes most of the stakeholders related to the forestry sector in Peru such as the environmental authority, research institutions, NGO, ministry of agriculture, environmental funds, university, and international cooperation (*Field visit*).
- At last, an e-mail was sent to the *Forest Policy Info Mailing List,* inviting forestry experts for contributions (*Forestry-Mailing List*).

During the process of contacting participants, different problems were found with e-mail addresses because a large number of them were not updated.

6.4.2 The questionnaire

The aim of the questionnaire was to validate a set of defined forestry criteria for assessing synergies in international forestry projects. Moreover, participants were also asked to provide the importance of forestry criteria, thus further information on criteria could be gathered and analysed.

Between September 2006 and January 2007, forestry experts were invited to participate to a questionnaire, thus an e-mail with an invitation letter and questionnaire were sent. An English and Spanish version of the questionnaire was prepared. After the first invitation, one remainder was sent to all participants.

The questionnaire has 5 sections which included: instructions, data from participants, general information on how criteria were selected, questionnaire on criteria (macro and micro), and description of criteria.

Simple and clear instructions on how to fill the questionnaire were provided. Also information related to participants was requested (country and the type of institution), in order to further analyse decision criteria (see section 6.5). The general information section provides information on the aim of the questionnaire, the type of projects that will be evaluated, how criteria were selected, and the objectives of the Rio Conventions.

The questionnaire section included four queries with space for comments (see Appendix 8). Fifteen (15) defined criteria were proposed (see section 6.3.3; Table 6.1), and if necessary participants were asked to add additional criteria ("Other – specify").

The last section of the questionnaire contains the description of the forestry criteria, in this way participants had information on criteria. In Table 6.4 the description of each forestry micro criteria is presented.

In the questionnaire, the importance of macro and micro forestry criteria were requested to participants (expressed in percentage, %), in this way preferences are captured directly (see Appendix 8). Information on macro criteria was given separately and the sum of the percentage was set in 100%. Moreover, information on micro criteria was asked in query 3, and the sum of each set of micro criteria (grouped in macro criteria) was set in 100%.

In the context in which the questionnaire took place, information on the importance of forestry criteria was requested in percentage. Therefore, a hierarchy procedure was proposed to participants. Moreover, through this procedure it was facilitated the elicitation of weights and was easily understood. In this way, forestry experts were quickly involved in the problem.

In the forestry sector, different publications with studies related to the importance of criteria are available (Hujala *et al*., 2007; Hujala and Leskinen, 2006; Sheppard and Meitner, 2005; Wolfslehner *et al*., 2005; Mendoza and Prabhu, 2003, 2000; Brown and Corbera, 2003[a],]b]; Ananda and Herath, 2003). In particular, Hujala and Leskinen (2006) have tested direct capturing of preferences with interval and ratio scales in the forestry sector. Besides, Hujala *et al*. (2007) have recommended that when not using pairwise comparisons, it might be useful to apply at least two direct rating techniques in order to acquire more reliable knowledge of the decision maker's preference.

6.5 Results from questionnaire process

In this section, results from the questionnaire are described. The first section provides general information on participants (6.5.1) and in the last two sections (6.5.2 and 6.5.3) the multivariate analysis has been used for analysing and describing information collected from the questionnaire.

6.5.1 General information

Response rate

The number of participants, who responded to the questionnaire is 97 (rate of response approximately 24%). For a descriptive purpose, participants have been classified by continent and group of participants (see Table 6.5).

The highest response rates came from participants of *Americas* (47%) and *Europe* (24%), followed by participants from *Africa* (11%) and *Asia* (15%). Fifty-eight (58%) percent were scientists and forty-two (42%) were policymakers.

Forestry decision criteria		Description
Social	Land tenure	Increased land/resource tenure security where deals results in the formalisation of land tenure to minimise risks
	Equitably share natural resources/benefits of development	Equitable share natural resources and benefits of development
	Skill development	Provision of sustained technical assistance including technical sessions in tree planting and plantation maintenance; creation of tree nurseries and on the environmental and social requirements related to sound carbon sequestration activities. Other related fields, sustainable forestry forest-based industries, ecotourism, project management
	Ensure strong local participation	The encouragement of participatory and democratic decision making. In particular the involvement of local stakeholders in decisions about the on-site project objectives
	Spiritual value maintenance	Protection of forest-based cultural heritage
Economic	Employment	Many options offer enhanced employment opportunities in key, underdeveloped regions or among key social group. Generation of local employment opportunities
	Financial returns to local entities	Provide financial returns to local entities
	Infrastructure	Improved infrastructure associated with market development (example, research facilities, transport, communications)
	Financial forestry incentives	Select the most suitable compensation mechanism
Environmental	Use of native species being encouraged	Species that are native to a region will have a higher biodiversity benefit than non-native species. Show that the project will only use species that are native to the region. Afforestation and Reforestation planned with native and mixed tree species
	Conservation and maintenance of soil resource	Projects should enhance the quality and quantity of soil resources
	Conservation and maintenance of water resource	Projects should enhance the quality and quantity of water resources
	Biodiversity conservation	Species and habitat conservation. Sustainable forest management offers benefits (respect tree density; logging practices; low impact harvesting methods, clearing of existing vegetation is minimised, multi-specie planting encouraged, rotation lengths are extended, natural regeneration being encouraged)
	Flood prevention/protection	Afforestation in river basins could prevent and control flooding risks
	Average carbon benefit	Average carbon benefit tonnes C per ha, for example, the carbon benefit from plantations are measured as the difference between the carbon stock plantation and the carbon stock of degraded land

Table 6.4 Description of the criteria for the questionnaire process

Besides, response from 44 different countries were received and represented: *Africa* (9) Central African Republic, Ghana, Lesotho, Kenya, Mozambique, Tunisia, Morocco, Congo and Madagascar; *Americas* (12): Dominican Republic, Canada, Mexico, Cuba, United States, Colombia, Honduras, Peru, Nicaragua, Brazil, Chile, and Uruguay; *Asia* (8): Lebanon, Indonesia, India, China, Japan, Pakistan, Armenia and Yemen; *Europe* (14): Austria, Czech Republic, Germany, Italy, Greece, Finland, Spain, Denmark, Romania, Sweden, Belgium, United Kingdom, Poland and the Netherlands; and *Oceania* (1): New Zeeland.

Continent	N. participants	N. Policy makers	N. scientists
Africa	11	5	6
Americas	46	20	26
Asia	15	6	9
Europe	23	10	13
Oceania	2	0	2
Total	**97**	***41***	***56***

Table 6.5 Number of participants by continent and type of group

Forty-one percent of countries participating in this study are from the top 10 countries with the largest forest area as reported in the Forest Resource Assessment 2005 (FAO (2006[a]).

Finally, information related to the "MEAs that participants follow" was obtained: 46% follow one Convention or UNFF process, 23% follow two Conventions or a Rio Convention and the UNFF process, 23% follow the Rio Conventions or two Rio Conventions and the UNFF process, 6% follow the Rio Conventions and UNFF process, and 2% did not follow a convention or process. Other international processes which were referred are: CITES, Ramsar Convention, Millennium goals, Montreal Protocol, UNCSD, and ITTO. Afterwards, these qualitative variables are analysed in section 6.5.

Forestry macro criteria

Descriptive statistics

The first step in the statistical analysis of the collected data use frequency graphics. The synthesis of qualitative or quantitative data is done by building frequency distribution. For the specific case of the variables used, the continuous variables are discretized by defining appropriate values intervals, from this values classification frequencies are evaluated (Camussi *et al*., 1995).

The frequency distribution of the importance attributed to social, economic, and environmental macro criteria, for the evaluation of forestry projects, is shown in Figure 6.1. The classes have been defined on the survey results. Therefore, the variable range has been divided in 7 classes, and extreme classes change every 10%. It is clear that a large number of participants (44 participants) have given more relevance to the environmental criterion, corresponding to class ≤40%, instead for the social (40 participants) and economic (39 participants) criteria, relevance relies in ≤30% class.

Furthermore, descriptive statistics allows us to summarize quantitative variables, by identifying an index or measure that can reflect as much as possible information or at least essential information (Camussi *et al*., 1995). This information can be represented by some characteristic points from the variable distribution, such as the mode, median, mean, other information are related to the shape of the distribution, the symmetry, and kurtosis. In particular, through a Chi-square, it has been found that social, environmental, and economic macro criteria can be described by a Gaussian distribution.

Estimated means, variance and ANOVA

The One-Way ANOVA tests the hypothesis that the means of two or more groups are not significantly different. One assumption of ANOVA is that the variances of the groups are equivalent; therefore, the homogeneity of variance test has been performed.

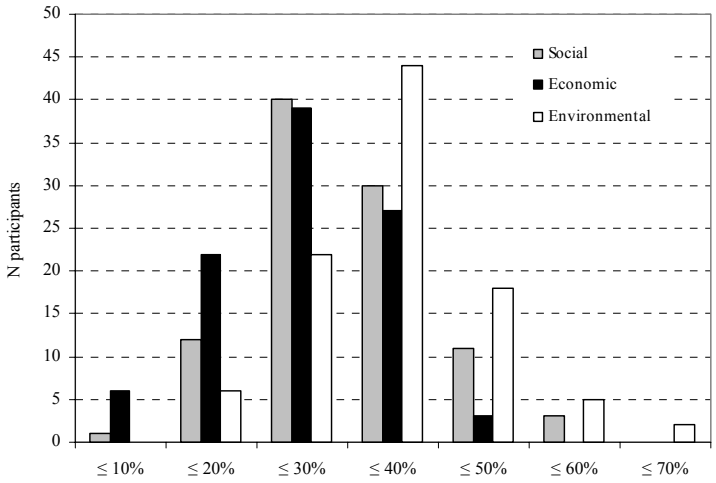


Figure 6.1 Frequency of response from participants

Different groups and estimated means from participants, expressed in percentage, are shown in Figure 6.2. As described in section 6.4.1, five groups account for 97 forestry experts: the *Rio Conventions* group (total n. 23), *Workshop* group (total n.18), *Forestry institutions* group (total n.18), *Forest- Mailing List* group (total n.28), and *Field Visit (Peru)* group (total n.10).

A test of homogeneity of variance shows that variances are similar among the groups for the social and economic criteria, but are different for the environmental criterion. The one-way ANOVA shows that there is no difference between the means of the groups for the social (*df*=4, F=1.874, sig=0.122) and economic criteria (*df*=4, F=0.814, sig=0.519), but there is difference for the environmental criterion (*df*=4, F=4.201, sig=0.004).

Then, with the Tukey multiple comparison for the environmental criteria, the pair of groups which differ were identified: *Rio Conventions* and *Forestry institutions*, and *Rio Conventions* and *Forest Mailing List*. From this analysis, initial results coming from the frequency response are verified, where the environmental criterion has got higher importance. Moreover, it can be initially stated that the *Rio Conventions* group, which is related to environmental agreements, has given more importance to the environmental criterion, instead forestry experts balance the assignment of importance to criteria.

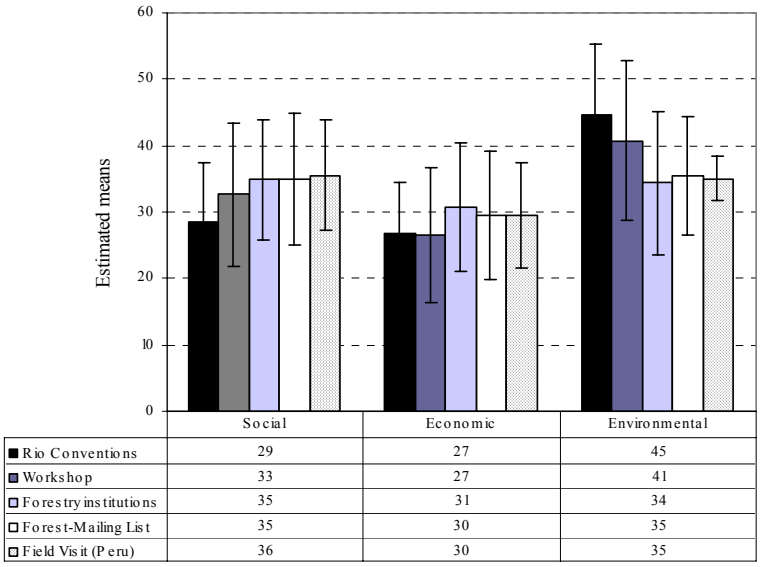


Figure 6.2 Estimated means from the different group of participants (%)

Different continents and estimated means, expressed in percentage, are shown in Figure 6.3. For this analysis the following number of participants was considered: *Africa* (total n. 11), *Americas* (total n. 46), *Asia* (total n. 15) and *Europe* (total n. 23).

The test of homogeneity of variance shows that variance of the continents are similar for the 3 macro criteria. The one-way ANOVA shows that there is no difference between the means for the social criterion (*df*=3, F=0.94, sig=0.42). On the other hand, there is difference between means for the economic (*df*=3, F=3.16, sig=0.03) and environmental (*df*=3, F=5.22, sig=0.002) criteria.

With the Tukey multiple comparison, differences between pair of groups do not differ for the economic criterion. But for the environmental criterion the pair of continents which differ are: *Africa-Europe*, and *Americas-Europe.*

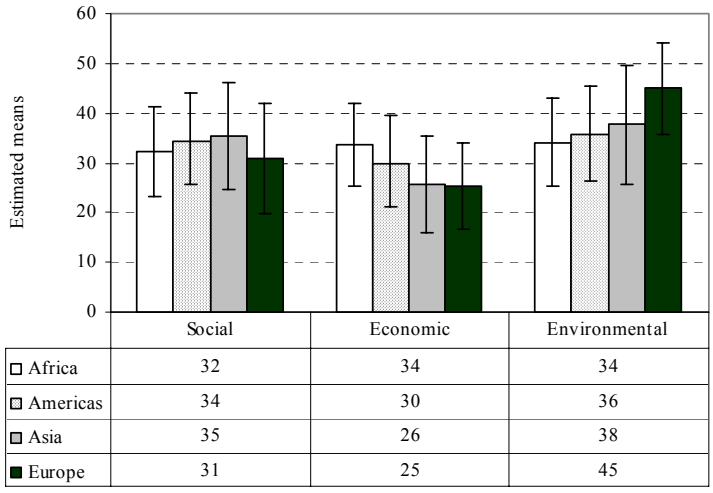
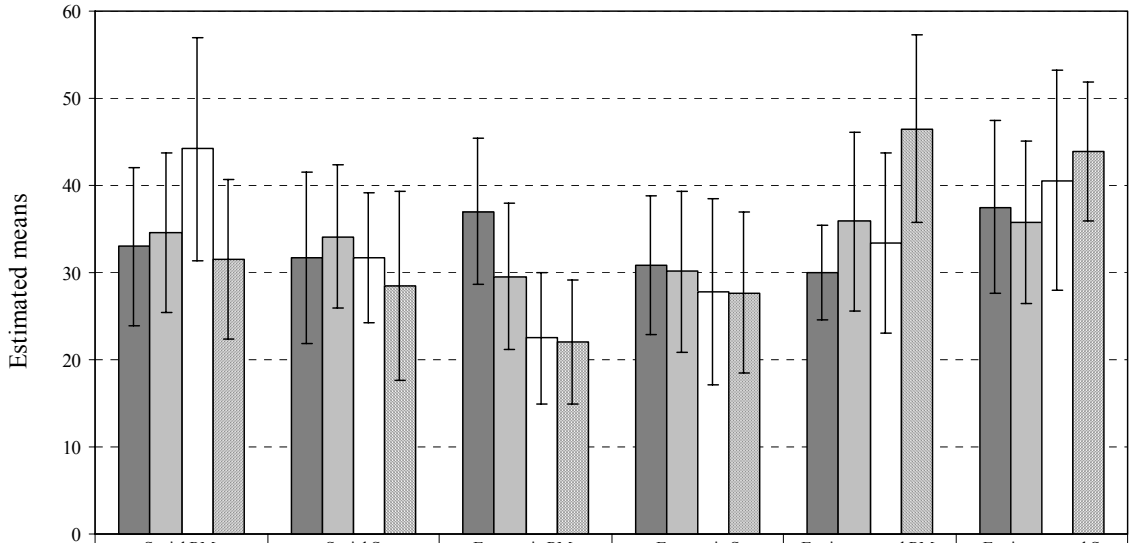


Figure 6.3 Estimated means from the different continents (%)

Finally, an analysis with the active actors, policymakers and scientists, was carried out. Response from actors classified by continents, expressed in percentage, is shown in Figure 6.4.

A test of homogeneity of variance shows that variance of the different groups of continents and actors are similar for the 3 macro criteria. The one-way ANOVA for the *scientists'* category shows there is no difference among criteria, instead for the *policymakers'* category shows that there is difference between means for the 3 macro criteria.

For this last category, the Tukey multiple comparisons identified the pair of groups which differ for the economic criterion: *Africa-Asia*, and *Africa-Europe*, and for the environmental criterion: *Africa-Europe*. Again with these results it can be initially stated that *scientists* balance the importance of macro criteria compared to those assigned from *policymakers*. In general, *policymakers* have provided higher importance to the social and environmental criteria, and *scientists* have given higher importance to the environmental criterion.



	Social PM	Social S	Economic PM	Economic S	Environmental PM	Environmental S
Africa	33	32	37	31	30	38
Americas	35	34	30	30	36	36
Asia	44	32	23	28	33	41
Europe	32	28	22	28	47	44

Figure 6.4 Estimated means from the different actors classified by continent (%)

Forestry micro criteria

There were two possibilities for analysing micro criteria data. The first was to consider micro criteria as direct response from participants, and the second was to transform data, multiplying the weight of the micro criteria by its corresponding macro weight.

For this research, the second option was followed, because in this way is possible the comparison among criteria (social, economic and environmental). Estimated means, expressed in percentage, are presented in Appendix 9. During the analysis, 18 micro criteria were considered, 15 defined criteria plus those suggested by participants. These additional criteria were named: other social, environmental, and economic criteria.

A ranking of the forestry micro criteria has been reported in Figure 6.5 (see Appendix 9). Through this ranking, 12 forestry criteria have been initially identified as relevant among continents, and they go from financial returns to local entities (bottom) to skill development (top). Besides, the five criteria with the highest means among continents are financial returns to local entities, ensure strong local participation, employment, equitably share/benefits development and conservation and maintenance of water (data available, Appendix 9).

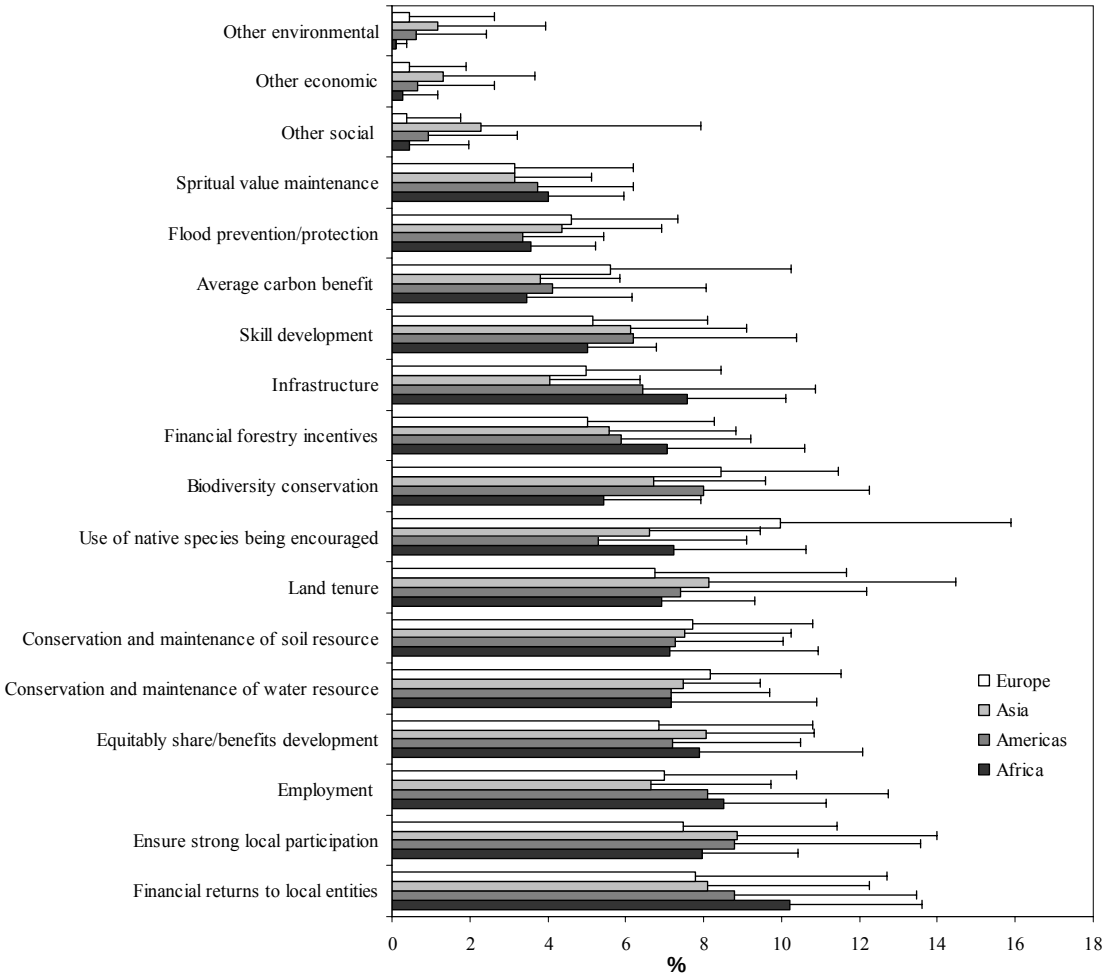


Figure 6.5 Criteria mean (%) and one-sided standard deviation

On the contrary, considering the top-5 criteria by continent (see Box 6.2), regional characteristics, and interests are reflected. For instance, in *Africa* the top-5 criteria include economic and social criteria, in *America* and *Asia* importance is also given to the environmental criteria, such as biodiversity conservation and conservation and maintenance of soil resource, respectively. Finally, for *Europe* top 5-criteria are mainly environmental criteria.

Few response has been obtained for the additional criteria (propose by participant). However, the author has considered relevant to further analyse them in the following section.

Ranking of forestry micro criteria by continent	
African group: 1° Financial returns to local entities (E2) 2° Employment (E1) 3° Ensure strong local participation (S4) 4° Equitably share/benefits development (S2) 5° Infrastructure (E3)	**Americas group:** 1° Ensure strong local participation (S4) 2° Financial returns to local entities (E2) 3° Employment (E1) 4° Biodiversity conservation (A4) 5° Land tenure (S1)
Asian group: 1° Ensure strong local participation (S4) 2° Land tenure (S1) 3° Financial returns to local entities (E2) 4° Equitably share/benefits development (S2) 5° Conservation and maintenance of soil resource (A2)	**European group:** 1° Use of native species being encouraged (A1) 2° Biodiversity conservation (A4) 3° Conservation and maintenance of water resource (A3) 4° Financial returns to local entities (E2) 5° Conservation and maintenance of soil resource (A2)

Box 6.2 Top-5 criteria by continent

Additional micro criteria analysis

The rate of response from a total of 97 experts for additional forestry criteria have been of 16%, 13% and 11%, for the social, economic and environmental additional criteria, respectively. For this section, only those participants which gave a response for the additional criteria were analysed.

Through the frequency distribution by class, most participants (63%) have given importance less or equal to 5% for this additional criteria. The list of the additional forestry criteria, which have been proposed by participants, are shown in Appendix 10.

Most additional criteria are linked to the continent provenance. For instance, additional **social** criteria, from the *Americas* group, gender and rights have been pointed out, instead from the *Africa* and *Asia* groups, food security and policy issues have been indicated.

Additional **economic** criteria, which have been indicated, for example from the *Africa* group, are related to equity on trade and market for environmental services; from the *Americas* group, to economic diversification and incentives, from the *Asia* group, to product oriented criteria; and from the *Europe* group, to bioenergy and economic sustainability.

Finally, for additional **environmental** criteria, which have been indicated, from the *Africa* group, are related to EIA, land use change and fire prevention; from *Americas* and *Asia* to combat desertification.

6.5.2 Correlation among forestry criteria

Factor Analysis (FA) is mainly applied for **data reduction** or **structure detection**. FA is often used to identify a small number of factors that explain most of the observed variability in a larger number of manifest variables (data reduction).

FA attempts to identify underlying patterns, or factors, that explain the correlations within a set of observed variables (structure detection). Two important things have to be considered. First the data, variables should be quantitative at the interval or ratio level. Second, the assumptions, data are supposed to have a bivariate normal distribution for each pair of variables, and observations should

be independent. Further information on FA can be found in Fabbris (1997), Manly (1994), and Beroggi (1999).

For the purpose of this research, SPSS for windows has been used. Relevant steps are described in Appendix 11. For this analysis, the response from all participants was considered (97 experts).

The correlation (structure detection) between forestry micro criteria, have been performed with factor analysis using the Principal Component Analysis and Varimax rotation. Through this analysis, 18 criteria were analysed. Moreover, two considerations were applied before using FA: a) to those criteria without response the value zero has been associated, and b) forestry micro criteria have been multiplied by their corresponding macro criteria (see section 6.5.1 – forestry micro criteria).

The screen plot with the eigenvalues and factors (component numbers) is shown in Appendix 12. Before determining the number of factors used for the FA, an analysis with different factors (8, 7, 6, 5, and 4) was carried out (see Appendix 13). Consequently, five factors, which explain 49.7% of the variance, were used for the analysis.

Factors and correlation among forestry criteria are show in Table 6.6. Only criteria with correlation values above 0.5 were selected (in grey). Then, factors can be characterised according to the criteria which have been selected, thus:

Factor 1 is associated to environmental and economic criteria, but negative correlation factors were also indentified. For example, a participant who tends to give high scores to the environmental criteria (*conservation and maintenance of water* and *soil resources*) tends to give low scores to the economic criteria (*financial forestry incentives* and *infrastructure*).

Factor 2 is mainly characterised by social and environmental criteria, while *land tenure* and *equitable share* are negatively correlated to *flood prevention* and *average carbon benefit*.

Factors 3 are associated to social and economic criteria, while *financial returns to local entities* is negatively correlated to *local participation* and *spiritual value maintenance*.

Factors 4 represent social, economic, and environmental criteria, while *employment* and *native species* negatively correlated to *spiritual value maintenance*.

Factors 5 is characterised by the additional criteria suggested by participants.

In general, each factor contains a set of criteria which are positively and negatively correlated. Moreover, factors contain a combination of criteria: economic-environmental criteria (Factor 1), social-environmental criteria (Factor 2), social-economic criteria (Factor 3), and social-environmental-economic (Factor 4).

Through the factor analysis and previous statistical analysis (frequency, descriptive, ANOVA), correlation of forestry criteria, and importance of criteria have been obtained, respectively. A first conclusion is that importance of criteria is mainly attributed to the provenance

of participants, similar results were presented in Sell *et al* (2006). Moreover, the correlation analysis makes evident the different interest of participants with regard to the defined micro criteria. But, probably other variables are playing a role in the response from participants. Consequently, in the next section, a Multiple Correspondence Analysis (MCA) was performed.

Through this questionnaire and analysis of results, the author of this research can conclude that the importance of criteria when evaluating forestry project are focused on different aspects from forests. Kangas and Kangas (2005) have described that criteria other than those related to wood production have been given more and more weight in the choice of management alternatives. In other words, forests are being used simultaneously for multiple purposes.

Criteria	Factors				
	1	2	3	4	5
Land tenure	-0.05	-0.69	-0.15	-0.05	-0.11
Equitably share natural resources/benefits development	-0.16	-0.55	0.07	0.23	-0.23
Skill development	-0.21	0.02	0.71	0.08	-0.20
Ensure strong local participation	0.02	-0.09	0.86	-0.07	-0.11
Spiritual value maintenance	0.20	-0.09	0.00	0.57	0.10
Other social criteria	-0.04	-0.22	-0.06	0.26	0.21
Employment	-0.20	0.04	0.00	-0.61	0.11
Financial returns to local entities	-0.40	-0.11	-0.53	-0.20	-0.34
Infrastructure	-0.53	0.17	-0.04	0.44	0.21
Financial forestry incentives	-0.54	0.12	0.00	-0.03	0.52
Other economic criteria	0.03	0.07	-0.05	-0.05	0.57
Use of native species being encouraged	0.28	0.01	-0.18	-0.56	-0.01
Conservation and maintenance of soil resource	0.73	0.09	-0.11	0.04	0.09
Conservation and maintenance of water resource	0.80	0.18	0.02	0.11	0.03
Biodiversity conservation	0.46	0.29	-0.01	0.28	0.12
Flood prevention/protection	0.24	0.50	-0.07	0.40	-0.39
Average carbon benefit	-0.02	0.65	-0.28	-0.16	-0.31
Other environmental criteria	0.05	-0.05	-0.10	0.10	0.50
Variance (%)	15.0	10.6	8.8	8.0	7.3

Table 6.6 Rotated matrix for forestry micro criteria

6.5.3 Description of the relationship of nominal variables

The objective of the Multiple Correspondence Analysis (MCA) is the description of the relationship which exists between **nominal** variables (qualitative information). For further information see Fabbris (1997).

Moreover, it is possible to describe the relationship between the categories of each variable. For each variable, the distance in a graphic between the points of the categories reflects the relationship among the categories, with similar categories represented one near to another one. The projection of the points from one variable over the vector from the origin till the point of category of the other variable, describe the relation among the two variables.

Besides, the MCA can analyse non-linear relationships, unlikely the factor analysis. On the other hand, the FA allows seeing the relationship which exists between variables in a space of few dimensions, requires interval data and the number of observations should be five times the number of variables. However, the MCA assumes that variables are nominal and allow describing the

relation among the categories of each variable, as well as the relation among variables. Further information on MCA is found in Appendix 14.

For the correspondence analysis, SPSS for windows and SPAD have been employed. SPSS has been used to get initial statistical information (e.g. data loss, frequency, quartiles) and to prepare data useful for the SPAD. The MCA was carried out with SPAD.

For this analysis the response of 95 participants was considered, and only 15 defined forestry criteria (additional criteria were excluded) were used. Besides, data from criteria was the same as the one used for the FA. From the questionnaire, **quantitative** and **qualitative** information was obtained. Quantitative information comes from the importance attributed to forestry criteria; instead, qualitative information are the 5 groups of participants, the actors (*policymakers* and *scientists*), the "MEAs that participants follow", and the continent provenance.

For the MCA, quantitative information has been transformed (label) into nominal variables with its categories (modalities), and was done thanks to the quartiles information obtained with SPSS software. Modalities, were designated low (B), medium-low (MB), medium-high (MA) and high (A). At the end, the MCA allows us to transform all the variables under a unique classification, therefore, only qualitative data was used.

Data transformed in SPSS have been exported to SPAD, where the final MCA was implemented. The method which has been selected in SPAD: Factor analysis (*Analyses factorielles*) and Multiple correspondence analysis (*Correspondances multiples -CORMU*). The MCA can graphically represent the interactions between modalities.

During the analysis, **nominal actives** and **nominal illustrative** variables were selected and exchange. Then, for the graphical representation, nominal active variables which included groups, actors, conventions and continents was found to be more useful for the MCA analysis. Information on the modalities was obtained through several graphics and excel files executed with SPAD. Moreover, characterization of the axis (coordinate) and the contribution of each modality are obtained. The most relevant representation of the nominal active variables is shown in Figure 6.6. Other graphics which have been used for interpreting results from the MCA are shown Appendix 16.

Through the representation it has been found that the **continents** and the **actors** discriminate variables, since they are clearly differentiated in the various quadrants. Then, the **groups** and the **convention** variables are still left. But from the representations, they can be considered as not discriminating variables. For instance, the group *Workshop* has a higher contribution for Axis 1 and the "F" (follow the UNFCC convention) is near to Axis 1. This is obvious because most of the participants in the workshop follow the UNFCCC convention. Another, example is the *Forestry*

institutions group ("For. I") and *Asia* continent that are near to Axis 1. Again most participants coming from *Asia* are part of *Forestry institutions*. At the end before, coming to this last conclusion, different combination of Axis have been displayed with SPAD (e.g. Axis 1-3, Axis 1-4, etc.).

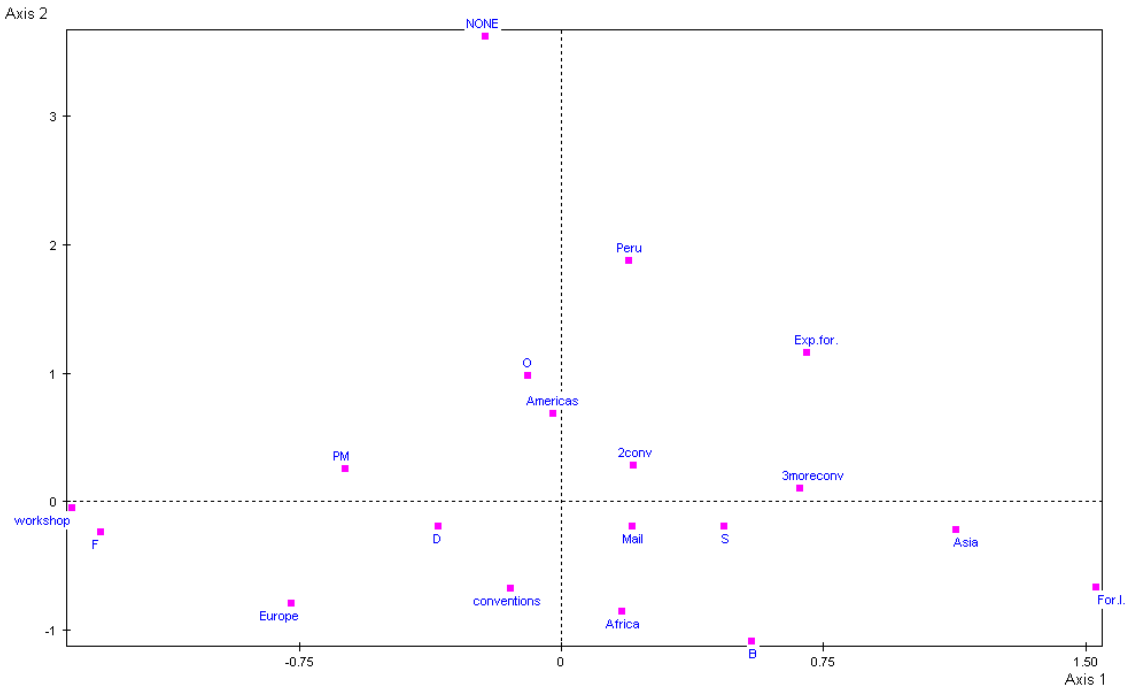


Figure 6.6 Graphical representation of the nominal active variables

Afterwards, nominal illustrative variables (forestry criteria information) with its different modalities have been projected onto the nominal active variables (groups, actors, conventions, and continents) plain. Representations which have been obtained are shown in Appendix 16. For a better and clear representation nominal active variables have been represented separately with the set of social, economic, and environmental criteria.

Regarding the social and economic criteria represented together with the nominal active variables, there is not a clear definition of the different modalities with respect to the continent variable. But for the environmental criterion, the representation makes evident that high modalities have been given by participants from *Europe*.

6.6 Conclusions

This chapter has attempted to describe a crucial aspect of a decision aiding process, which is the identification of **decision criteria,** which are later on used in the multicriteria evaluation model. Therefore, the author of this research wants to remark that the selection and validation has been done for a specific decision aiding process which aims to assess synergies at forestry project level (see Chapter 7).

The author has found useful for the whole decision aiding process to describe and present the **strategy** which has been used to select forestry decision criteria. Besides, in a context where experts' involved are from different regions of the world, a questionnaire process has been convenient and effective for validating the selected criteria. On one hand, the validation task has been given to forestry experts. On the other hand, the work of gathering and processing information for the selection of criteria has been carried out by the author of this research. Therefore, the role of the author was to **filter** information and to **converge** with a sufficient number of decision criteria.
With information obtained from the questionnaire further analysis were undertaken (multivariate analysis). Hence, the questionnaire has made possible to better understand forestry decision criteria, providing further insight in the decision problem and giving the opportunity to go through a learning process.

Through the Factor Analysis (FA), positive and negative correlations among forestry criteria have been found. Moreover, the FA has evidenced a correlation characteristic of forestry criteria, information which could be useful to get when using multicriteria methods (see section 7.3.2). The Multiple Correspondence Analysis (MCA) has identified variables, such as the actor (*policymaker* and *scientists*) and continents (Africa, Americas, Africa, and Asia), with discriminating ability with respect to the response from participant on forestry decision criteria. Results obtained with the MCA, verify and complement information obtained with the FA, and has also supported the whole decision aiding process. Consequently, information obtained from this chapter is used for model evaluation that is presented in Chapter 7.

The author of this research can also conclude that because of the complex situation in which decision criteria have been identified, the use of more than one multivariate analysis (FA and MCA), might be helpful in order to acquire information on decision criteria. At the same, this information con contribute to improve the quality of the decision aiding process.

CHAPTER 7. FORESTRY DECISION AIDING PROCESS FOR ASSESSING SYNERGIES AT PROJECT LEVEL

This chapter attempts to convey different aspects addressed in previous chapters, and a specific decision aiding process is described. Moreover, the application of the multicriteria approach in the context of synergies among the Rio Conventions at forestry project level.

7.1 Introduction

This research starts with a general background, where synergies among the Rio Conventions at different levels of implementation are described. Through this process, the need for exploring methodologies or tools to assess synergies at local level was identified (Chapter 2). Then, a chapter has been dedicated to describe the forestry sector for further exploring synergies among the Rio Conventions (Chapter 3). Afterwards, the scientific framework of this research and application examples have been described (Chapter 4 and Chapter 5).

Theoretically, the characteristics of the multicriteria approach have been explored and described. Therefore, the approach can be useful and appropriate for environmental problem situations, in particular, for exploring synergies in the forestry sector. On the other hand, different aspects such as the concept of compromise solution (see section 4.4.5) and applications to a sustainable development concept (see section 4.5) have been addressed.

Afterwards, a complete chapter has been devoted to describe how forestry decision criteria were constructed, as part of a whole decision aiding process which is described in this chapter. Forestry decision criteria contain different dimensions of sustainability, such as social, economic and environmental; thus, they make possible the assessment of international forestry project in the context of synergies among the Rio Conventions.

In this chapter, the author wants to emphasise a whole decision aiding process which has been triggered for assessing synergies. Not all decision aiding activities have been object of scientific investigation and among the ones not for which it has been the case not all of them are founded on the use of abstract[33] and formal[34] model (Tsoukiàs, 2007). The chapter describes a decision aiding process, which has allowed the assessment of synergies at forestry project level.

[33] Abstract because independent from the specific domain for which the decision aiding has been asked (Tsoukias, 200/)
[34] Formal because aimed at reducing the ambiguity inherent to human communication (Watzlawick et al. 1967 in Tsokias, 2007).

7.2 Forestry decision aiding process

7.2.1 Decision aiding process

In this section, the author describes a specific environmental decision situation. This research started by asking how to contribute to the implementation of synergies among the Rio Conventions. This process has as initial framework a global context (Rio Conventions: UNFCCC, CBD and UNCCD), and at this level, the necessity for methodologies or tools which can assess synergies have been identified (see Chapter 2). Therefore, a decision aiding process was triggered. A preliminary discussion of the decision aiding process was presented in Cóndor *et al*. (2007[a], [b]).

Together with the decision maker (or client) the focus of the decision process was defined at forestry project level. The description of the decision aiding process activities has supported the organization of information obtained by the author during this research. In section 4.3, the concepts of a decision aiding process are described.

For this decision aiding process, the decision maker was the Director of DISAFRI (University of Tuscia), who is involved in the Rio Convention process and interested to assess synergies at project level.

Problem situation

Participants in this process were directly and indirectly involved. The direct participant was the decision maker (or client), the person who asked for support. Instead, indirect participants were forestry experts (national and international), which were also interested in the assessment of synergies among the Rio Conventions.

Furthermore, the client is not necessarily the decision maker, but for instance an adviser to the decision maker. Then, a client is not necessarily an individual, but could be a collective body (a body of directors, a committee, a group of experts) (Bouyssou *et al*., 2006).

Interests in the decision problem are associated with the objectives and principles from the Rio Conventions, having as a cross-cutting thematic the forestry sector. Moreover, two types of interests were identified: i) a global interest, link to the Rio Conventions aims; and ii) local interest, link to a specific sectoral interest (forestry sector).

The resources assigned in the process are linked to the knowledge obtained from interaction with experts from different sectors (forestry, synergies, ecosystem services, projects evaluation). For instance, forestry experts involved in the questionnaire and in the personal interviews (see Appendix 5).

Problem formulation

For this decision process, a group of international forestry project was chosen as alternatives for evaluation. Then, the different points of view are related to those from the Rio Conventions: the stabilization of GHG emissions (UNFCCC), sustainable use of natural resource (CBD), and combat desertification (UNCCD). Moreover, the different forestry ecosystem services and sustainable development themes are cross-cutting issues, which have been considered.

The problem statement has been discussed with the decision maker, and for this purpose, different decision problems were presented (choose, rank or sort) (see section 4.4.3). During the discussion, the author together with the decision maker identified as appropriate to **sort forestry projects** for assessing synergies among the Rio Conventions.

In this process, the decision maker recognised that between the rank and sort of projects, the aim of assessing synergies could be probably reached through sorting projects into pre-defined categories, where categories are defined by norms. Moreover, the decision maker has recognised that ranking allows answering an operational request, for instance, an amount of funds for projects, where probably a ranking of project to finance is needed. But ranking is independent of the appropriateness of the project; the selection should be done anyway.

On the other hand, through sorting, the alternative is evaluated on all criteria with respect to the profiles (pre-determined) and assigned to the categories. For instane, these categories could include projects which are more or less synergistic. Furthermore, sorting deals with an **absolute** evaluation, then the projects are judged on the **intrinsic** desirability. Therefore, projects are not compared among them, as it is done with ranking or choosing decision problems.

All these elements have reinforced the interest of the decision maker and the author of this research to sort international forestry projects.

Evaluation model

The initial set of alternatives (projects) which have been selected are those available in the UNFCCC web site. The reason for selecting these projects is that they are publicly available and they have a unique format for describing the project (called Project Design Document – PDD).

On the other hand, social, economic, and environmental, are aspects of sustainable development under which alternatives (forestry projects) are evaluated in this decision aiding process. Afterwards, as requested by the decision maker, a set of defined forestry decision criteria, selected for the assessment of forestry projects in the context of synergies among the Rio Conventions, were validated through a questionnaire process (see Chapter 6).

Then, for each forestry decision criteria, a specific set of indicators was developed (see section 7.2.3). The set of indicators are qualitative, therefore, can be considered flexible [35]. Moreover, qualitative indicators are able to evaluate projects from different regions of the world.

[35] Simone Rose. 2007. Personal communication/interview. Forestry expert from FAO – criteria. September 2007.

ELECTRE TRI method has been selected to elaborate the solution of the problem (see section 5.2.2 and 5.3). The selection of the method has been discussed with the decision maker, who agreed to use it and was also interested in understanding the use of the method. Bouyssou *et al*. (2000) have claimed that the ideal decision analyst should master several methodologies for building a model, the method has to be **accepted** in a particular decision situation; this means that the questions asked to the decision maker must make sense and should not be asked for information that is unable to provide in a reliable manner. In this context, other multicriteria methods have also been tested and shown to the decision maker (AHP, PROMETHEE, and ELECTRE III).

There are several reasons for using ELECTRE TRI method. In general ELECTRE methods are the oldest and simplest outranking method, and decision situations such as choice, ranking and sorting can be solved with the ELECTRE family methods (see section 5.2.5). This characteristic of the ELECTRE methods have been useful for showing the different problem statements proposed to the decision maker.

Further logical validation for ELECTRE TRI method is described in section 7.5. In general, characteristics of ELECTRE TRI method, such as the possibility to assign projects to pre-defined categories, use ordinal scales, independent alternatives, thresholds, veto, deals with incomparabilities and the aggregation of conflicting and numerous criteria, are some of the reasons for using this multicriteria method.

Final recommendation

The final recommendations are linked to the results which are obtained with the evaluation model. Before giving recommendations, a sensitivity analysis was done and a final interaction with a policy maker took place. Final results are presented in section 7.4.

Regarding, legitimation of the recommendation with respect to context of this decision process, there has been an *internal legitimation*, with the group directly involved in the process, and an *external legitimation*, with other people which one is interested to convince.

7.2.2 Representation of the process

In this section a graphical representation of the decision situation is presented (Figure 7.1). The first discussion of the representation was presented in EURO 22nd Conference at Prague (Cóndor *et al*., 2007[b]).

The representation has allowed a better interaction between the decision maker and the researcher. Moreover, the scales of interest are evidenced (global and local), and they can be described as a peculiarity of this decision problem where synergies among the Rio Convention have been assessed.

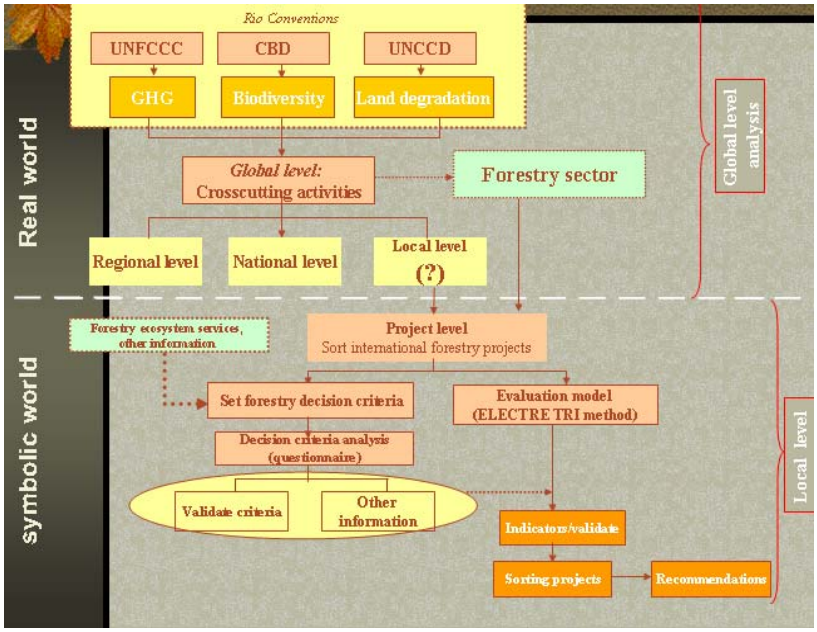


Figure 7.1 Representation of the decision aiding process

7.2.3 Forestry indicators for assessing synergies

As described in Chapter 6, a set of defined criteria for assessing synergies at project level has been validated through a questionnaire, as requested by the decision maker. To make criteria operational, indicators with an ordinal scale for evaluating projects has been proposed. These indicators have been developed considering the information available from forestry projects (PDD). Afterwards, a second validation process, through personal interviews, was carried out with forestry experts. Comments and suggestions received from experts have been considered for improving indicators (see Appendix 18).

During the interview process, 13 criteria with their indicators were presented. Besides, an ordinal scale of evaluation was developed for indicators (Appendix 17). Each scale value is linked to a specific description that is useful while assessing forestry projects. A description of criteria and indicators is shown in Table 7.1. Normally, ordinal scales are described with ELECTRE methods while using qualitative indicators (see Arondel and Girardin, 2000; Srinivasa Raju *et al.*, 2000).

The validation procedure consists in contacting some national and international forestry experts. National experts are linked to field international forestry projects (n° 6 participants) and international experts working at FAO Forestry Department (n° 5 participants). The interviews took place between June and October 2007, lasting between 30-40 minutes. Moreover, a power point support was used for presenting the decision problem and scale of evaluation (see Appendix 17).

Subsequent to the results obtained in Chapter 6 (forestry decision criteria), the author of this research has proposed for validation 13 criteria, which includes the first 12 criteria from the ranking (see section 6.5.1), and the "carbon average benefit" criterion. However, during the interview process, forestry experts agreed to use only 12 decision criteria for evaluating international forestry projects.

Criteria	Indicators	Description
Land tenure	• Clear defined land tenure • Long term land tenure • Achieve land tenure with the project	Land tenure indicators refer to the clear definition described in the project, term, and achievement of land tenure. Better score is given to those projects in which land tenure is clearly defined and described.
Equitably share natural resources/benefits of development	Different stakeholders which take advantage of the project	Equitable share is related to the amount of local stakeholders which are able to benefit from the project. The indicator is linked to the number and type of stakeholders. Guidelines are provided for the different stakeholders who can be involved (NGO, local government, farmers, community, etc.).
Skill development	Skill development of project stakeholders	Skill development indicator refers to the quality of the activities that are undertaken in the project. In particular, the indicator looks for the development of practical experience (field experience). Therefore, a better score is given to projects which describe a training programme instead of those which tackle punctual issues as training activities.
Ensure strong local participation	Stakeholder participation in project activities	Local participation, this indicator wants to evaluate the level of participation, considering that already local participation is in place. Therefore, more score is given to those projects which have implemented or are planning to implement participatory process.
Employment	• Direct and indirect employment for local people • Term of the employment	Employment indicator is linked to the type of employment. Therefore, direct and indirect local employments have been considered, but also importance has been given to the term of employment.
Financial returns to local entities	Financial returns through diversification of local economy	Financial returns, this indicator is linked to forest and agricultural products that ensure returns to local entities, through the diversification of the economy.
Infrastructure	Impact of new physical infrastructure in the project implementation area	Infrastructure is an indicator which considers the impact of new physical infrastructure in forestry projects. A scale proposed by Zimmermann (1992) has been used.
Financial forestry incentives	Define financial forestry incentives in the project	Forestry incentives, is an indicator that considers the definition of different incentives for forestry projects. In particular, this indicator is related to what the project can offer; therefore, incentives related to different environmental services (not only carbon sequestration) and other types are evaluated.
Use of native species being encouraged	Define the use of native species and/or exotic species	Native species indicator considers the clear argumentation for the use of native and exotic species in forestry projects. A higher score is given to projects which encourage only the use of native species.
Conservation and maintenance of soil resource	Procedures to conserve and maintain soils (during the project)	Soil resource indicator considers the adoption and definition in the project of procedures to conserve and maintain soils during the implementation of the project.
Conservation and maintenance of water resource	Procedures to conserve and maintain water resources	Water resource indicator considers the adoption and definition in the project of procedures to conserve and maintain water resources during the implementation of the project.
Biodiversity conservation	Diversity of composition of forest plantations	Biodiversity indicator considers the other two levels of biodiversity (except for specie): genetic and population, for evaluating forestry projects. Moreover, higher score is given to those projects which encourage biodiversity (corridors, etc).

Table 7.1 Description of indicators for assessment of forestry projects

Munda (2005) has described that anonymous questionnaires and personal interviews are an essential part of the participatory process. These tools were useful for this forestry decision process. Furthermore, the number of experts interviewed was found to be enough for the validation process, and after a certain number of experts' interviews, an agreement on the scale of evaluation and indicators description was reached.

On the other hand, there are two aspects to highlight from this process. First, experts were able to identify specific aspect for improvements, and second that there were no contradictions among them. In conclusion, the author of this research has found necessary and useful to ensure the quality of the decision aiding process through the interaction with a team of experts with experience on forestry projects.

7.3 Assessing synergies at project level

This section describes the evaluation model from this decision aiding process, where synergies were assessed at forestry project level.

7.3.1 Multi Criteria Sorting Method

For the decision aiding process, the ELECTRE TRI software was used for aggregating information (see section 5.3). ELECTRE TRI is a Multi Criteria Sorting Method (MCSM).

The evaluation model assigns alternatives to pre-defined categories; which mean that forestry projects are sorted into 3 categories for this specific decision aiding process. Bouyssou *et al*. (2000) have claimed that the aggregation procedures included in an evaluation model are choices that have to be carefully studied and justified; thus the validation of ELECTRE TRI method is further described in section 7.4.

For ELECTRE TRI method different parameters such as alternatives (forestry projects), criteria (forestry criteria), importance coefficients, profiles, thresholds (indifference, preference, and veto thresholds), and cutting level are required.

7.3.2. Model information

In this section information needed for the evaluation model is presented, such as the criteria, alternatives and preference information parameters (importance coefficients, thresholds and category profiles, lambda cutting level). Parameters allow adapting to some extent a rigid mathematical model, taking the values or preferences into account (Bouyssou *et al*., 2006). However, there is always discussion on how to obtain appropriate parameters. Therefore, these issues are discussed in the following paragraphs.

Dias and Climaco (1999) have claimed that it is unrealistic to make the decision maker determine the value of each parameter, and then the combination of values for the parameters should be seen as a <u>working hypothesis</u> which allows the decision process to advance. Moreover, Dias and Climaco (1999) have argued that demanding less information to decision maker is a way to encourage a faster (yet more confident) decision process, at the cost of providing intervals as results, instead of precise values.

For this research, the author has attempted to use information obtained from the questionnaire and interview processes, as working hypothesis for assessing synergies at forestry project level.

Criteria and indicators

According to results from the questionnaire (see section 6.5.1) and the last interview process (see section 7.2.3), twelve (12) forestry criteria were selected (see Table 7.2). However, the "infrastructure" criterion has not been used, because not enough information could be obtained from the projects. Therefore, eleven (11) forestry criteria have been used for the evaluation model.

In this context, Mousseau *et al*. (2000) have claimed that the different phases for defining an assignment model interact. For example, during the assignment of alternatives, one may find the need for a criterion or when evaluating alternatives more specific indicators are required. The author of this research has found, while evaluating projects, that a clear and a specific description of the indicators was needed. Moreover, these indicators have been improved also during the process of the project evaluation.

In natural resources management, descriptive expressions instead of quantitative measures and qualitative or ordinal information are frequently faced, on the contrary to most decision-aid methods (Kangas *et al*., 2001). Moreover, Kangas and Kangas (2005) have concluded that ordinal statements may reflect the true preferences better than exact cardinal values.

The direction of preference information needed for computing the partial concordance and discordance index for decision criteria can be decreasing or increasing. For this research, the 11 decision criteria have an increasing direction, which means that the highest the evaluation, the better the alternative. Equations which are used for computing the ELECTRE indexes are shown in Appendix 19.

The author has considered useful to identify the level of interest of each criterion (see Table 7.2). For dealing with synergies among the Rio Conventions at project level, local and global levels have been considered. An initial exercise of this approach has been presented in section 3.3.4 with forestry ecosystem services.

Code	Forestry criteria	Level of interest
Cr1	Land tenure	Local
Cr2	Equitably share/benefits development	Local/Global (CBD)
Cr3	Skill development	Local
Cr4	Ensure strong local participation	Local
Cr5	Employment	Local
Cr6	Financial returns to local entities	Local
Cr8	Financial forestry incentives	Local/Global (UNFCCC)
Cr9	Use of native species being encouraged	Local/Global (CBD)
Cr10	Conservation and maintenance of soil resource	Local/Global (UNCCD)
Cr11	Conservation and maintenance of water resource	Local/Global (CBD, UNCCD)
Cr12	Biodiversity conservation	Local/Global (CBD)

Table 7.2 Forestry decision criteria

Eleven forestry criteria were used, and values are the input data for the ELECTRE TRI method. In general, for environmental decision situations, there is variability in the number of criteria which are used, probably depending on the complexity of the situation and the number of participants.

For this research, the number of criteria is related to the complexity (synergies assessment) and the multidimensional sector under analysis (forestry sector). For instance, 12 criteria have been used to assess an action plan for the diffusion of renewable energy technologies at regional scale (Beccali *et al*., 2003), 13 criteria for sorting cropping systems on the basis of their impact on groundwater quality (Arondel and Girardin, 2000), 10 criteria for the analysis of sustainable water resources planning (Srinivasa Raju *et al*., 2000), 8 criteria for choosing a solid waste management system (Hokkanen and Salminen, 1997), 8 criteria for choosing urban stormwater drainage management (Martin *et al*., 2007) or 7 criteria for improving petroleum contaminated land remediation decision-making (Balasubramaniam *et al*., 2007).

Furthermore, in project evaluation the number of criteria using other MCDA methods have considered 12 criteria for evaluating construction projects (Zavadskas *et al*., 1994) or 12 criteria for a sorting procedure in the public administration (Norese and Viale, 2002).

On the other hand, Figueira *et al*. (2005) have suggested that ELECTRE methods are more adequate for cases where heterogeneity of scales occurred (see section 5.2.5), but it doesn't imply they cannot be used otherwise [36]. Through the factor analysis, the correlation among forestry criteria has been analysed (see section 6.5.2). However, in this study the correlation of forestry criteria can be considered only as a characteristic for further consideration, because this information has not been incorporated in the ELECTRE TRI method.

Furthermore, for natural resource management, Leskinen and Kangas (2005) have claimed that the assumption of independent decision criteria is <u>not always realistic</u>. For example, the importance of the amount of old forests to biodiversity may depend on the amount of dead wood. Leskinen and Kangas (2005) have presented how multicriteria natural resource management problems can be analysed in a case involving dependent decision criteria. In this article, dependence is considered in the above sense and referred to as 'dependent decision criteria' or 'decision criteria with interactions'. However, these authors emphasised that the correlations of the assessments of management alternatives between different decision criteria were not studied. Still further studies are needed in this direction.

From the methodological point of view, Figueira *et al*. (2007) are analysing the use of the concordance index of ELECTRE methods to consider information on the interaction between

[36] Figueira J. 2007. Personal communication. Expert in ELECTRE familiy methods. E-mail 09/10/2007 (reply).

criteria. Three types of interaction are being considered: self-strengthening, self-weakening, and antagonism.

Besides, Vincke (1992) have made some reflections on the correlation of criteria. Then, the fact that 2 criteria are strongly correlated (in the sense of the correlation coefficients of statistics), due to the existence of some factors which influence both criteria in the same direction (a direction functional dependence between the two criteria is excluded if family F of criteria is consistent, because of the non-redundancy condition). Besides, due to the complexity of the links which may occur through these factors, it is **utopian** to try to redefine family F in a way which avoids any correlation between the criteria (try to avoid as far as possible). Furthermore, eliminating a criterion because it is strongly correlated with another destroys information which, in decision aid term, is not necessarily redundant and may therefore be useful, if not indispensable.

Alternatives

Alternatives used for the assessment of synergies at forestry project level have been proposed in the *problem formulation* (see section 7.2.1). The ten (10) forestry projects are briefly described in Table 7.3. More information is found in the UNFCCC web site [37].

For this study, projects which have been considered for assessment are: large scale industrial plantations, agroforestry, forest rehabilitation and regeneration, and protected areas (see section 3.5.2; Table 3.5).

Categories and profiles

For ELECTRE TRI method, profiles and categories need to be specified. Therefore, **profiles** can be described as reference alternatives, which delimitate categories (see section 5.3.1) and are defined by their values on the criteria. Then, each alternative (forestry project) is assigned to a category through the comparison with the reference profiles. In general, categories are proposed independent of the set of alternatives.

For this research, categories have been determined based on the fact that the synergistic forestry projects can be adequately distinguished from those less synergistic, and should be simple to manage. As a result, 3 categories for assessing synergies at forestry project (FP) level have been defined together with the decision maker: synergistic project (C01), moderate synergistic (C02) and less synergistic (C03). The description of the different categories is shown in Box 7.1. Furthermore, the grouping (categories) does not propose any rejection category of projects since it was assumed that they already fulfil some requirements under the Kyoto Protocol.

[37] Projects PDD are available: http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

Project	Description
China A0001	Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin, China. Therefore activities are: sequester CO_2 through forest restoration in small watershed areas and test and pilot how reforestation activities generate high-quality emission reductions in greenhouse gases that can be measured, monitored and certified; (2) to enhance biodiversity conservation by increasing the connectivity of forests adjacent to pasture reserves; (3) To improve soil and water erosion control; and (4) To generate income for local communities.
R. Moldova A0002	The Moldova Soil Conservation Project proposes to achieve multiple objectives in terms of the restoration of degraded lands through improvement in the vegetative cover, enhanced supplies of forest products to local communities, and increases in the GHG removals from the degraded lands.
Albania A0003	Assisted Natural Regeneration of Degraded Lands in Albania. Therefore, it is planned to undertake the present carbon sequestration project trough afforestation and reforestation of degraded lands, by setting aside and protecting land to make natural re-growth possible, leading to enhanced sources of livelihood and incomes in poor rural areas, reduced soil degradation, improved water quality and conservation of biodiversity.
Honduras A0004	Reforestation around Pico Bonito National Park, Honduras. Therefore including as activities: (1) agro-forestry for Small Scale Producers 600 hectares; (2) natural Forest Restoration through Reforestation of Degraded Land for Conservation 1,000 hectares; and (3) reforestation for Sustainable commercial Forestry 1,000 hectares.
Brazil A0005	The establishment of plantations as a renewable source of wood supplies for energy to meet the industrial needs is expected to result in twofold benefits: (1) generation of carbon stocks and of GHG removals by sinks additional to those that would occur in the absence of such plantations, and (2) substitution of sustainable sources of biomass in place of fossil fuels and non-renewable biomass, which contribute to GHG emissions in one of Brazil's major development sectors, i.e. the iron and steel industry.
China (2) A0006	Afforestation for Combating Desertification in Aohan County, Northern China. Therefore activities are: (1) sequestering carbon dioxide and mitigating climate change; (2) creating job opportunities and improving socio-economic conditions within the area of influence of the project; (3) improving local environmental conditions (desertification combating, wind breaking; increasing environmental awareness, particularly among the youth; and (4) developing, testing and disseminating the best practice in desertification combating and strengthening capacity building through support for training and technical assistance to the relevant agencies and communities.
Ecuador A0007	Chocó-Manabí Corridor Reforestation and Conservation Carbon Project. The project has a sustainable development focus and will provide long-term benefits for climate, biodiversity and watershed protection in a region identified both nationally and internationally as a top conservation and sustainable development priority.
Madagascar A0008	The project aims to acquire carbon emission reduction (CER) and wood chips for pulp materials on degraded land where grasslands are studded the isolated tree and shrubs as a non-forest land, in the area around Brickavill and Toamasina in the province of Toamasina, in the Democratic Republic of Madagascar. Moreover, the project participants will support "Community forest of the local inhabitants". Therefore, local inhabitants will plant free seedlings donated by the project participants, manage the forest by themselves in addition to the industrial plantation activity.
Colombia A0009	The Project seeks to establish on abandoned pastures, forestry, agroforestry, and sylvopastoral systems and secure their sustainable management, with the active community participation. Objectives: generation of financial resources and improvement of livelihoods of small-scale landholders; sustainable management of watersheds; conservation of biodiversity; and active participation and involvement of local communities, NGOs, government, and the private sector of the area.
Brazil A0010	The project activity here proposed as A/R CDM comprises 8,094 hectares of riparian areas, currently occupied by unmanaged grassland and to be reforested using a composition of native species tree buds. In addition to the environmental benefits, particularly for the climate through the removal of atmospheric carbon, the afforestation/reforestation activity will impede invasions of the riparian areas by settlers, for urban lots or any other types of construction.

Table 7.3 Forestry projects used for ELECTRE TRI

The profiles defined for this evaluation model are 2 diving 3 categories. Therefore, the Pr01 (*b1*) profile corresponds to the minimum values of the criteria set that a project must receive to be considered in the C01 category (synergistic). Then, the Pr02 (*b2*) profile corresponds to the values of the criteria set that a project must have as minimum to be considered in the C02 category (moderate synergistic), but does not belong to C01 or C03.

Initial reference profiles have been chosen based on the minimum standard that can be considered suitable for a project to be synergistic, reasonable, or not synergistic. In some cases, the

construction of the reference profile, for example Pr01, suggests to include information of a specific project. However, it should not be the best project, like this, it will be possible to have projects which are better than the reference and can be assigned to the first category (C01).

Furthermore, profiles for the different criteria have been fixed according to the ordinal scale of the criteria. For all criteria, the Pr01 and Pr02 have been fixed in 5 and 3, respectively, except for the Cr1 and Cr5 were the higher profile has been fixed in 6.

Category	C01	C02	C03
Definition	FP which can be considered synergistic	FP which is reasonable synergistic	FP which is not considered synergistic
Advice	Certainly evident that this type of project can be considered synergistic	Sufficient evidence that this type of project is reasonable synergistic	Not evident that this type of project is synergistic

Box 7.1 Forestry project categories for ELECTRE TRI method

Preference (*p*) , indifference (*q*) and veto (*v*) thresholds

Inter criterion information (veto threshold) and intra criterion information (thresholds) are specific parameters needed (see section 5.3.3). In particular, for the ELECTRE TRI method, preferential information is required for each profile (Pr01, Pr02), defined for the set of criterion. Kangas *et al*. (2001) have claimed that in outranking methods the analyst may choose the values of threshold values. Probably, this consideration is valid, since the researcher is able to understand and also translate these values to the decision maker.

Roy *et al*. (1986) have claimed that fixing a threshold involves not only the estimation of error in physical sense, but also a significant subjective input. Then, in order to verify that this subjective input does not significantly affect the final result, a sensitivity analysis using extreme values is required.

Rogers and Bruen (1998[b]) have claimed that is imperative that p and q be chosen in a rational and defendable manner. In Roy *et al*. (1986) a clear description on why and how thresholds are chosen is provided. Therefore, one important consideration regarding thresholds is the following:

$$q<p<v$$

For the indifference threshold, a constant, proportional to the criterion (g_j) or a combination of both can be used. Besides, the preference threshold can also be constant in absolute value or in relative value, but can sometimes vary with the criterion (g_j) in a complex way (Roy *et al*., 1986). On the other hand, some recommendations are given for the veto threshold. Thus, v is set at an elevated value, relative to p for the less important criteria, whereas v is set relatively close to p or the more important ones. Consequently there is a connection between the thresholds and the important coefficients.

Moreover, Kangas *et al*. (2001) have claimed that the veto threshold is very powerful tool, by which the importance of the considered criteria can be greatly emphasized. Furthermore, the veto

threshold is an additional instrument to limit the risk of compensation, penalizing relevant deviations on specific criteria. At the end, Roy *et al*. (1986) have emphasized that important coefficients and the veto threshold represent the decision maker's **deliberate policy decision**, which are necessarily of a qualitative nature.

For this research, a set of thresholds for sorting forestry projects have been defined. Some recommendations while choosing the thresholds have been suggested. Thus, when there is confident data, smaller threshold were suggested. But, if there is imprecision and uncertainty, thresholds were recommended to be larger [38].

Thresholds were defined for each criterion and profile in terms of the ordinal scale constructed for the criteria (see Appendix 17). For this reason, the difference of one score does not allow differentiating between two projects; instead a difference of two scores can constitute a difference. Thus, the preference (p) and indifference (q) thresholds for each criterion was fixed in p=2 and q=1, respectively. For the veto threshold associated to each criterion and profile the values were fixed in v=3.

Thresholds were determined by interactive use of the ELECTRE TRI software minimizing false assignments of projects. For the determination of thresholds, the sensitivity analysis has played an important role (see section 7.3.3). Moreover, this type of analysis is useful when used as a single integrated approach while defining thresholds.

Importance coefficients (or weight)

For ELECTRE TRI method, the weights do not depict **trade-offs** among the criteria, but, rather, 'votes' given to the criteria (see also section 5.3.3). Besides, the indices of importance affect only the concordance of the ELECTRE TRI method. On the other hand, the attribution of the importance coefficients (weights) to each criterion allows showing the impact of a decision in a determinate context.

Siskos *et al*. (2007) have used equal weight for all criteria, claiming that is considered a simplification that does not alter significantly the results, although different weights can be used. Moreover, Andre (2007) has also implemented ELECTRE TRI method for synthesizing indicators of environmental performance without using weights.

Moreover, case studies where ELECTRE TRI method is used show that the importance coefficients are proposed in different ways. For instance, in water resource planning, Srinivasa Raju *et al*. (2000) have used different set of weights. Then, a revised 'weighting with cards' method has been used in Arondel and Girardin (2000) and Rousval (2005), for sorting cropping systems and the environmental evaluation of transport, respectively.

[38] Bouyssou D. 2006. Personal communication. Expert on ELECTRE family methods. LAMSADE, Université Paris IX Dauphine. 6-10 November 2006.

For this research, a working hypothesis of the importance coefficients, has considered normalized information coming from the questionnaire (see Table 7.4).

Forestry criteria		Importance coefficient
Cr1	Land tenure	9.12
Cr2	Equitably share/benefits development	9.36
Cr3	Skill development	7.01
Cr4	Ensure strong local participation	10.32
Cr5	Employment	9.42
Cr6	Financial returns to local entities	10.86
Cr8	Financial forestry incentives	7.34
Cr9	Use of native species being encouraged	9.07
Cr10	Conservation and maintenance of soil resource	9.24
Cr11	Conservation and maintenance of water resource	9.34
Cr12	Biodiversity conservation	8.91

Table 7.4 Forestry decision criteria and importance coefficient

Cutting level

The cutting level parameter is used in the exploitation procedure and has to be defined according to the strictness the decision maker wants to adopt in the aggregation procedure.

The concept of cutting level (λ) is conceived as a minimum value of percentage of votes which leads to the outranking. λ ranges between 0 and 1. For instance, λ=0.7 means that at least 70% of favourable votes are needed. A default proposed by ELECTRE TRI software has been initially used for the evaluation (λ=0.76). Later on, with the sensitivity analysis this parameter has been tested.

7.3.3 Sensitivity analysis

In order to determine the parameters and provide valid final recommendation for this decision aiding process, a sensitivity analysis was carried out.

The sensitivity analysis evaluates how the solution varies when parameters are changed. Therefore, a solution, which appears to be sensible to very small perturbations of the parameters, implies that the solution strongly depends on this particular instance of the method and less on the preferential information (Tsoukiàs, 2007).

For the sensitivity analysis, the author has considered the following parameters relevant to test: cutting level and thresholds. Therefore, an interactive use of ELECTRE TRI software was carried out for the sensitivity analysis.

The cutting level was also evaluated through the interactive use of the ELECTRE TRI software. Therefore, the tests have evidenced that cutting level values are determinant for differentiating the assignment of forestry projects. After testing different values of lambda (λ), a

default value of λ=0.76 has been used. Different tests have shown the role of lambda in the strictness of the evaluation. For instance, a lower value (λ=0.70) allows to assign projects only to the C02 and C01 category, and no assignment for the last category (C03).

Thresholds values have been attributed taking into account the scale of project evaluation, and the sensitivity analysis helped to determine the final values.

7.3.4 Performance of alternatives

In this section, the performance of the alternatives is presented (see Table 7.3). Therefore, the evaluation of forestry projects, based on the information obtained from the PDD format has been carried out. Scores have been attributed to international forestry projects based on the ordinal scale of evaluation were prepared for the indicators (see Table 7.1; Appendix 17). Results of the performance for the 10 projects are shown in Table 7.5.

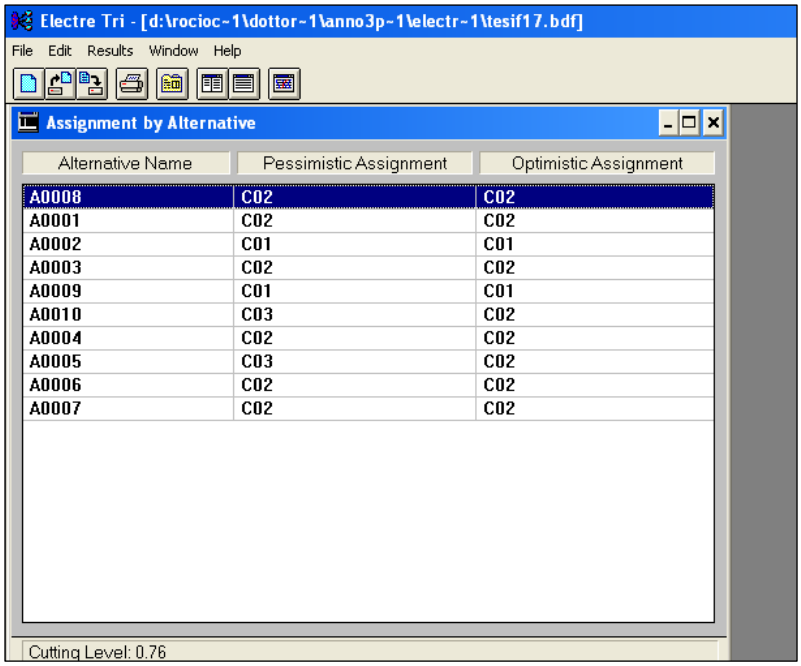
Criteria	AM0001	AM0002	AM0003	AM0004	AM0005	AM0006	AM0007	AM0008	AM0009	AM0010
Cr1	7	6	6	6	7	7	7,7	2	5	7
Cr2	5	5	4	5	1	5	3	4	7	1
Cr3	5	7	3	5	3	5	5	6	6	1
Cr4	6	5	5	4	2	3	4	5	7	3
Cr5	3	6.7	5.7	5.7	3	5	5	4	6	3
Cr6	3	3	3	7	1	5	3	3	7	1
Cr8	4	5	3	3	3	3	4	3	5	3
Cr9	5	5	5	7	1	5	7	2	6	7
Cr10	5	7	6	3	5	5	5	5	3	5
Cr11	7	5	3	3	5	5	3	3	4	3
Cr12	6	5	6	5	2	3	5	3	8	7

Table 7.5 Performance of forestry projects

7.4 Results and discussions

In this section, results obtained with ELECTRE TRI method are presented. The outranking relations and exploitation procedures are shown in Appendix 19.

Through an interactive use of ELECTRE TRI software, thresholds, weights, and cutting level have been determined. With ELECTRE the value of the weight is not independent of the other parameters: concordance, discordance, indifference, and preference thresholds (Bouyssou *et al.*, 2006). Therefore, before selecting the final set of values, different tests among thresholds (*p, q, v*) and weights were done. Final results obtained with ELECTRE TRI are shown in Figure 7.2.



Alternative Name	Pessimistic Assignment	Optimistic Assignment
A0008	C02	C02
A0001	C02	C02
A0002	C01	C01
A0003	C02	C02
A0009	C01	C01
A0010	C03	C02
A0004	C02	C02
A0005	C03	C02
A0006	C02	C02
A0007	C02	C02

Figure 7.2 ELECTRE TRI results for sorting forestry projects

International forestry projects have been assigned to the different categories described in section 7.3.2 (*Categories and profiles*). This assignment can be explained because of the integrated evaluation of the 11 forestry decision criteria.

The optimistic and pessimistic approach in ELECTRE TRI method, result from the management of incomparability of the alternatives. In general, the pessimistic approach is used when it is required to apply a conservative policy or when the available resources are limited, while the optimistic approach is used for problems where the decision maker wants to give a comparative advantage to certain alternatives with a specific interest (Siskos *et al.*, 2007).

Furthermore, Bouyssou *et al.* (2000) have described that incomparability can be interpreted in two different ways. The first, that some alternatives are too contrasted to be compared. The second, support the idea that incomparability results from insufficient information; the available information sometimes does not allow to make up one's mind on whether *a* is preferred to *b* or the converse.

For this research, the author has considered the use of the pessimistic results from ELECTRE TRI to remain with a conservative approach for the final recommendations.

Two projects, A0002 and A0009, were assigned to the first category (C01, synergistic), which means favouring the projects that perform the best on the greatest number of criteria. Then, forestry projects: A0001, A0003, A0004, A0006, A0007, and A0008 were assigned to the second category (C02, moderate synergistic). Finally, A0005 and A0010 were assigned to the last category (C03, less synergistic).

On one hand, A0009 and A0002 forestry projects, implementing agroforestry and sylvopastoral systems, and restoration of degraded lands, respectively, have been assigned to a category were there is certainly an evidence of synergistic characteristics (category *C01*). On the other hand, A0005 and A0010 projects, implementing large scale plantations for different purposes have been assigned to the last category (*C03*), where there is no evidence of synergistic characteristics.

The assignment of the projects to the different categories has differentiated the type of forestry projects and their contribution to the achievement of synergies. In some cases, there could be the risk that *large forestry plantations* projects exclude local population participation; however, *agroforestry* projects can contribute with local development and employment issues. Another example, are *protected area* projects which exclude local communities and huge social impacts can occur. However, *multiple use community forestry* projects can have a conservation component but also social including local communities in the project.

In this context, Barker *et al*. (2007) have described that plantations can contribute positively to employment, economic growth, exports, renewable energy supply and poverty alleviation, but may also lead to negative social impacts such as loss of grazing land and source of traditional livelihoods. However, agro-forestry can produce a wide range of economic, social and environmental benefits; probably wider than large scale afforestation.

Agroforestry systems include a wide variety of practices (SBCD, 2003): agrosilvicultural systems; silvopastoral systems; and tree-based systems such as fodder plantations, shelterbelts, and riparian forest buffers. Moreover, agroforestry systems may lead to diversified and sustainable production systems, and may provide increased social, economic, and environmental benefits (SBCD, 2003). Halsnaes and Markandya (2002) have described different situations. For instance, in terms of environmental benefits, native forest management options, particularly, concession forests, offer a great deal of secondary benefits with great relevance to biodiversity protection. For the development impacts, plantations are more important for the activity level of the economy as a whole, but less for the regional economy. In terms of regional benefits, private sustainable logging in native forests is more relevant.

Other authors have also addressed the importance of the type of forestry projects. For instance, Totten *et al*. (2003) have described that projects that offer the greatest **synergies** include the prevention of deforestation, the ecological restoration of fragmented landscapes, the sustainable improvement of agro-ecological farming systems, and the expansion of new growth on degraded lands. In addition, these projects have the potential to reduce overall carbon mitigation costs, to

protect threatened and endangered species and habitats which deliver critical ecosystem and climate adaptation services, and to provide sustainable development opportunities to local communities.

Besides, Appanah (2003) has addressed that, rehabilitation procedures seek to go beyond that of commercial timber production and trials are underway to increase biodiversity and ecological services as additional products. Therefore, the majority of forest restoration schemes can also provide additional income to rural communities.

Also, Smith and Scherr (2003) have concluded that community based projects, such as agroforestry, small-scale plantations, agroforests, secondary forest fallows, community forest rehabilitation and multiple-use forest management, have the highest potential for local livelihood benefits and pose the fewest risks to communities, because production of carbon benefits are contingent on the collaboration of communities. On the contrary, large-scale industrial plantations and strict forest protection pose considerable risks for communities, the most significant among them being loss of access to land and forests which communities have long used under customary law.

Finally, Both End (2005) have concluded that it is crucial and beneficial to stimulate the development and implementation of comprehensive projects contributing to several environmental issues, because of the added value capable of interlinking solutions.

From the results further information can be provided. For instance, project A0004 implements agroforestry, restoration, and reforestation for commercial purposes. This project has been assigned to the second category (*C02*), where there is sufficient evidence that this type of project is reasonable synergistic. Furthermore, project A0008, which implements a large scale plantation and supports a community forest of the local inhabitants, has also been assigned to *C02.* As a result, it can be concluded that apart from considering the type of forestry project which can give social, economic and environmental benefits, it is equally important to take into account how forestry projects are conceived, planned, and implemented. For this reason, a large plantation and an agroforestry/restoration project, such as A0008 and A0004, respectively, have been assigned to *C02*.

In general, impact of activities on climate change mitigation and biodiversity conservation are beneficial or adverse depending on: a) the selection of practices within the activity; b) the management options related to the activity; c) biological and physical conditions of the area; and d) the socio-economic conditions of the region (UBA, 2004[b]; 2001).

The author of this research wants to underline two important contributions from this research. The first, that the assessment of synergies at project level was based on evaluation model defined in a decision aiding process. Therefore, after understanding the problem situation and formulating a number of formal problems, the selection of the appropriate evaluation model was possible.

Furthermore, the author can conclude that providing decision support is much more crucial than applying a technical tool to solve a decision problem; and it is also important to organise a complex situation with the support of an appropriate scientific framework.

The Multi Criteria Sorting Method (MCSM) has been helpful to assess synergies through the use of specific forestry decision criteria. Besides, criteria consider different levels of interest (see 7.3.2; Table 7.2), and should be strong for demonstrating synergies among the Rio Convention and sustainable development at local level. Second, the strength of using a MCSM is to assign international forestry projects, to pre-established categories, evaluated under multiple criteria. Therefore, projects that perform the best on the greatest number of criteria are assigned to the first category (C01). Finally, the author can conclude that the assessment of synergies has been possible, thanks to the use of a multicriteria approach that has found a compromise solution while assigning projects to the different categories. On one hand, projects are evaluated absolutely, on the other hand; this method does not compensate a bad performance with many good performances, providing a compromise solution for the assessment of synergies at project level.

The author of this research has found in many environmental literature and scientific articles, the use of trade-off concept while addressing different objectives at the same time. However, to achieve sustainable development, trade-offs should be avoided. Additionally, also optimisation or maximisation concepts should be neglected. For instance, there are conflicts between CBD and UNFCCC when trying to maximise carbon uptake with fast growing monoculture tree plantations that can promise the maximum short-term removal of carbon dioxide.

Munda (2005) has claimed that results depend very much on the quality of information available, indicators chosen, direction of each indicator, relative importance of these indicators and method used. In this sense, qualitative indicators have been chosen for the evaluation of projects. Making them quantitative would have not allowed the assessment of project from different regions of the world.

Furthermore, the quality of information is linked to the information obtained from the questionnaire and interview process. Then, the combination of different approaches, methods, and tools can provide concrete opportunities for addressing synergies and sustainable development goals.

7.5 Model validation

The processes of modeling and validating are to be integrated into a single one, which can be called the modelling-validating process (Landry et a., 1983). The modeling-validating activities are grouped in four basic interrelated and interactive stages: problem situation, conceptual model, formal model, and solution/recommendations. The concepts which are presented in this section have

supported the decision aiding process. Thus, it has encouraged the author of this research to justify and validate activities from the decision aiding process (see section 7.2.1)

Landry *et al*. (1983) have addressed that evaluation models are subject to a conceptual, logical, experimental, and operational validation.

Conceptual validation

The conceptual validation can verify the suitability of the concepts used. Therefore, it has to be validated if assumptions which have been considered are appropriate for the problem formulation. It is clear that for a given problem situation, several conceptual models can be elaborated, each reflecting a different perspective (Landry *et al*., 1983).

In particular, for the assessment of synergies at project level, the sorting of international forestry projects into pre-defined categories has been identified, together with the decision maker, appropriate (see also section 7.2.1; problem formulation).

Logical validation

The logical validation verifies the logical consistency of the model. Then, the capacity of the formal model is to describe correctly and accurately the problem situation as defined in the conceptual model (Landry *et al*., 1983). The concept of outranking is considered appropriate for exploring **synergies** among the Rio Conventions at project level. The outranking model seeks to establish the **strength** of evidence favouring selection of one alternative over the other, which means for example favouring the alternative that performs the best on the greatest number of criteria (Linkov *et al*., 2004).

On the other hand, the concepts of concordance and discordance, which are used for the construction of the outranking relation, are of interest (see section 5.2.5). For instance, the discordance index uses the **veto threshold** for the criteria. This means that if an alternative performs badly with regard to one criterion, that the difference exceeds the veto threshold, even good values regarding the other criteria will not be sufficient to compensate this great deficiency (Kangas and Kangas, 2005; Kangas *et al*., 2001). Therefore, the veto thresholds may be used as non-compensatory features determining a discordance index of alternatives (Wolfslehner, 2006). From a theoretical perspective, the computation of the credibility index corresponds to the concordance index weakened by eventual veto effects (Mousseau *et al*., 1999). Afterwards, the concept of compensation can be connected with the strong and weak sustainability, as non-compensation methods can provide us with a strong sustainability concept (see section 4.5).

The exploitation procedure applied for the ELECTRE TRI method considers a pessimistic and optimistic procedure, giving the opportunity also to consider a conservative option in the context of assessing synergies at forestry project level.

Linkov *et al*. (2004) have described that outranking models are appropriate when **criteria** metrics are *not* easily aggregated, measurement scales vary over wide ranges, and units are incommensurate or incomparable. For this research, criteria and indicators are representing different dimensions (social, economic and environmental) in the forestry sector. Moreover, an interesting advantage of ELECTRE TRI method is that criteria may be ordinal or even descriptive, on the contrary to most decision-aid methods (Kangas *et al*., 2001).

Srinivasa Raju *et al*. (2000) have described that ELECTRE TRI method is found to be a useful screening methodology when the number of alternatives and/or criteria is large. For this research 12 criteria are used for project sorting. Furthermore, **alternatives** (forestry projects) used with ELECTRE TRI satisfy the assumption of independence, specifically, because forestry projects are from different regions of the world.

Finally, ELECTRE TRI method allows the use of **thresholds**, which are important not only because they address imprecision, uncertainty and ill determination of the data but also because it is something that appears useful and important in real life when making decisions. As described by Kangas *et al*. (2001), the outranking methods are typically used for group decision making situations, where the analyst typically chooses the values for the thresholds, and the decision makers only choose the weight of the criteria.

Experimental validation

The experimental validation verified the results using experimental data (Landry *et al*., 1983). ELECTRE TRI method has been used for the assessment of synergies at forestry project level. Parameters used for the analysis are described in section 7.3.

In general, ELECTRE TRI method has responded positively to the needs which have been addressed by the decision maker. Therefore, through sorting projects into pre-defined categories it has been possible to assess synergies at project level. Furthermore, the sensitivity analysis as part of the experimental validation process has been carried out (see section 7.4).

Operational validation

The operational validation verifies the implementation and use of the model in everyday life (Landry *et al*., 1983). The author has considered important to contact a policy maker from the Ministry for the Environment, Land and Sea from Italy, with interest in the assessment and implementation of synergies among the Rio Conventions. Therefore, a personal interview took place with a representative from the ministry, expert in international forestry projects.

The aim and the methodological framework of this research were presented. For this purpose a graphical representation was used (see section 7.2.2). In general, the comments of the policy maker have been positive toward the findings, and some additional recommendations were provided. The

author has to assure that the policy maker has recognised the importance of organising and structuring a whole decision aiding process, giving insights to the problem situation for assessing synergies at project level.

7.6 Conclusions

In this chapter the author of this research has attempted to describe a real decision aiding process for assessing synergies at forestry project level. Different activities which are involved in the process have been described and justified, such as the problem situation, problem formulation, evaluation model, and recommendation. Moreover, importance has been given to the graphical representation of the decision problem. This representation has been used during a dialog process with the decision maker and policy maker, to describe the decision problem.

The decision aiding process has been supported by information coming from a questionnaire and interview process. In this way the quality of process has been ensured through the interaction with different experts. Landry *et al*. (1983) have also concluded that the participation of stakeholders in the modelling process can considerably contribute to the improvement of model validation.

Results have contributed with the structuring of a decision problem where synergies are assessed at forestry project level. Then a complex environmental decision situation has been organised, where conflicting criteria, independent alternatives and different actors were part of the decision problem. Therefore, the decision process has proceeded towards the organization of the situation; one arrives at a measure of anti-entropy (Scarelli, 1995). Besides, the research has stimulated interest in modelling synergies at project level and shown that multicriteria approach is useful tool for environmental decision problems.

The problem statement of the decision aiding process has been identified together with the decision maker. The sorting of international forestry projects into pre-defined categories was considered appropriate in this context. Afterwards, ELECTRE TRI method has been chosen as evaluation model; therefore the sorting of forestry project was carried out. The author of this research can concluded that different type of forestry projects can give social, economic, and environmental benefits, such as the agroforestry or land restoration projects, but it is equally important to take into account how forestry projects are conceived, planned and implemented. As a result, this research has been able to provide a scientific documentation of the decision. Besides, the aim of assessing synergies has been achieved, because the multicriteria approach has found a compromise solution while assigning projects to the different categories.

Norese and Viale (2002) have claimed that the multicriteria modelling procedures can be used in a learning phase to explore decision and action contexts, problematic situations, the solution space and the evaluation space. Furthermore, the decision aiding process has allowed to explore in depth the problem situation, where synergies among the Rio Conventions need to be assessed.

ELECTRE TRI a MCSM was used as evaluation model in the decision aiding process, where different information was required. After revising different procedures for obtaining parameters that are used in the model and having a real problem in hands, the author of this research has concluded that each procedure has to be adapted to the situation in which the decision situation takes place. For this research, a working hypothesis and sensitivity analysis has supported the determination of parameters. Information from a questionnaire and interview processes were the basis, together with the requirements of the decision maker.

The author has found useful to have a validation process (conceptual, logical, experimental, and operational). These elements have reinforced the whole decision aiding process, from the identification of the problem statement and choice of an appropriate multicriteria method to the final use of the model in a real-world decision problem.

CONCLUSIONS AND RECOMMENDATIONS

In order to provide answers to the initial research questions addressed in the introduction (Chapter 1; Figure 1.1), this section summarised the conclusions drawn in the different chapters of the thesis.

General conclusions

The thesis contributes to define a multicriteria decision framework that supports the assessment of synergies among the Rio Conventions at forestry project level.

This research is interesting due to its conceptual aspects and remarks for the forestry and environmental domain, in addition to its application aspects.

Conceptual contribution

The thesis provides the background and justification to explore an appropriate scientific framework which allows the assessment of synergies among the Rio Conventions at local level (see Chapter 2). Besides, the research was focused in the forestry sector (Chapter 3).

The assessment of synergies among the Rio Conventions was considered a decision problem. In comparison to how classical environmental decision problems are treated, this research has proposed to structure a decision situation through the conduction of a decision aiding process. Decision aiding is a process during which different activities are constructed thanks to the interaction with the actors participating in the decision process.

The set of activities of a decision aiding process implies the definition of the problem situation, problem formulation, evaluation model, and final recommendation. Therefore, the assessment of synergies at project level was not to reduce the application of a formal method, but a set of activities in a decision aiding process was defined and justified in agreement with the decision maker.

Furthermore, activities from the decision aiding process have guided the decision process, and have encouraged reasoning and revising all steps undertaken. Besides, through the decision aiding process, instruments to justify the selection of a certain evaluation model are given. Few studies have addressed a whole decision aiding process, therefore, this research contributes to demonstrate the usefulness of structuring a decision process, considering for the first time, the environmental decision domain.

On the other hand, the Multicriteria Decision Aid (MCDA) approach was explored and proposed as scientific framework. This research provides a conceptual and operational validation of the use of MCDA approach where synergies among the Rio Conventions were assessed at project level. In other words, MCDA can have a crucial role for implementing and assessing synergies among the Rio Conventions.

Remarks for the forestry and environmental sector

Forestry ecosystem services categorization and analysis were used as a tool for further exploring synergies and conflicts. Moreover, levels of interest at local and global were recognised as useful while assessing synergies at forestry project level (Chapter 3).

On one hand, the organization of a complex decision situation is of particular interest when dealing with environmental decision problems. Therefore, a decision aiding process can support to structure environmental situations. On the other hand, the perspective to use a multicriteria approach allows considering simultaneously conflicting, multidimensional and incomparable multiple criteria. Thus, MCDA gives the opportunity to aggregate different information and expectations which are commonly found in environmental decision problems (Chapter 4 and Chapter 5).

While dealing with multiple objectives or multiple dimensions, as for example in the forestry sector, the multicriteria approach has the strength of providing compromise solutions. This last concept should always be considered for environmental decision problems, and optimisation or maximization concepts should be neglected.

Furthermore, MCDA methods are linked to a compensatory concept, referring to the existence of trade-offs between the performance of alternatives on criteria. For environmental situations, the use of non-compensatory MCDA methods should be more appropriate when assessing sustainability (see section 4.5).

Application contribution

Constructing a set of environmental criteria is a crucial activity in a decision aiding process. Therefore, the author of this research has found useful to describe and present the strategy used to select forestry decision criteria.

Furthermore, a questionnaire process was convenient and effective for validating the selected criteria, where experts from different regions of the world were involved. Besides, the researcher should gather and process information for the selection of criteria; consequently, he/she should filter information and converge with a sufficient number of criteria (Chapter 6)

On the other hand, different instruments were used for improving the quality of the decision aiding process, namely the questionnaire, the personal interviews, and the multivariate statistical analysis. These instruments allow the researcher to get more information of the decision problem and give the opportunity to go through a learning process. Moreover, in environmental situations, combining or integrating different tools support the decision aiding process (Chapter 6 and Chapter 7).

In the decision aiding process, the application of multicriteria approach has demonstrated to be a useful for assessing synergies among the Rio Conventions at forestry project level. Hence, the coherence of international forestry projects with sustainable development and the objectives of the Rio Conventions were assessed with a multicriteria sorting method, which has found a compromise solution.

ELECTRE TRI method was used as evaluation model, thus forestry projects were assigned to three pre-determined categories, providing advice for project sorting. The assignment of an alternative to a certain category results from the comparison with the profiles, which means that the alternative is at least as good as the profile on a sufficient set of criteria and not extremely worse on any criterion. Besides, ELECTRE TRI method has as technical strength, the capacity to (Chapter 7):

- use multiple criteria (11 decision criteria),
- evaluate independent projects (absolute evaluation),
- use ordinal performance scale for the qualitative project evaluation,
- use thresholds that consider the imprecision, uncertainty and indetermination of the data, and
- use veto threshold to limit compensation.

For the first time, ELECTRE TRI method has been used in the forestry sector, where multiple and conflicting criteria were used.

Recommendations

In this section suggestions and ideas for further research are given according to the questions that have arisen during the thesis.

Multiple actors in an environmental context is common, therefore, further research can be focused in the use of the game theory for better comprehension of the compromise solution.

Preferential information such as the correlation of forestry decision criteria has been assessed in this research through the use of multivariate statistical analysis. However, this information has not been incorporated in the evaluation model. Further research is needed in this domain.

Further research is needed to understand the relationship between the modelling-validating process and the activities of a decision aiding process.

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Appendix 1. Principles from the Rio Conventions

UNFCCC (Art.3)

1. The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.

2. The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration.

3. The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties.

4. The Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change.

5. The Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties, particularly developing country Parties, thus enabling them better to address the problems of climate change. Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.

CBD (Art. 3)

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

UNCCD (Art. 3)

(a) the Parties should ensure that decisions on the design and implementation of programmes to combat desertification and/or mitigate the effects of drought are taken with the participation of populations and local communities and that an enabling environment is created at higher levels to facilitate action at national and local levels;

(b) the Parties should, in a spirit of international solidarity and partnership, improve cooperation and coordination at sub regional, regional and international levels, and better focus financial, human, organizational and technical resources where they are needed;

(c) the Parties should develop, in a spirit of partnership, cooperation among all levels of government, communities, non-governmental organizations and landholders to establish a better understanding of the nature and value of land and scarce water resources in affected areas and to work towards their sustainable use; and

(c) the Parties should take into full consideration the special needs and circumstances of affected developing country Parties, particularly the least developed among them.

Appendix 2. Cooperation with relevant international organizations at the UNFCCC

Document/date	Report/note	Content
FCCC/SBSTA/2000/14 (20/12/2000)	SBSTA 13th session report, The Hague, 13-18 November 2000	Appreciated the information contained in a discussion note prepared by CBD secretariat. Initial consultation on biodiversity and climate change issues started.
FCCC/SBSTA/2001/INF.3 (29/06/2001)	SBSTA 14th session: Issues related to the Convention on Biological Diversity (*)	Background information based on the discussion note by the CBD COP6 session. CBD proposed the creation of **Joint Liaison Group**, assessment on the integration of biodiversity and UNFCCC/Kyoto protocol issues, invited IPCC to contribute with a technical paper.
FCCC/SBSTA/2001/2 (18/09/2001)	SBSTA 14th session report, Bonn, 24-27 July 2001	Endorsement of the formation of the **Joint Liaison Group** with the three Rio secretariats. Information contained in FCCC/SBSTA/2001/INF.3 and FCCC/SBSTA/2001/MISC.3 and Add.1 was considered.
FCCC/CP/2001/13/add.1 (21/01/2002)	COP 7th session report, Marrakesh, 29 October – 10 November 2001	Decision **5/COP.7** requested the organization of a workshop on synergies
FCCC/SBSTA/2001/8 (07/02/2002)	SBSTA 15th session report, Marrakesh, 29 October- 6 November 2001	Reaffirmed need for enhanced cooperation among the Rio Conventions. Request to the JLG to collect and share information on the work programmes and operations of each convention. Emphasized the role of countries at the **national level**. Took note of FCCC/SBSTA/2001/MISC.7 and FCCC/SBSTA/2001/MISC.8
FCCC/SBSTA/2002/6 (12/08/2002)	SBSTA 16th session report, Bonn, 05-14 June 2002	Welcome the paper prepared by IPCC on interlinkages between biological diversity and climate change. SBSTA requested the preparation of a scoping paper to identify cross-cutting thematic areas and activities under the UNFCCC, CBD, and UNCCD. Took note of FCCC/SBSTA/2002/MISC.9 and Add.
FCCC/SBSTA/2002/INF.16 (11/10/2002)	Cross-cutting thematic areas and activities under the UNCCD, CBD and UNFCCC (*)	This paper offers a broad overview of activities and provides an example to illustrate linkages between the conventions.
FCCC/SBSTA/2002/13 (12/02/2003)	SBSTA 17th session report, New Delhi, 23-29 October 2002	Took note of FCCC/SBSTA/2002/INF.16. Establish terms of reference for the synergies workshop. Emphasized the need to strengthen coordination of **national focal points** as a task essential to achieving these objectives.
FCCC/CP/2002/7/Add.1 (28/03/2003)	COP 7th session report, New Delhi, 23 October- 1 November 2002	Decision **13/COP.8** requested SBSTA to continue cooperating with SBSTTA and CST. Enhance cooperation in order to avoid duplication of efforts, strengthen joint efforts, and use available resources more efficiently.
FCCC/SBSTA/2003/10 (31/07/2003)	SBSTA 18th session report, Bonn, 04-13 June 2003	Agreed to continue discussion on cooperation with other conventions, taking into consideration the outcome of the workshop in Espoo, Finland.
FCCC/SBSTA/2003/15 (24/03/2004)	SBSTA 19th session report, Milan, 01-09 December 2003	Welcomed outcome from Finland workshop (FCCC/SB/2003/1). Welcomed the AHTEG report on interlinkages between biological diversity and climate change. Recognized that enhanced cooperation between Rio Conventions can help countries attain objectives of sustainable development at the national level.
FCCC/SBSTA/2004/6 (20/09/2004)	SBSTA 20th session report, Bonn, 16-25 June 2004	Took note of outcomes from the Viterbo workshop and report from the 5th JLG meeting presented in FCCC/SBSTA/2004/INF.9
FCCC/SBSTA/2004/INF.19 (02/11/2004)	Options for enhanced cooperation among the three Rio Conventions (*)	Presented for the first time detailed options for further enhancing cooperation: a) at national and international levels, b) on thematic issues; and) in specific cross-cutting areas.
FCCC/SBSTA/2004/13 (02/03/2005)	SBSTA 21st session report, Buenos Aires, 09-14 December 2004	Took note of FCCC/SBSTA/2004/INF.19. Countries were asked to submit their views on the option paper.
FCCC/SBSTA/2006/5 (13/09/2005)	SBSTA 24th session report, Bonn, 18-26 may 2006	Recognized that cooperation at the national level (national focal points), provides the greatest opportunities for efficient and effective cooperation on issues of relevance to the three Rio Conventions.
FCCC/SBSTA/2006/11 1 February 2007	SBSTA 25th session report, Nairobi, 6-14 November 2006	No activities were addressed. It was informed the intention for having the JLG meeting.
FCCC/SBSTA/2007/L.7 (16/05/2007)	SBSTA 26th session report, Bonn	No activities on synergies were addressed at Bonn. For SBSTA 27th no items related to synergies on agenda are foreseen.

(*) note by the secretariat

Appendix 3. Cooperation with other bodies at the CBD

Document/date	Report/note	Content
UNEP/CBD/COP/3/29 (11/02/1997)	COP 3rd report, 4 - 15 November 1996, Buenos Aires, Argentina	Decision **III/21** requested a closer relationships with, in particular, the UNFCCC and UNCCD in those countries experiencing serious Drought and/or Desertification, particularly in Africa, with a view to making implementation activities and institutional arrangements mutually supportive.
UNEP/CBD/COP/4/27 (15 June 1998)	COP 4th report, Bratislava, 4-15 May 1998	Decision **IV/15** further requested to strengthen relationships with UNFCCC/Kyoto Protocol, and UNCCD.
UNEP/CBD/SBSTTA/4/14 (27 June 1999)	SBSTTA 4th report, Montreal, 21-25 June 1999	Representatives considered important for the secretariat to establish and/or strengthen cooperation UNFCCC/Kyoto Protocol and the programmes dealing with the effects of carbon sequestration; the UNCCD.
UNEP/CBD/COP/5/3	SBSTTA 5th report, Nairobi, 15-26 May 2000	SBSTTA recommendation **V/1,** invited secretary to strengthen the cooperation with the UNFCCC, including its Kyoto Protocol, on issues relevant to forest biological diversity and coral reefs.
UNEP/CBD/COP/5/23 (22 June 2000)	COP 5th report, Nairobi, 15-26 May 2000	Decision **V/21** invited the secretary to strengthen the cooperation with the UNFCC, including its Kyoto Protocol, on relevant issues such as dry and sub-humid lands, forest biological diversity, coral reefs, and incentive measures.
UNEP/CBD/COP/6/3 (27 March 2001)	6 SBSTTA Report, The Hague, 8-19 April 2002	SBSTTA recommendation **VI/7** proposes to explore the formation of the **Joint Liaison Group** with the UNFCCC and UNCCD. Proposal for the assessment to integrate biodiversity considerations into the implementation of the UNFCCC/Kyoto Protocol. Established an *Ad hoc* technical expert group.
UNEP/CBD/SBSTTA/6/11 (21 December 2000)	Climate change and forest biodiversity (*) Montreal, 12-16 March 2001	Note on biological diversity and climate change, including cooperation with the UNFCCC brief overview of the impact of climate change on forest biological diversity, brief overview of the impact of climate change on forest biological diversity (see UNEP/CBD/SBSTTA/6/INF/13).
UNEP/CBD/COP/6/4 (7 December 2001)	SBSTTA 7th report, The Hague, 7-19 April 2002	SBSTTA recommendations **VII/3** addressed the importance of synergies in the context of biological diversity of dry and sub-humid lands, **VII/6** related to forest biological diversity and the UNFCCC, and **VII/9** under incentive measures Annex II (forestry and UNFCCC).
UNEP/CBD/COP/6/20 (27 May 2002)	COP 6th report, The Hague, 7-19 April 2002	Decision **VI/20** welcomed activities with UNFCCC, the formation of the JLG. Presentation of document on Cooperation with other bodies and contribution to the 10-year (UNEP/CBD/COP/6/15)
UNEP/CBD/COP/6/4 (9 April 2003)	SBSTTA 8th report, Kuala Lumpur, 9-20 and 27 February 2004	SBSTTA recommendations **VIII/4** related to Dry and sub-humid lands, suggest concrete activities related to national biodiversity strategies and action plans with national action programmes for the UNCCD, national adaptation programmes of action under the UNFCCC.
UNEP/CBD/COP/7/4 (23 November 2003)	SBSTTA 9th report, Kuala Lumpur, 9-20 and 27 February 2004	SBSTTA recommendations **IX/11** related to biodiversity and climate change activities. Welcomed report from the *Ah hoc* expert group: UNEP/CBD/SBSTTA/9/11 and UNEP/CBD/SBSTTA/9/INF/12 and the Technical Paper on Climate Change and Biodiversity
UNEP/CBD/COP/8/2 (18 April 2005)	SBSTTA 10th report, Brazil, 20-31 March 2006	SBSTTA recommendation X/**13** terms of reference for the AHTEG to develop advice or guidance for promoting synergy at the national, regional, and international level.
UNEP/CBD/COP/8/3 (19 December 2005)	SBSTTA 11th report, Montreal, 28 November –2 December 2005	SBSTTA recommendations **XI/14** welcomes the Report of the meeting of the Ad hoc technical expert group on biodiversity and adaptation to climate change (UNEP/CBD/SBSTTA/11/INF/5)
UNEP/CBD/COP/9/2 (16/07/2007)	SBSTTA 12th report, UNESCO Paris, 2-6 July 2007	For SBSTTA 12th a note from the secretariat has proposed guidance on the integration of relevant climate change impacts and response activities into the programmes of work of CBD (UNEP/CBD/SBSTTA/12/7). Also report UNEP/CBD/SBSTTA/12/INF/19 was presented. Finally, recommendation **XII/5** has presented a **"**Proposals for the integration of climate-change activities within the programmes of work of the Convention ".
UNEP/CBD/SBSTTA/13/7 (5 November 2007)	SBSTTA 13th, Rome 18-22 February, 2008	This document presented a proposal on options for mutually supportive activities for the secretariats of the Rio conventions.

(*) note by the secretariat

Appendix 4. Activities for the promotion and strengthening of relationships with relevant conventions and organizations at the UNCCD

Document/date	Report/note	Content
ICCD/COP(1)/11 (29 December 1997)	COP 1st report, 29 September- 10 October 1997, Rome	Decision **13/COP.1** requested collaboration with different conventions such as UNFCCC, UNCBD, etc.
ICCD/COP(2)/14/Add.1 (5 February 1999)	COP 2nd report, 30 November - 11 December 1998, Rome	Decision **8/COP.2** requested collaboration with different conventions.
ICCD/COP(2)/7 (17 November 1998)	Promotion and strengthening of relationships with other relevant conventions (*)	Collaboration and synergies among Rio conventions for the implementation of the UNCCD, which explains the rationality, scientific and technical linkages and areas for institutional collaboration.
ICCD/COP(3)/20/Add.1 (31 December 1999)	COP 3rd report, 15 to 26 November 1999, Recife	Decision **17/COP.3** requested further collaboration with UNFCCC, UNCBD and Ramsar
ICCD/COP(3)/9 (28 September 1999)	Review of activities for the promotion and strengthening of relationships (*)	Collaboration and synergies among Rio conventions for the implementation of the UNCCD, which includes sections of ecological linkages, synergies in field implementation, and partners for synergies.
ICCD/COP(4)/6 (1 November 2000)	Review of activities for the promotion and strengthening of relationships (*)	Collaboration and synergies among Rio conventions for the implementation of the UNCCD, which includes section as collaboration and strengthening of relationships with other conventions and relevant institutions, and institutional and logistical aspects.
ICCD/COP(4)/AHWG/6 (14 June 2001)	Ad Hoc Working Group Inter-sessional meeting, 19 March - 6 April 2001, Bonn	Report of the Ad Hoc Working Group to the fifth session of the COP, linkages and synergies with other multilateral environment agreements and/or strategic frameworks on environment and development must be further encouraged through concrete initiatives were addressed.
ICCD/COP(5)/11/Add.1 (13 November 2001)	COP 5th report, 1 to 12 October 2001, Geneva	Decision **7/COP.5** requested to enhance cooperation with SBSTTA from CBD and SBSTA from UNFCCC.
ICCD/COP(5)/6 (20 August 2001)	Review of activities for the promotion and strengthening of relationships (*)	Describe collaboration and strengthening of relationships with other relevant conventions, international organizations, and institutions.
ICCD/CRIC(1)/10 (17 January 2003)	CRIC 1st report, from 11 to 22 November 2002, Rome	This document addressed linkages and synergies with other environmental conventions and, as appropriate, with national development strategies.
ICCD/COP(6)/11/Add.1 (7 November 2003)	COP 6th report, 25 august to 5 September 2003, Geneva	Decision **12/COP.6** requested collaboration with UNFF, UNFCCC, and the CBD to promote activities with Low Forest Cover Countries (LFCCs), for a joint approach on forests. Encourages the Joint Liaison Group (JLG) to identify possible areas for developing joint activities.
ICCD/COP(6)/4 27 June 2003	Review of activities for the promotion and strengthening of relationships (*)	Describe collaboration and strengthening of relationships with other relevant conventions, international organizations, and institutions. Propose and describe the National synergies workshops programme
ICCD/COP(7)/16/Add.1 (25 November 2005)	COP 7th report, 17 to 28 October 2005, Nairobi	Decision **12/COP.7** further requested and support the development of cooperation activities
ICCD/COP(8)/4 (13 July 2007)	Promotion and strengthening of relationships with other relevant conventions (*)	Conclusions encourage Parties to endorse the effort towards capacity-building at the national level. With document ICCD/COP(8)/MISC.1, comments on the "Options for enhanced cooperation" (FCCC/SBSTA/2004/INF.19) were received as well as success stories of field activities on synergies.

(*)Note by the secretariat

Appendix 5. List of Interviewed

5.1 National Experts (Italy)

Riccardo De Laurestis	Agency for the Protection of the Environment and Technical Services
Domenico Gaudioso	Agency for the Protection of the Environment and Technical Services
Antonio Lumicisi	Ministry for the Environment, Land and Sea

International cooperation forestry project experts:

Lucia Perugini	DISAFRI - Tuscia University, Viterbo
Luca Belleli	DISAFRI - Tuscia University, Viterbo
Chiara Corradi	DISAFRI - Tuscia University, Viterbo
Elisa Grieco	DISAFRI - Tuscia University, Viterbo
Federico Chiani	DISAFRI - Tuscia University, Viterbo

5.2 Forest national Experts (Peru)

Javier Fernández-Baca	TNC (Yungas &Central Selva Project Coordinator, Southern Andes Conservation Program)
Mario Palomares	AIDER (Project coordinator)
José Dancé	Bosques, Sociedad y Desarrollo, BSD (President)
Pedro Vásquez	Universidad Nacional Agraria La Molina, UNALM
Benjamin Kroll	PRONATURALEZA (Forestry Coordinator)
Leonidas Suasnabar	PRONATURALEZA (Forestry Coordinator)
Nicola Cedron	INRENA – Ministry of agriculture (Project Unit)
Jualia Justo	FONAM (Executive Director)
Ana Maria Gonzales	CONAM (Project coordinator of NCSA)
Enrique Toledo	FONDEBOSQUE (Executive Director)
Lily Rodriguez	Programa Desarollo Rurale Sostenibile, PDRS –GTZ (Technical council for the German Cooperation)
Marina Rosales	Biodiversity – INRENA
Delia Arana	Desertification – INRENA
Bertha Alvarado	Conservation and Ecotourism Concenssions – INRENA
Lucia Carhuapoma	Forest Concenssions – INRENA

Abbrevations of institutions are found in Appendix 6.

5.3 International Experts

Initial interviews:

Jim Carle	Plantations and protection
Michel Malagnoux	Arid Zone and Fuel wood Production
Dieter Schoene	Forests and Climate Change
Heiner Von Luepke	Forests and Climate Change
Tiina Vahanen	Forestry Information and Liaison Unit
Jerry Velasquez	United Nations Environment Programme, Division of Environmental Law and Conventions

Final interviews (Forestry Department - FAO):
Froylan Castañeda
Govil Kailash
Olman Serrano
Simmone Rose
Jim Carle

Appendix 6. Stakeholders from the forestry sector in Peru

Institution	Abbreviations		web	Description
Consejo Nacional del Ambiente	CONAM	National Environmental Council	http://www.conam.gob.pe	CONAM is the national environmental authority, which aims to plan, coordinate, control and protect the environment and the natural patrimony in Peru.
Centro Mundial de Agroforesteria ICRAF	ICRAF Peru	Research institution	http://www.icraf-peru.org/pages/index.php	ICRAF is focused on ecosystem forests of the jungle region of Peru. The mission is to develop science and practices of agroforestry to transform life and landscapes, for poor rural people.
Fundación Peruana para la Conservación de la Naturaleza (Pronaturaleza)	PRONATURALEZA	NGO	http://www.pronaturaleza.org/1_nosotros.htm	PRONATURALEZA aims the conservation and protection of the environment in Peru.
Asociación para la Investigación y Desarrollo Integral	AIDER	NGO	http://www.aider.com.pe/	AIDER has as mission to contribute with the quality of life of rural population of low income through productive technical proposals oriented to conserve and rehabilitate the environment and biodiversity.
The Nature Conservancy	TNC	NGO	http://www.nature.org/wherewework/southamerica/peru/	The Nature Conservancy's mission is to preserve plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.
Insituto Nacional de Recursos Naturales	INRENA	National Institute of Natural Resources	http://www.inrena.gob.pe/index_inicio.htm	The National Institute of Natural Resources is a decentralized public body from the Ministry of Agriculture (Law Nº 25902, 27/11/992), in charge to carry out actions for the sustainable use of natural resources, conservation of sustainable management of rural environment and the wildlife biodiversity.
Fondo de Promoción del desarrollo Forestal	FONDEBOSQUE	Fund for the promotion of forestry development	http://www.fondebosque.org.pe/	FONDEBOSQUE is a private institution of public and social interests, which aims to promote sustainable forest development in Peru.
Fondo de las Americas	FONDAM	Environmental Fund	http://www.fondoamericas.org.pe/home02.htm	Promotes activities aimed at the preservation of natural and biological resources as well as the improvement of children survival and development in Peru, financing projects in benefit of the needed population, which are carried out by Civil Society non-profit Organizations and NGO's
Programa Nacional de Manejo de Cuencas y Conservacion de suelos - Ministerio de Agricultura	PRONAMACHCS	National Program for river basin management and soil conservation	http://www.pronamachcs.gob.pe/default.asp	PRONAMACHCS promotes the sustainable management of natural resources in basin from the highlands, improvement of the quality of life of rural populations and the preservation of the environment.
Center for International Forestry Research	CIFOR	Research institution	http://www.cifor.cgiar.org/ContactUs/ProjectOffices/	CIFOR wants to contribute to the sustained well-being of people in developing countries, particularly in the tropics, through collaborative strategic and applied research and related activities in forest systems and forestry, and by promoting the transfer of appropriate new technologies and the adoption of new methods of social organisation, for national development.
Asociación Especializada para el Desarrollo Sostenible	AEDES	Development NGO	http://www.aedes.com.pe/	AEDES implement actions oriented to address human and political rights from population, promote business development as well as the process of democratisation of local governments, in order to strength management capacities for the development n Natural Protected Areas.
Universidad de Piura, Unidad de Proyectos Ambientales y de Desarrollo Integral (UPADI)	UPADI	University	http://www.udep.edu.pe/upadi/	UPADI is responsible for the coordination and implementation of environmental projects and rural development in the framework of dry and fog forests from Piura. It has a representation in the Regional Environmental Commission from Piura (CAR Piura), and in the national focal points from UNCCD and CBD.
Fondo Nacional del Ambiente	FONAM	Environmental Fund	http://www.fonamperu.org/default.php	FONAM aims to promote private and public investment in the development of environmental project priorized in Peru. Activities are oriented to promote investment in plans, programs, and projects oriented to improve the quality of life, sustainable use of natural resources and strengthening of capacities for an adequate environmental management.
SNV – Netherlands Development Organisation	SNV Peru	International cooperation	http://www.snvla.org/peru.htm	SNV Peru capacity building services are focused on: poverty reduction, management of forest and protected areas, integrated water management, education, and democracy and effective governability. The 3 cross-cutting themes: improvement of institutional operations (in particular public sector), equity, and reallocation, and management of conflicts.

Appendix 7. References used for collecting information

***Rio Conventions links*:**

UNFCCC: Documentation

http://unfccc.int/documentation/items/2643.php

Cooperation with international organizations

http://unfccc.int/cooperation_and_support/cooperation_with_international_organisations/items/2533.php

UNCCD: Official documents

http://www.unccd.int/

CBD: COP decisions

http://www.cbd.int/convention/decisions.shtml

Cooperation

http://www.cbd.int/cooperation/rio.shtml

Library

http://www.cbd.int/information/library.shtml?tab=1

Other web sites:

Earth Negotiations Bulletin (ENB) http://www.iisd.ca/

ENB reports ongoing multilateral negotiations on environment and sustainable development, specific links are provided for:

Climate Change http://www.iisd.ca/process/climate_atm.htm

Biodiversity http://www.iisd.ca/process/biodiv_wildlife.htm

Desertification http://www.iisd.ca/vol04/

Multilateral Environmental Agreement http://www.iisd.ca/email/mea-l.htm

Appendix 8. Questionnaire on assessing synergies in forestry projects

QUESTIONNAIRE

Question 1. Which of the three Rio Conventions do you follow? Fill the space with "X"

If you follow any other convention or forum please specify

UNFCCC	
UNCBD	
UNCCD	
Other	

Question 2. **If you are asked to evaluate a forestry project:**
Which would be the weight you will attribute to each macro-criteria for the evaluation of forestry projects?

Macro-criteria	Example (%)	Participant
Social	40	
Economic	30	
Environmental	30	
TOTAL	100	

Question 3. **In the following table, a set of micro-criteria organised by macro-criteria (social, economic and environmental) are presented.**
Can you attribute the importance of each micro-criteria?

3.1 Express the importance of each micro-criteria in terms of percentage (%)

3.2 Each group of macro-criteria (social, economic and environmental) must sum 100%

3.3 If you consider that there is a criteria which has not been addressed fill "Other:specify". Otherwise use the micro-criteria which have been proposed and if necessary add a comment to the micro-criteria.

Question 4. **If you have any comment on the choosen criteria please fill the last column**

Fill the column "any comment"

Criteria		Question 3	Question 4
		Participant	Participant
Macro-criteria	Micro-criteria	importance in %	Any comment
Social	Land tenure		
	Equitably share natural resources/benefits of development		
	Skill development		
	Ensure strong local participation		
	Spritual value maintenance		
	Other (specify):		
	TOTAL	0	
Economic	Employment		
	Financial returns to local entities		
	Infrastructure		
	Financial forestry incentives		
	Other (specify):		
	TOTAL	0	
Environmental	Use of native species being encouraged		
	Conservation and maintenance of soil resource		
	Conservation and maintenance of water resource		
	Biodiversity conservation		
	Flood prevention/protection		
	Average carbon benefit		
	Other (specify):		
	TOTAL	0	

Comments

General comments related to the criteria in the formulation or selection of forestry projects related to the Rio Conventions:

Appendix 9. Forestry micro criteria analysis

Forestry micro criteria (*)	Code (-)	Africa		America		Asia		Europe		RANKING	
		mean	s.d.	mean	s.d.	Mean	s.d.	mean	s.d.	Sum	Rank
Financial returns to local entities (+)	E2	10.20	3.41	8.78	4.68	8.10	4.15	7.77	4.93	34.86	**1**
Ensure strong local participation (+)	S4	7.95	2.46	8.81	4.77	8.87	5.11	7.49	3.93	33.12	**2**
Employment (+)	E1	8.50	2.66	8.11	4.62	6.65	3.06	6.98	3.40	30.24	**3**
Equitably share/benefits development(+)	S2	7.91	4.18	7.20	3.28	8.07	2.77	6.86	3.95	30.03	**4**
Conservation and maintenance of water resource (+)	A3	7.16	3.74	7.16	2.55	7.48	1.98	8.18	3.35	29.98	**5**
Conservation and maintenance of soil resource	A2	7.14	3.80	7.28	2.76	7.50	2.75	7.72	3.07	29.64	**6**
Land tenure	S1	6.93	2.37	7.42	4.75	8.15	6.31	6.76	4.91	29.26	**7**
Use of native species being encouraged	A1	7.25	3.38	5.29	3.83	6.61	2.85	9.98	5.90	29.13	**8**
Biodiversity conservation	A4	5.43	2.50	8.01	4.25	6.71	2.87	8.43	3.01	28.58	**9**
Financial forestry incentives	E4	7.07	3.53	5.89	3.31	5.58	3.25	5.03	3.23	23.57	**10**
Infrastructure	E3	7.59	2.52	6.43	4.46	4.03	2.34	5.00	3.44	23.05	**11**
Skill development	S3	5.02	1.77	6.20	4.20	6.12	3.00	5.14	2.95	22.48	**12**
Average carbon benefit	A6	3.44	2.71	4.11	3.96	3.81	2.04	5.62	4.63	16.99	13

(*) weight data multiplied by 100
(-) code of the criteria: S= social; E=economic; A= environmental
(+) in yellow top 5-top criteria for continents, in grey 5-top criteria by continent

Appendix 10. Additional forestry criteria proposed by participants

Social criteria	continent	Economic criteria	continent	Environmental criteria	continent
Improved Forest Law Enforcement & Governance	Africa	Encouragement of value-added process	Africa	Environmental impact assessment (EIA)	Africa
Food security, hunger & poverty reduction	Africa	Removal of trade barriers to forest products	Africa	Land use change	Africa
Ensure access to resources through control conditions	Americas	Build markets for environmental services	Africa	Forest fire prevention & control	Africa
Recuperation of local ancestral knowledge and maintenance of the culture	Americas	Providing incentives (*bonificaciones de fomento*)	Americas	Drought prevention/protection	Americas
Local planning	Americas	Traditional economy	Americas	Global environmental conservation	Americas
Sense of place, community stability	Americas	Viability: sustainable income	Americas	Fight against desertification	Americas
Ensure women participation	Americas	Area (hectares)	Americas	Programmes of environmental education	Americas
Strength local capabilities	Americas	Economic diversification	Americas	Landscape	Americas
Strength trust of actors in the social structure	Americas	Allied industries	Asia	Landscape	Asia
Indigenous rights and gender	Americas	Forest and non-forest products cost management	Asia	Prevent desertification	Asia
Good governance	Asia	Novel bioenergy production	Europe	Climate regulation	Europe
Food security	Asia	Economic sustainability	Europe		
Policy	Asia				
Extension/awareness	Asia				
Gender issues	Europe				
Recreation: hunting	Europe				

Appendix 11. Factor analysis with SPSS

Factor analysis (FA) is a statistical data reduction technique used to explain variability among observed random variables in terms of fewer unobserved random variables called factors. Factor analysis originated in psychometrics, and is used in behavioural sciences, social sciences, marketing, product management, operations research, and other applied sciences that deal with large quantities of data.
Some aspects related to the procedure carried out for the thesis are briefly summarised. Three main steps are described:

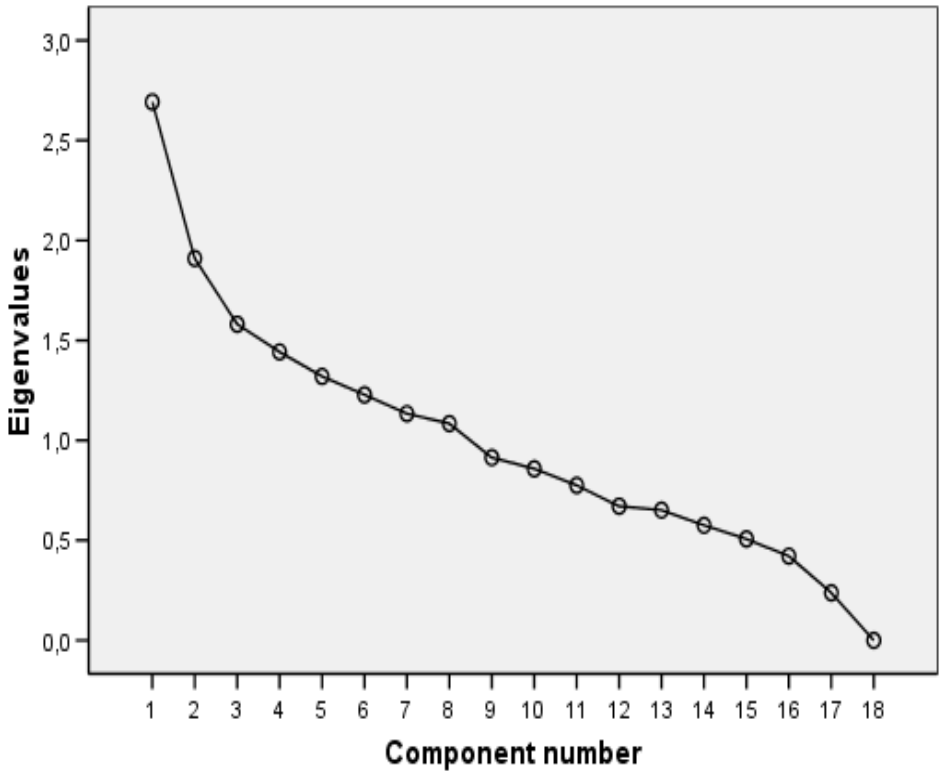
Factor Analysis Descriptive
Information on **statistics** and **correlation matrix** is given. For the statistic part, the mean, standard deviation, and number of valid cases for each variable are included. Also, initial solution displays initial communalities, eigenvalues, and the percentage of variance explained. For the correlation matrix, there are options for coefficients, significance levels, determinant, KMO and Bartlett's test of sphericity, inverse, reproduced, and anti-image. In particular, the **KMO** and **Bartlett's Test** of **Sphericity** were considered as initial indicators of the suitability of data for structure detection.
The Kaiser-Meyer-Olkin measure of sampling adequacy tests whether the partial correlations among variables are small, in other words, is a statistic that indicates the proportion of variance in your variables that might be caused by underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful with your data. If the value is less than 0.50, the results of the factor analysis probably won't be very useful. Bartlett's test of sphericity tests the hypothesis that your correlation matrix is an identity matrix, which would indicate that your variables are unrelated and therefore unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that a factor analysis may be useful with your data.

Factor Analysis Extraction
In this part it is possible to choose the method of factor extraction, these methods are principal components, unweighted least squares, generalized least squares, maximum likelihood, principal axis factoring, alpha factoring, and image factoring. For the purpose of the research, the **Principal Component Analysis** (PCA) was selected. The PCA is used to form uncorrelated linear combinations of the observed variables. Then, the first component has maximum variance; instead successive components explain progressively smaller portions of the variance and are all uncorrelated with each other. For the analysis, a **correlation matrix** was display, and is useful if variables in the analysis are measured on different scales. It is possible also to specify all factor whose **eigenvalues** exceed a specified value or retain a specific number of factors. For the thesis, 5 factors were specified, after evaluating results without any specification of factors (8) and with 7, 6, and 4 factors. At the end, is possible to get a screen plot of the eigenvalues (graphical representation of the eigenvalues).

Factor Analysis Rotation
In this part, it is possible to select the method of factor rotation, these are: varimax, direct oblimin, quartimax, equamax, or promax. After analysing the different methods, for the thesis, the **varimax method** was considered. The varimax method is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors. Final a rotation matrix is display and from there it is possible to start with identification of the factors.

More detail information is found in: http://www.statsoft.com/textbook/stathome.html

Appendix 12. Screen plot with the eigenvalues of the factors



Appendix 13. Analysis of the different specified factors

Criteria for choosing the number of factors:

a) total variance which is explained with the different number of factors specified,

b) forestry criteria associated criteria to each factor, and

c) the expected range of factors to be considered, between 17-33%

Specification	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Variance (%)	Range (%)
8 factors:	15 Conservation soilwater/biodiversity	11 Carbon sequestration/flood, not equitable share/land tenure	9 Skill development/local participation, not financial returns	8 Infraestructure/financial incentives	7 Spiritual value/not financial returns	7 Not employment/enhace flood prevention	6 Other economic and environmental criteria	6 Other social, not native species	**69**	**44**
7 factors:	15 Conservation soilwater/biodiversity	11 Carbon sequestration/flood, not equitable share/land tenure	9 Skill development/local participation, not financial returns	8 Infraestructure/financial incentives	7 Not employment, not native species	7 Spiritual value, other social criteria	6 Other economic and environmental criteria		**63**	**39**
6 factors:	15 Conservation soilwater/biodiversity	11 Carbon sequestration/flood, not equitable share/land tenure	9 Skill development/local participation, not financial returns	8 Infraestructure and financial incentives, not native species	7 Spiritual value, other social criteria	7 Other economic and environmental criteria			**57**	**33**
5 factors:	15 Conservation soilwater, not infraestructure/financial incentives	11 Carbon sequestration/flood prevention, not land tenure,equitable share	9 Skill development/local participation,not financial returns	8 Spiritual value, not native species/employment	7 Other economic/environmental criteria, financial forestry incentives				**50**	**28**
4 factors:	15 Spiritual value, not employment/financial returns	11 Conservation soilwater, not Infraestructure/final incentives	9 Carbon sequestration/flood, not land tenure/equitable share	8 Not skill development/local participation					**42**	**22**

Note: the range, expressed in percentage, have been calculated by dividing the number of factors by 18, which is the total number of criteria under evaluation.

Appendix 14. Multiple Correspondance Analysis (MCA)

Correspondence analysis (CA) is a descriptive/exploratory technique designed to analyze simple two-way and multi-way tables containing some measure of correspondence between the rows and columns. The Multiple Correspondence Analysis (MCA) is an extension of simple CA to more than two variables. This analysis is carried out on an indicator matrix with cases as rows and categories of variables as columns. Actually, one usually analyzes the inner product of such a matrix.

Analyzing the design matrix: results of the MCA would provide column coordinates that would allow relating the different categories to each other, based on the distances between the row points. The approach to analyze data can easily be extended to more than two categorical variables.

Fuzzy coding: It is not necessary that each case is assigned exclusively to only one category of each categorical variable. Rather than the *0*-or-*1* coding scheme, one could enter probabilities for membership in a category, or some other measure that represents a fuzzy rule for group membership

Interpretation of coordinates and other results: the interpretation of coordinate values, quality values, cosine^2's and other statistics reported as the results from a MCA can be interpreted in the same manner as described in the context of the simple CA.

Supplementary column points and "multiple regression" for categorical variables: another application of the analysis of design matrices via correspondence analysis techniques is that it allows you to perform the equivalent of a Multiple Regression for categorical variables, by adding supplementary columns to the design matrix.

The Burt table**:** computations in MCA are not performed on a design or indicator matrix (which, potentially, may be very large if there are many cases), but on the inner product of this matrix; this matrix is also called the *Burt* matrix. With frequency tables, these amounts tabulating the stacked categories against each other.
The Burt table is the result of the inner product of a design or indicator matrix, and the MCA results are identical to the results one would obtain for the column points from a simple correspondence analysis of the indicator or design matrix.

More detail information is found in: http://www.statsoft.com/textbook/stcoran.html

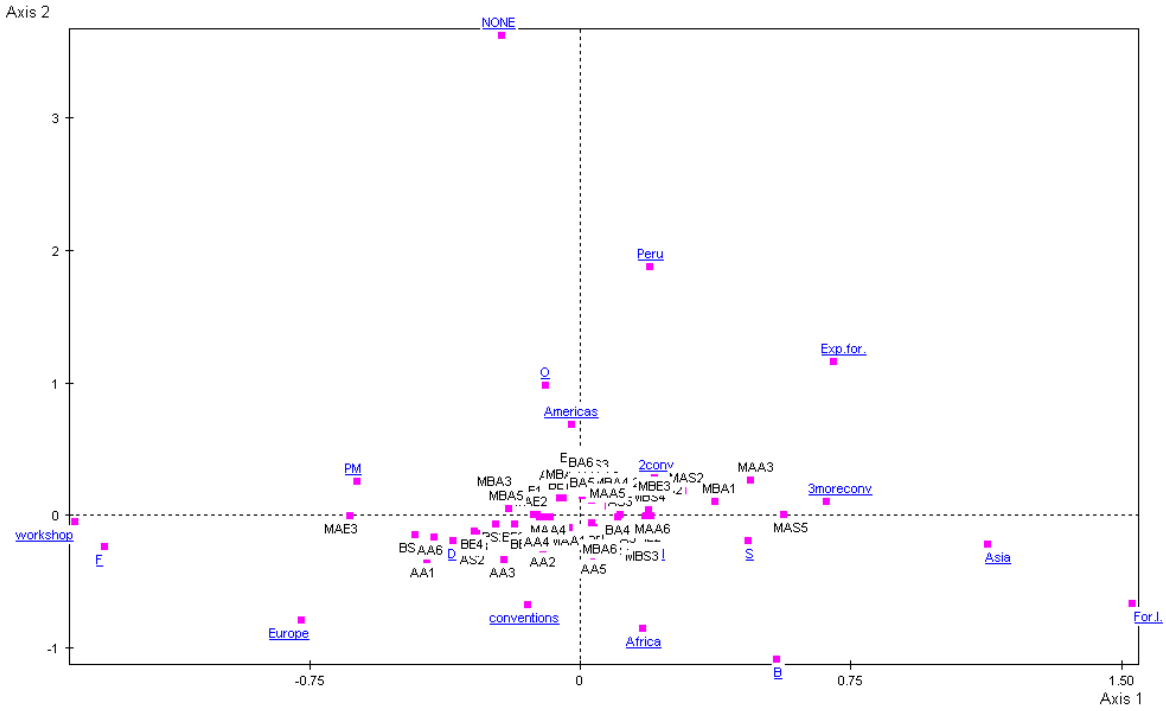
Appendix 15. Multiple Correspondance Analysis results

Coordonnées des modalités actives							
Libellé	**Poids relatif**	**Distance à l'origine**	**Axe 1**	**Axe 2**	**Axe 3**	**Axe 4**	**Axe 5**
CODICE_G							
Conventions (*Rio Conventions*)	5,789	3,31818	-0,14	-0,68	-0,80	-0,42	0,32
Workshop	4,737	4,27778	-1,40	-0,06	0,73	-0,51	-0,13
Exp.for. (*Forestry experts*)	2,105	10,87500	0,70	1,16	-0,37	-1,00	-1,96
For.I. (*Forestry institutions*)	2,632	8,50000	1,53	-0,67	0,57	-0,75	0,59
Peru (*Field visit in Peru*)	2,632	8,50000	0,19	1,88	-0,35	0,07	1,31
Mail (*Forestry-Mailing List*)	7,105	2,51852	0,20	-0,20	0,19	1,23	-0,30
CODICE_A							
PM (policymaker)	10,790	1,31707	-0,62	0,26	0,41	0,26	-0,10
S (scientist)	14,211	0,75926	0,47	-0,19	-0,31	-0,20	0,08
Continente numerico							
Americas	12,105	1,06522	-0,02	0,68	-0,10	-0,08	0,32
Asia	3,947	5,33333	1,13	-0,22	0,58	0,28	-1,29
Africa	2,895	7,63636	0,17	-0,86	1,47	-0,55	0,94
Europe	6,053	3,13043	-0,77	-0,80	-0,88	0,25	-0,24
codici convenzioni aggregati							
NONE	0,526	46,50000	-0,22	3,63	-0,09	-0,94	-0,45
B (CBD)	3,158	6,91667	0,54	-1,10	-0,19	0,48	0,47
D (UNCCD)	2,105	10,87500	-0,35	-0,20	-1,87	-0,75	0,39
F (UNFCCC)	5,263	3,75000	-1,32	-0,25	0,60	-0,28	-0,28
O (Other)	1,053	22,75000	-0,09	0,97	-0,36	3,11	1,12
2conv (2 Conventions)	5,526	3,52381	0,21	0,28	-0,58	0,04	-0,62
3moreconv (More than 3 Conventions)	7,368	2,39286	0,68	0,10	0,68	-0,20	0,22

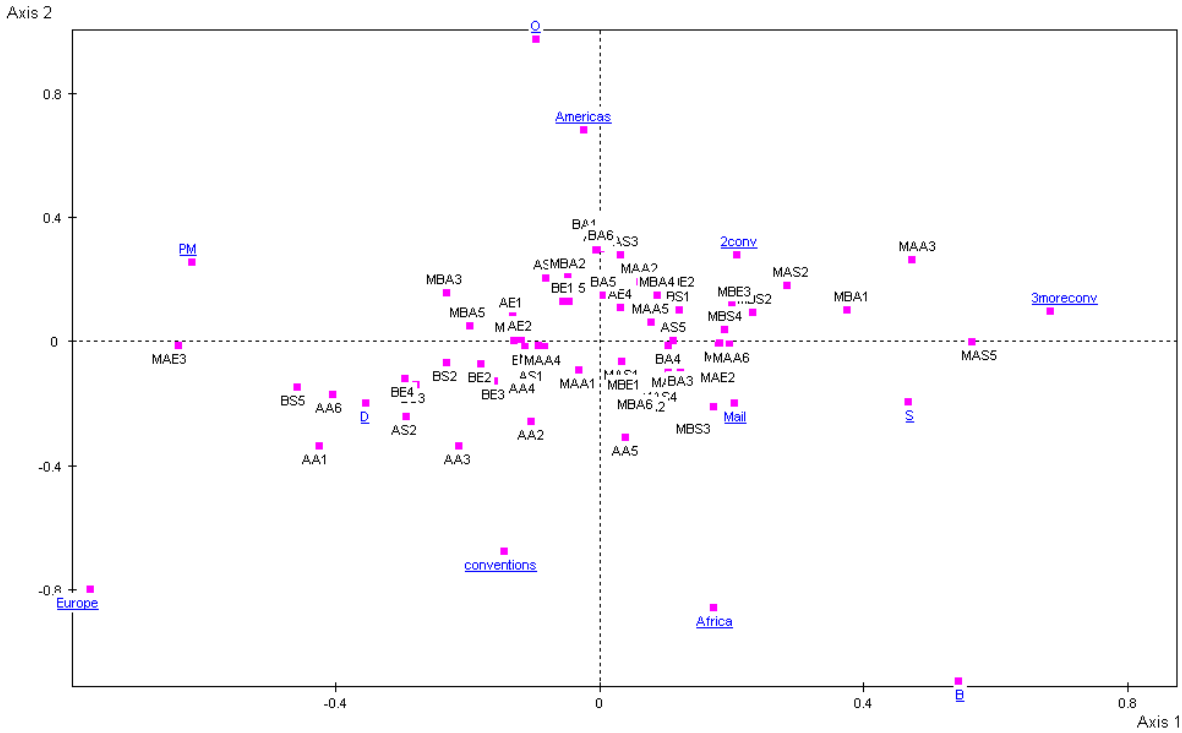
Contributions des modalités actives							
Libellé	**Poids relatif**	**Distance à l'origine**	**Axe 1**	**Axe 2**	**Axe 3**	**Axe 4**	**Axe 5**
CODICE_G							
Conventions (*Rio Conventions*)	5,789	3,31818	0,26	6,34	**9,70**	3,05	1,91
Workshop	4,737	4,27778	**19,78**	0,04	**6,65**	3,75	0,25
Exp.for. (*Forestry experts*)	2,105	10,87500	2,21	6,76	0,75	**6,44**	**26,04**
For.I. (*Forestry institutions*)	2,632	8,50000	**13,15**	2,84	2,22	4,54	2,92
Peru (*Field visit in Peru*)	2,632	8,50000	0,21	**22,16**	0,84	0,04	14,49
Mail (*Forestry-Mailing List*)	7,105	2,51852	0,63	0,68	0,68	32,73	2,00
			36,23	38,81	20,85	50,54	47,62
CODICE_A							
PM (policymaker)	10,790	1,31707	8,72	1,68	4,76	2,18	0,34
S (scientist)	14,211	0,75926	6,62	1,28	3,61	1,66	0,26
			15,34	2,96	8,37	3,84	0,60
Continente numerico							
Americas	12,105	1,06522	0,01	**13,29**	0,33	0,26	3,93
Asia	3,947	5,33333	**10,70**	0,46	3,45	0,93	**21,27**
Africa	2,895	7,63636	0,18	5,09	**16,24**	2,70	8,28
Europe	6,053	3,13043	7,66	9,27	12,10	1,17	1,15
			18,56	28,11	32,13	5,06	34,63
codici convenzioni aggregati							
NONE	0,526	46,50000	0,05	16,52	0,01	1,43	0,34
B (CBD)	3,158	6,91667	1,99	9,08	0,30	2,26	2,27
D (UNCCD)	2,105	10,87500	0,56	0,20	**19,23**	3,59	1,05
F (UNFCCC)	5,263	3,75000	**19,44**	0,75	4,91	1,27	1,33
O (Other)	1,053	22,75000	0,02	2,38	0,35	**31,06**	4,27
2conv (2 Conventions)	5,526	3,52381	0,51	1,02	4,89	0,03	**6,76**
3moreconv (More than 3 Conventions)	7,368	2,39286	7,29	0,16	8,97	0,91	1,14
			29,86	30,11	38,65	40,56	17,15

Appendix 16. Representation of the nominal active and illustrative variables

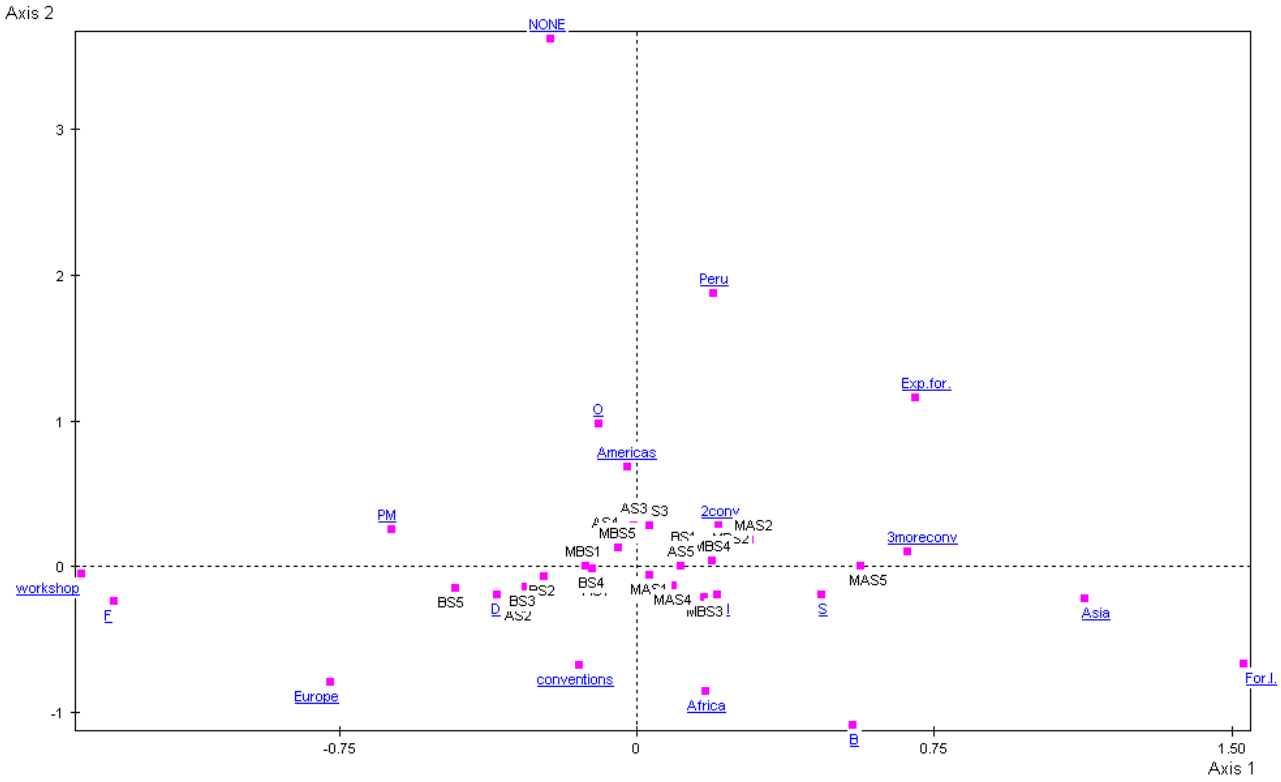
Set social, economic and environmental criteria + nominal active variables:



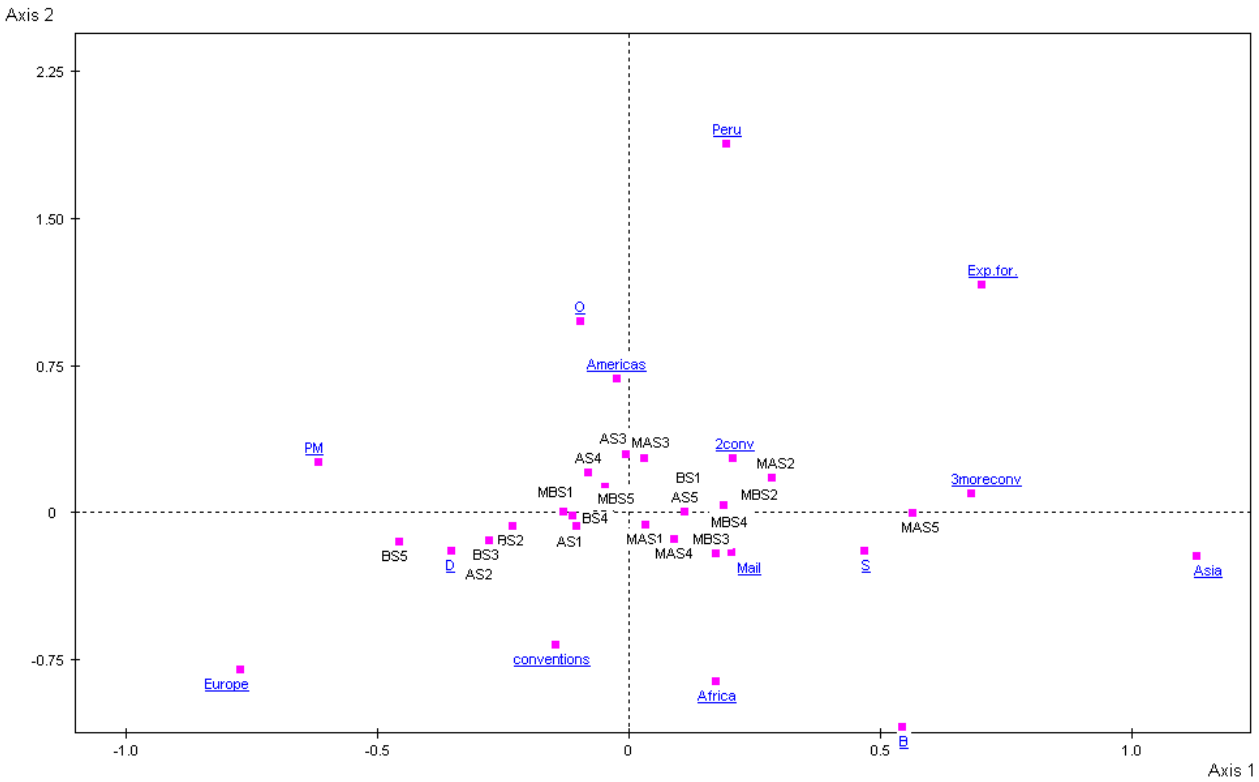
Enlargement of the graphic:



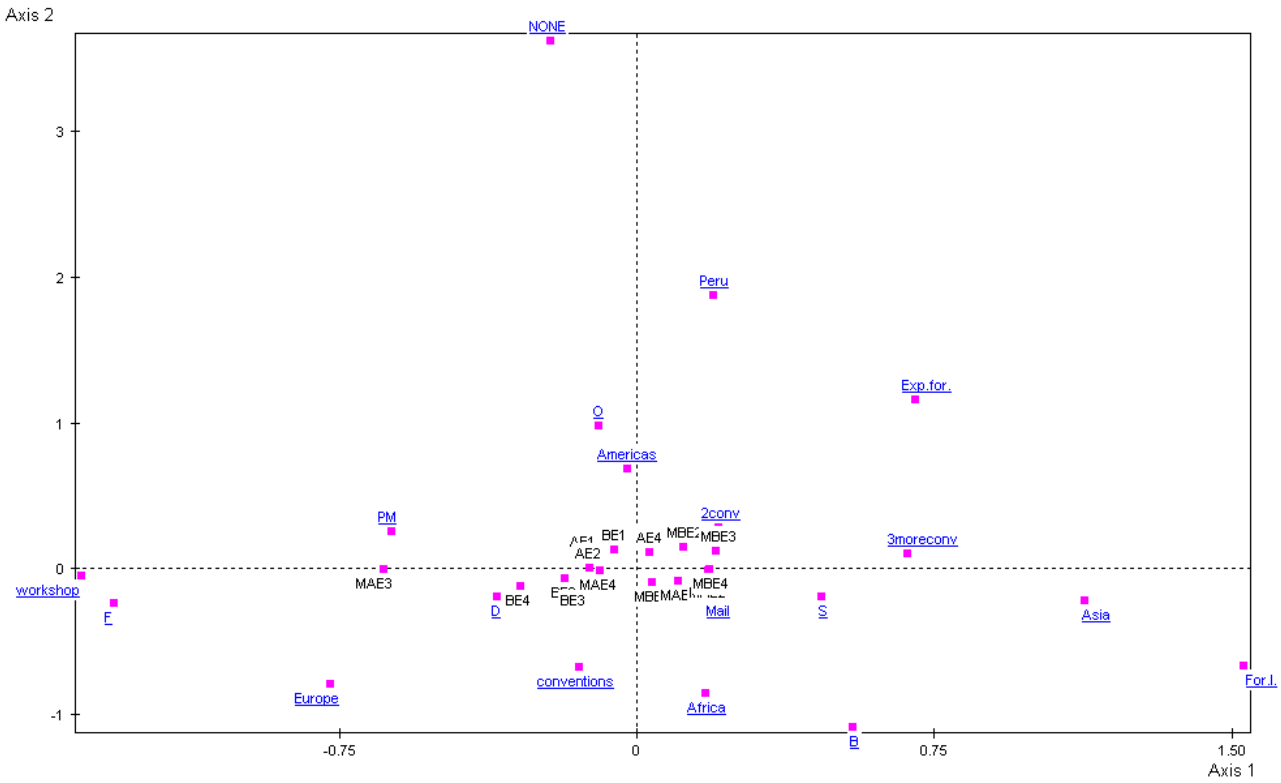
Set social criteria + nominal active variables:



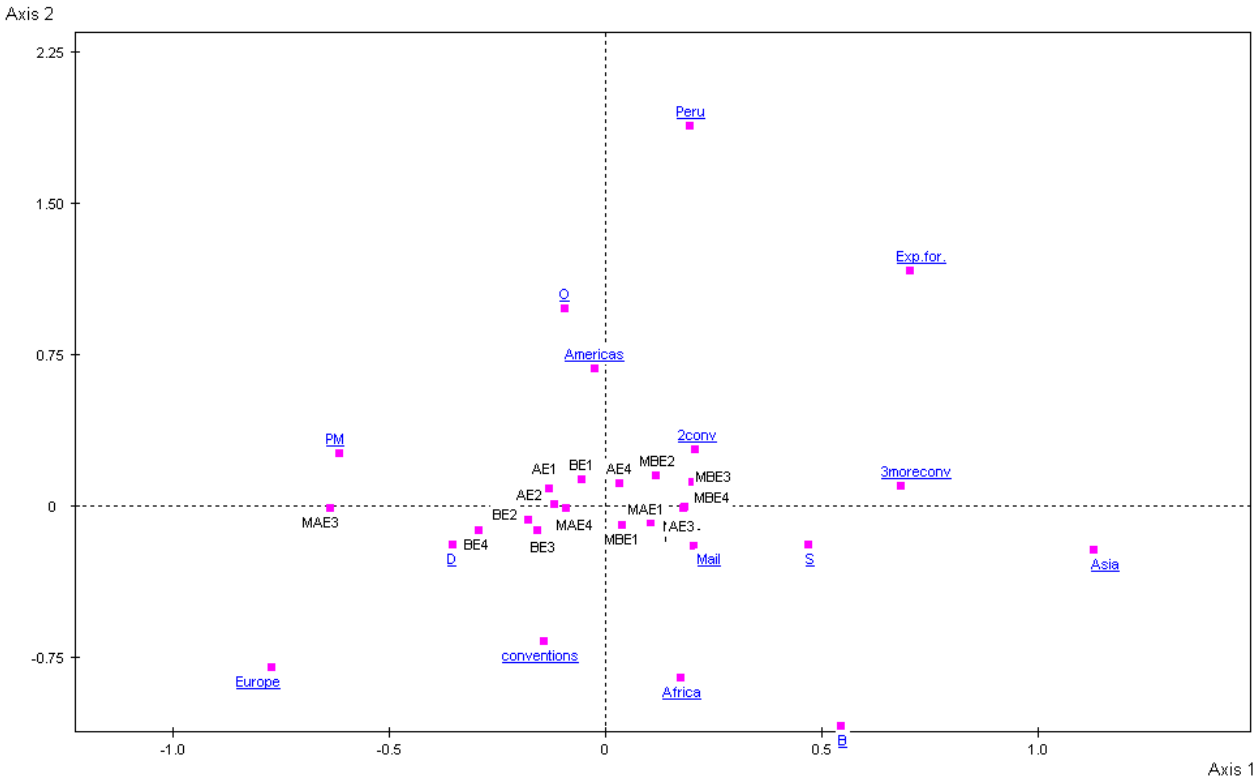
Enlargement of the graphic:



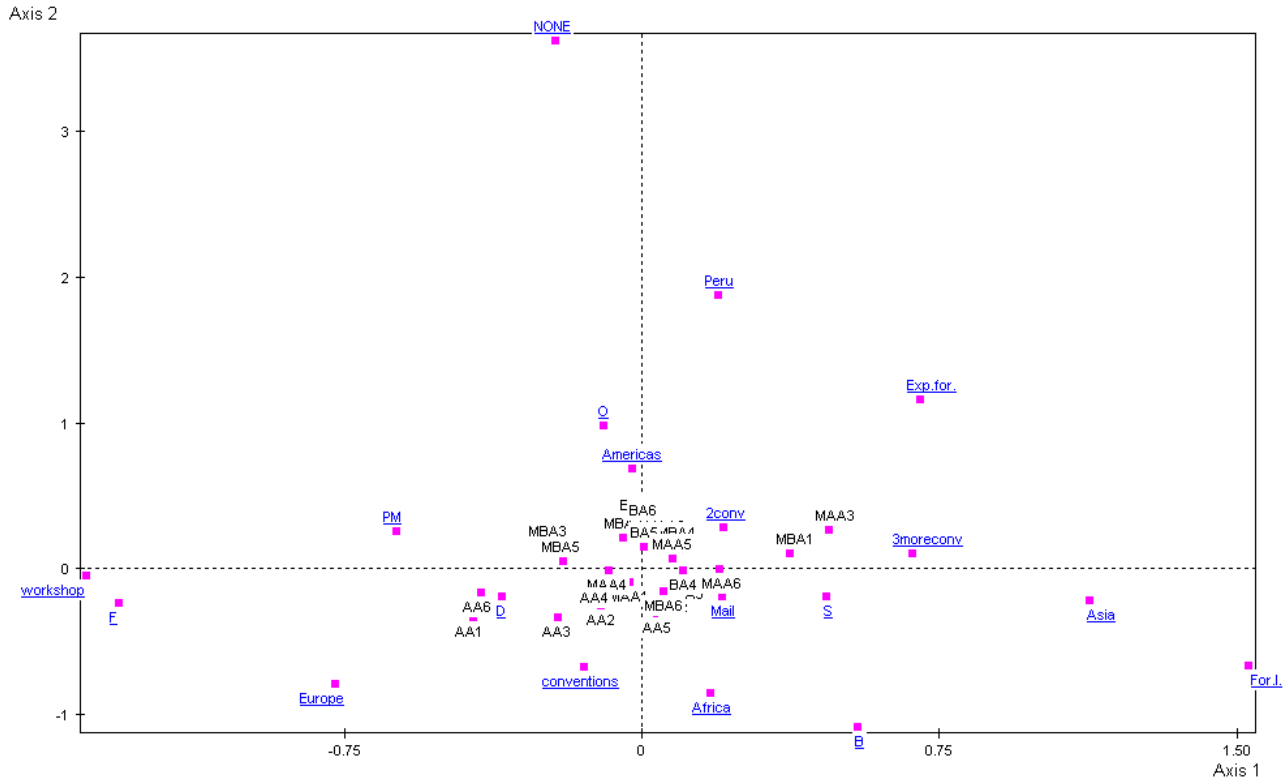
Set of economic criteria + nominal active variables:



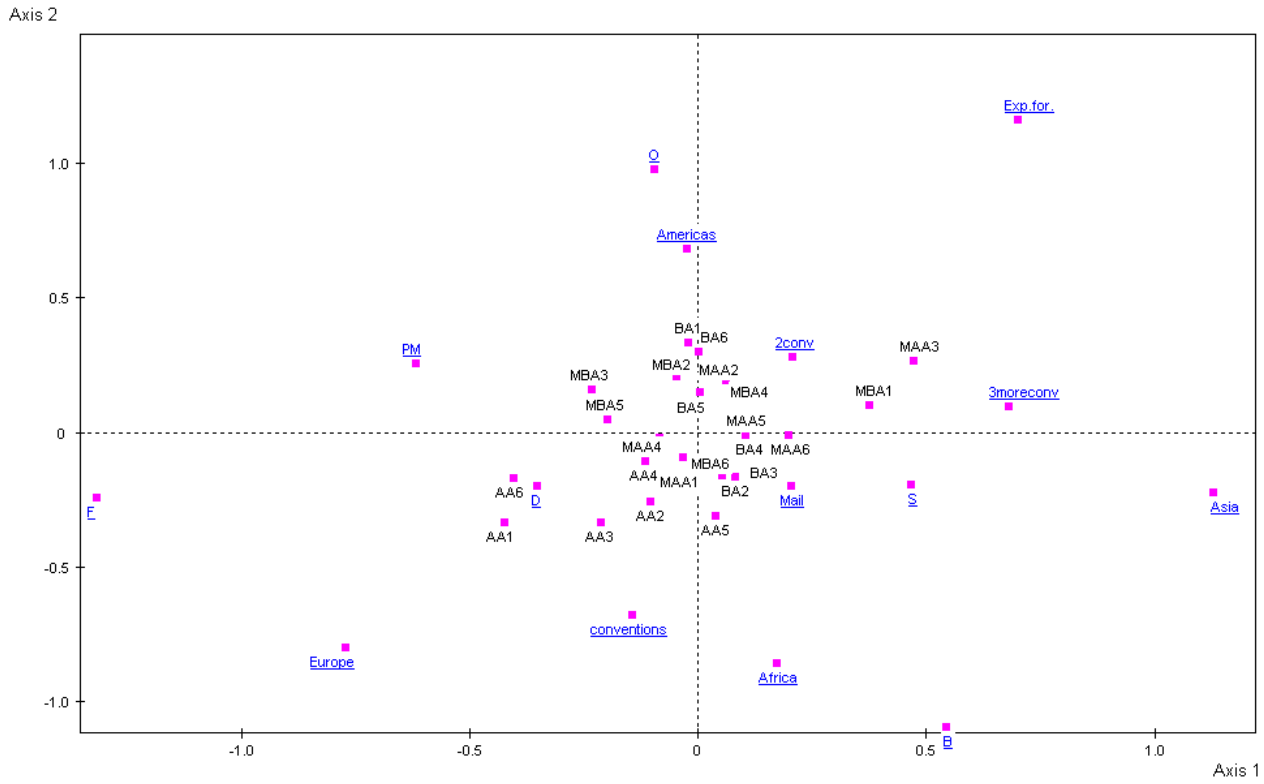
Enlargement of the graphic:



Set of environmental criteria + nominal active variables:

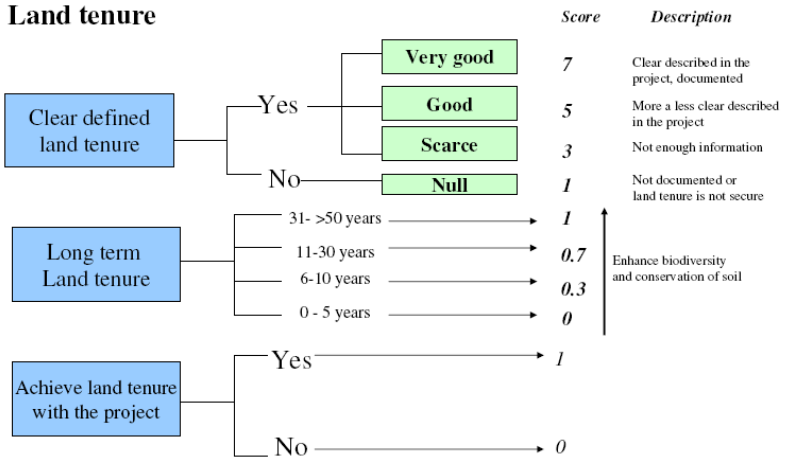


Enlargement of the graphic:

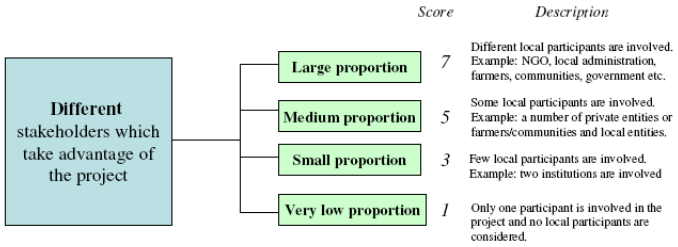


Appendix 17. Description of the scale of evaluation of forestry criteria

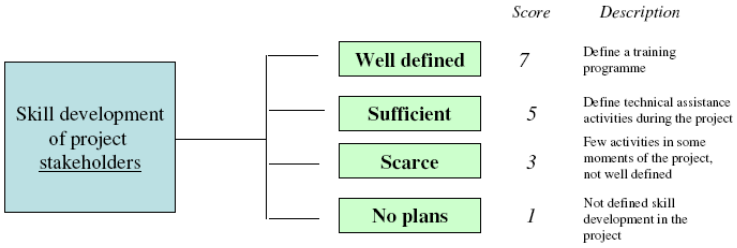
Land tenure



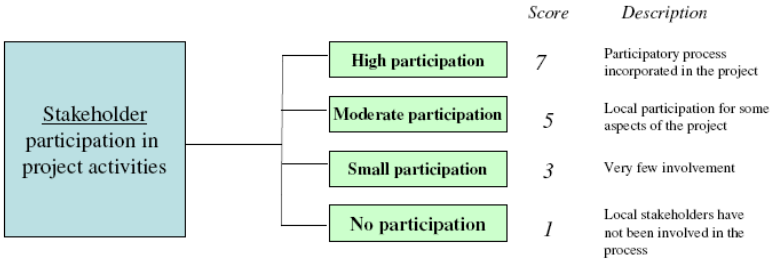
Equitably share natural resources/benefits of development



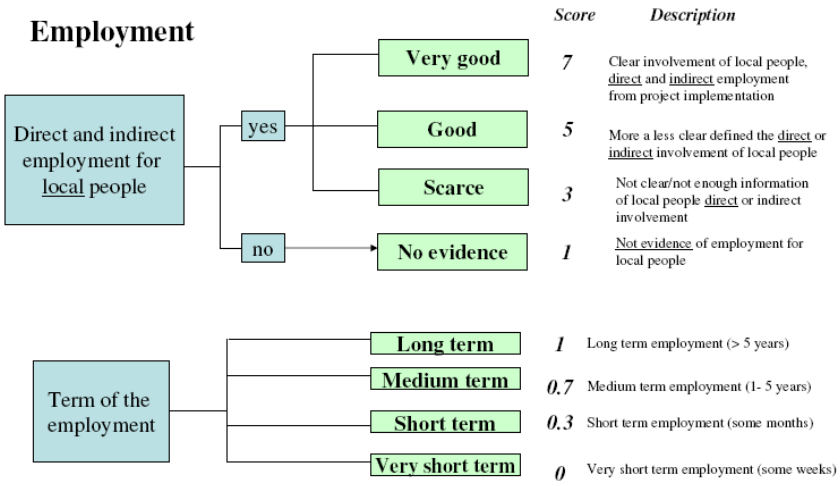
Skill development



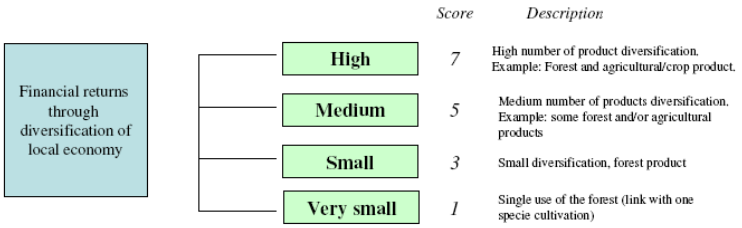
Ensure strong local participation



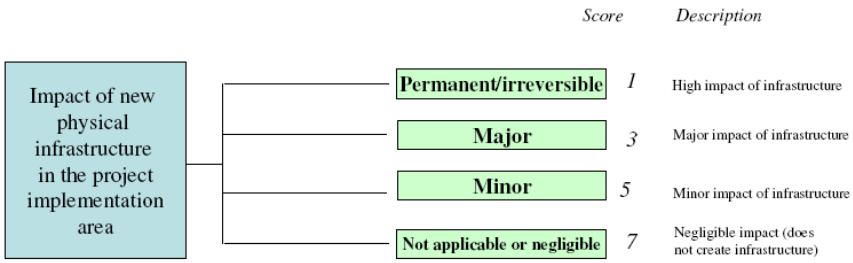
Employment



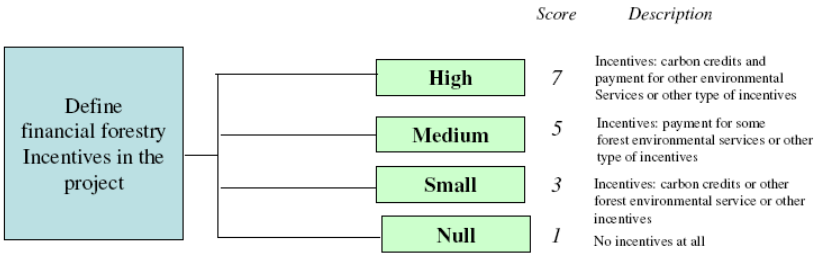
Financial returns to local entities (stakeholders)



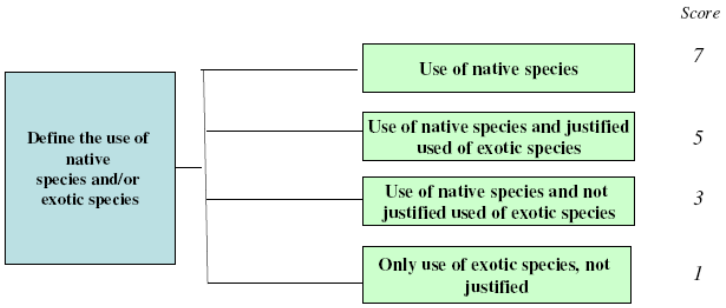
Infrastructure (creates housing, road and other infrastructure needs)



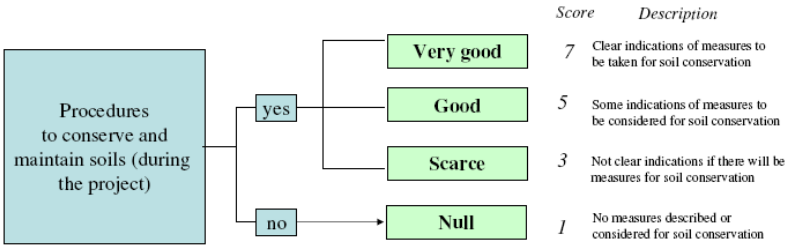
Financial forestry incentives



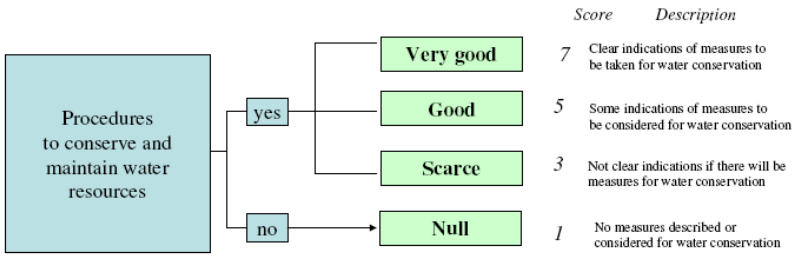
Use of native species



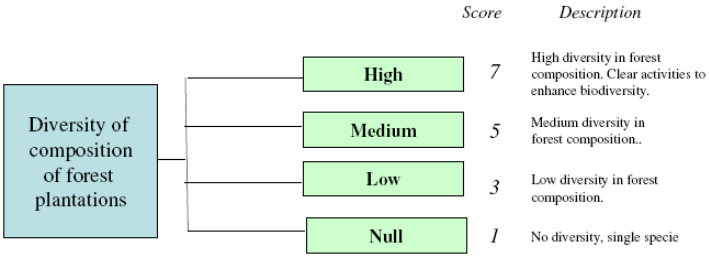
Conservation and maintenance of soil resource



Conservation and maintenance of water resource



Biodiversity conservation



Appendix 18. Forestry expert interview: scale of evaluation of forestry projects

General comments

General suggestions on methodological aspects were addressed by experts:

1. The use of the "Yes" or "No" during the evaluation of projects. Therefore, an agreement has been reached with experts in order to use "yes" or "no" questions only for some criteria.
2. Consistency among the scale of forestry criteria, therefore, the use of scales for all criteria which goes from 1 to 7 for all criteria was implemented. Besides, a clear explanation for the use of the different scales was suggested.

Other suggestions have addressed the need for interviewing the **manager** of the forestry projects. On one hand, this can be an interesting idea while trying to incorporate field. Actually, national experts which have been interviewed for this research are linked directly to international projects. On the other hand, managers from the projects are not involved directly in this decision aiding process, at least not in this phase of the research. Therefore, they have not been considered during the interview process.

Some experts have proposed the use of a quantitative value for criteria for monitoring forestry projects. Criteria which have been defined are not used for monitoring, where quantification is useful, but they have been proposed in a decision aiding process, where the assessment of synergies at project level is evaluated. On the other hand, an expert has commented on the flexibility of the criteria, which depends if criteria are quantitative or qualitative. Thus, some forestry criteria are very rigid, since they are quantitatively evaluated, but at the same time criteria assure to measure accurately. However, when criteria are not rigid many projects are accepted, therefore, general criteria are needed and they have to be qualitative.

Some comments were also related to the set of forestry criteria itself. A participant has argued that **many set of criteria** have already been proposed. For example, GEF (donor) use some criteria for evaluation and then FAO (implementing) use other type of criteria. What is more, at field level there are also set of criteria which are proposed mainly by NGO, directly representing in many cases local farmers. Therefore, it has to be clear specifying the purpose of criteria, developed specifically in a decision aiding process and **strong** for demonstrating synergies among the Rio Convention at forestry project level.

Comments on forestry criteria

Land tenure

For the evaluation of land tenure, different suggestions were received. For instance, it was suggested to prepare a matrix which considers different type of forests for the long term land tenure indicator. On the other hand, an expert claimed that from a technical point of view, the number of year's minimum for land tenure should be at least 50 years. Then, theoretically requirements point a land tenure of minimum 50 years, but farmers are willing to have a forest plantation only if incomes are available in some year's time (3-5 years) minimum, therefore, land tenure issues are important.

An expert has addressed that land tenure is also an issue that depends very much on the country where forestry projects are implemented. Then, in developing countries this is a huge issue, for OECD countries is not. Other issues, which are related to land tenure, are the owner of the crop, carbon credits, etc.

Equitable share of natural resources

Different participants have agreed to consider qualitative information for this criterion, others prefer also quantitative information. For this research, quantitative information was not available; therefore, qualitative information was gathered from the PDD. Furthermore, some comments related to the difficult of achieving equity were addressed. In real-world, in the forestry sector there is a multi-stakeholder situation in which there is inequity. Thus, the power to negotiate is different for the stakeholders. Therefore, it could happen that a stakeholder can have some rights, but do not have the power to negotiate; therefore, an inequity situation appears evident.

Skill development

An expert has suggested that skill development could consider: a) expertise (academic knowledge) and b) experience (application, practical). Therefore, for this research, the indicator was specified for the second option. Different experts considered that this criterion is very important and should be always present in forestry projects.

In the framework of PDD projects, there are no specific requests for describing skill development activities. However, when this type of activities is present in a project, they are described because they can ensure the sustainability of the project.

Ensure local participation

An expert has addressed the types of local participation in forestry projects: a) dialog, b) advising, and c) true participation (partner). In real-world what happens is that sometimes participation is only dialog, and not true participation. Sometimes there is dialog in one direction, this means that there is only advising. On the other hand, this criterion is very important for forestry projects, in particular, CDM A/R projects have it as requirement.

Employment

The generation of direct and indirect employment is one aspect considered for this research. However, an expert suggested also considering how the situation of employment is. Therefore, if there are: employees (wage), with union rights, ILO rights, remuneration; contracts, no rights, employ today but not tomorrow, and casual/informal. This is very specific information which sometimes is specified in forestry projects.

On the other hand, an expert has highlighted the importance of direct and indirect employment. Since, the indirect employment can guarantee the sustainability of the project. Only one of the experts considers that probably the term of employment is not important, since forestry projects activities are mainly concentrated in the first years. However, including both direct and indirect employment can considered also short, medium and long term.

Financial returns to local entities
The diversification of local economy has been correlated with ensuring financial returns to local entities, from a synergistic perspective issues such as biodiversity, sustainability, etc are considered. An expert has provided an example. For instance, higher financial returns can be achieved with one forest plantation; however, there is very low diversification of economy. On the other hand, agroforestry projects can have a lower financial return compared to an industrial plantation, but diversification contributes with biodiversity and the sustainability of the project.
Another expert has highlighted the importance of diversification, therefore, taking into account forestry and agricultural products. One participant has suggested to change the name of the criteria to "financial diversification of returns to local entities or "spread of financial risk".
Infrastructure
An expert highlighted that the criterion can assess positive and negative impacts. Therefore, for this research it has been evaluated the negative impact, since this information is most of the time available in the description of the projects. On the other hand, when assessing positive effects of the infrastructure criterion, the social point of view is considered. In many cases the development of isolated communities is linked to the infrastructure developed by the project. For example, logging concessions normally are asked to build roads, houses, this could have a high positive impact for local communities. Moreover, an expert described that if roads are done with certain measures and good practise there will not be impact. Nevertheless, there can be a negative aspect of infrastructure, which is the encouragement for example of illegal logging.
Financial forestry incentives
For financial incentives carbon credits (carbon sequestration) and other environmental service were considered, but also importance is given to other services which can also incentive forestry projects. This criterion has been appreciated by experts. Since, the assessment of projects considers in forestry project and not only CDM forestry projects, other environmental services were also considered important. On the other hand, this criterion is not dealing with the beneficiary of the incentives, but with the different type of incentives which can be considered. For example, CDM forestry projects need to comply with the "additionality" requirement, therefore, demonstrating that emission reductions must be beyond what would have happened in the absence of the project. Like this projects are accepted under the Kyoto Protocol mechanism.
Use of native species
This issue is very important, in particular for the CBD, which discourage the use of exotic species. For this reason, a separate criterion has been considered from the "biodiversity conservation criterion". On the other hand, experts have addressed that there are situations where species have being already introduced for some years, therefore, they are not anymore considered exotic species.
Conservation and maintenance of soil/water resources (quality and quantity)
Experts have recommended that this criterion should include characteristics that are needed to achieve conservation and maintenance of the soil resource. Moreover, they have highlighted the importance, because even if it is implicit, for many years little importance has been given.
On the other hand, forest ecosystems provide as environmental service the conservation and maintenance of soil resource. Therefore, the criteria should be concentrated in describe how to conserve the environmental service.
Biodiversity conservation
For this criterion two levels were considered: genetic and population (already the specie level was considered). Experts have suggested providing an orientation for high, medium and low biodiversity. Therefore, it should be evidence in the project activities which will encourage biodiversity. An expert has provided an example with a project in China, where there a project used a single specie (Poplar), which can initially help to stop desertification process, but can be good only for the beginning (colonization), after biodiversity should be encourage.
Average carbon benefit
This criterion was proposed to all experts, and all of them agreed that it was not necessary to have it as criterion when evaluating forestry projects.
This criterion is an important issue for CDM forestry projects (Kyoto mechanism). However, for this particular situation in which forestry projects from different parts of the world are evaluated experts agree that is not possible to compare among forestry projects. An expert has mentioned that the net carbon sequestration balance considers sink and emissions from forestry projects, and that in general forestry projects implicitely contribute with an average carbon benefit. Furthermore, an expert has commented that biomass burning is an important issue, instead transport and fertilizers, are issues which sometimes can not be avoided, because of local or regional situations in which projects are implemented. On the other hand, an expert considered important the use of fire as a practise, land clear, land management. But, also other issues such as healthy, vitally and productive of forests were addressed, as they are becoming important in the context of climate change. Since, trees are under stress, they are exposed and vulnerable to insects, fires, etc.

Appendix 19. ELECTRE TRI procedures

Equations which are shown in this section have been taken from the Manual of ELECTRE TRI (Mousseau *et al*., 2001; 1999):

- Partial concordance indices $cj(a,b_h)$ and $cj(b_h,a)$, for increasing direction of preferences

$$\left.\begin{array}{l} \text{if } g_j(a) \leq g_j(b_h) - p_j(b_h), \text{ then } c_j(a,b_h)=0 \\ \text{if } g_j(b_h) - p_j(b_h) < g_j(a) \leq g_j(b_h) - q_j(b_h), \\ \\ \text{then} \quad c_j(a,b_h) = \dfrac{g_j(a) - g_j(b_h) + p_j(b_h)}{p_j(b_n) - q_j(b_h)} \\ \\ \text{if } g_j(b_h) - q_j(b_h) < g_j(a), \text{ then } c_j(a,b_h)=1 \end{array}\right\}$$

$$\left.\begin{array}{l} \text{if } g_j(a) \geq g_j(b_h) + p_j(b_h), \text{ then } c_j(b_h,a)=0 \\ \text{if } g_j(b_h) + q_j(b_h) \leq g_j(a) < g_j(b_h) + p_j(b_h), \\ \\ \text{then} \quad c_j(b_h,a) = \dfrac{g_j(b_h) - g_j(a) + p_j(b_h)}{p_j(b_n) - q_j(b_h)} \\ \\ \text{if } g_j(a) < g_j(b_h) + q_j(b_h), \text{ then } c_j(b_h,a)=1 \end{array}\right\}$$

- Overall concordance indices $c(a,b_h)$

$$c(a,b_h) = \frac{\sum_{j \in F} k_j \; c_j(a,b_h)}{\sum_{j \in F} k_j}$$

$$c(b_h,a) = \frac{\sum_{j \in F} k_j \; c_j(b_h,a)}{\sum_{j \in F} k_j}$$

- Partial discordance indices $dj(a,b_h)$ and $dj(b_h,a)$, for increasing direction of preferences:

$$\left.\begin{array}{l} \text{if } g_j(a) > g_j(b_h) - p_j(b_h), \text{ then } d_j(a,b_h)=0 \\ \text{if } g_j(b_h) - v_j(b_h) < g_j(a) \leq g_j(b_h) - p_j(b_h), \\ \\ \text{then} \quad d_j(a,b_h) = \dfrac{g_j(b_h) - g_j(a) - p_j(b_h)}{v_j(b_h) - p_j(b_h)} \\ \\ \text{if } g_j(b_h) - v_j(b_h) \geq g_j(a), \text{ then } d_j(a,b_h)=1 \end{array}\right\}$$

$$\left.\begin{array}{l} \text{if } g_j(a) \leq g_j(b_h) + p_j(b_h), \text{ then } d_j(b_h,a)=0 \\ \text{if } g_j(b_h) + p_j(b_h) < g_j(a) \leq g_j(b_h) + v_j(b_h), \\ \\ \text{then} \quad d_j(b_h,a) = \dfrac{g_j(a) - g_j(b_h) - p_j(b_h)}{v_j(b_h) - p_j(b_h)} \\ \\ \text{if } g_j(a) > g_j(b_h) + v_j(b_h), \text{ then } d_j(b_h,a)=1 \end{array}\right\}$$

- Credibility indices $\sigma(a,b_h)$
  1. when no criteria are discordant, the credibility of the outranking relation $\sigma(a,b_h)$ is equal to the concordance index,
  2. when a discordant criterion opposes a veto to the assertion "a outranks b_h (i.e., $dj(a,b_h)$=1), then credibility index $\sigma(a,b_h)$ becomes null (the assertion "a outranks b_h is not credible at all),
  3. when a discordant criterion is such that $c(a,b_h)<dj(a,b_h)<1$, the credibility index $\sigma(a,b_h)$ becomes lower than the concordance index $c(a,b_h)$, due to the effect of the opposition on this criterion.

$$\sigma(a,b_h) = c(a,b_h)\prod_{j\in F}\frac{1-d_j(a,b_h)}{1-c(a,b_h)}$$

- λ-cut of the fuzzy relation in order to obtain a crisp outranking relation

  - $\sigma(a,b_h) \geq \lambda$ and $\sigma(b_h, a) \geq \lambda \Rightarrow aSb_h$ and $b_hSa \Rightarrow aIb_h$, i.e., a is indifferent to b_h,
  - $\sigma(a,b_h) \geq \lambda$ and $\sigma(b_h,a) < \lambda \Rightarrow aSb_h$ and not $b_hSa \Rightarrow a \succ b_h$, i.e., a is preferred to b_h (weakly or strongly)
  - $\sigma(a,b_h) < \lambda$ and $\sigma(b_h,a) \geq \lambda \Rightarrow$ not aSb_h and $b_hSa \Rightarrow b_h \succ a$, i.e., b_h is preferred to a (weakly or strongly)
  - $\sigma(a,b_h) < \lambda$ and $\sigma(b_h,a) < \lambda \Rightarrow$ not aSb_h and not $b_hSa \Rightarrow aRb_h$, i.e., a is incomparable to b_h.

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