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Social Multi-Criteria Evaluation in practice: Two real-world case studies

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This dissertation is the last step of a journey that started seven years ago. After being a sales engineer in a Chilean oil company for two years and travelling around United States for about 5 month, I decided to back to the university to study something related with sustainability (which in those times was a new word for me). This was a huge turn in my life, and as always my family support my decision. Gladys and Víctor (my parents), and Rodrigo, Paola and Andrés (my siblings) were always behind me, supporting me and making me feeling that I was going in *my* right direction.

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Abstract

The following dissertation presents two case studies in which I have applied Social Multi-Criteria Evaluation (SMCE), and also presents some learned lessons from these experiences.

The first case presents a conflict around the construction of an industrial complex (an aluminium smelter plant and its associated infrastructures) in the Chilean Patagonia. Here, I analyse the advantages of SMCE compared with the Environmental Impact Assessment systems (EIAS) commonly used in public decision-making. I propose the former in order to overcome some recognized pitfalls of the last.

Then, I explore the problems and conflicts around the construction of windfarms, and I analyse the main mechanisms aimed at their implementation. There exist different levels and dimensions of social acceptance of windfarms: socio-political, market and social acceptance. I argue that market-based mechanisms are not enough for public policy implementation, and that SMCE is appropriate so as to deal with community acceptance; that is, to deal with issues related to distributional justice, procedural justice and trust at local level.

Finally, I develop some ideas and learned lessons from the practical application of participatory approaches in combination with a multi-criteria analysis structure, and I delineate some areas and issues for further research.

Resumen

La presente disertación presentan dos casos de estudio en los cuales se ha llevado a cabo una Evaluación Multi-Criterio Social (SMCE por sus siglas en inglés), además de las lecciones aprendidas a través de estas experiencias.

El primer caso presenta el conflicto alrededor de la construcción de un complejo industrial (una planta reductora de aluminio y sus infraestructuras asociadas) en la Patagonia Chilena. Aquí, se analizan las ventajas de una SMCE comparada con los sistemas de Evaluación de Impacto Ambiental (EIA) comúnmente utilizados en el marco de las decisiones públicas. Se propone por tanto, la SMCE con el fin de resolver algunos de los inconvenientes ampliamente reconocidos de los EIAs.

Luego, se exploran los problemas y conflictos alrededor de la construcción de parques eólicos, y se analizan los principales mecanismos para su implementación. Cabe destacar que existen diferentes niveles y dimensiones de aceptación social de tales infraestructuras: socio-política, de mercado y comunitaria. En esta disertación se sostiene que los mecanismos de mercado no son suficientes para la implementación de políticas públicas, y que la SMCE provee un marco adecuado para tratar la aceptación (o rechazo) de la comunidad local; es decir, para atender los aspectos relacionados con la justicia en términos distributivos y de proceso, y con la confianza a escala local.

Finalmente, se desarrollan algunas ideas y lecciones aprendidas desde la aplicación práctica de metodologías participativas en combinación con la estructura del análisis multi-criterio, y se delinean algunas áreas para la investigación futura.

Chapter 1
Introduction

1.1. Motivations: Public policy, globalization and democracy

Nowadays, there is a wide recognition of the need to consider altogether the social, ecological and economic dimensions in decision-making processes within the framework of public policy and environmental management. Past decades have witnessed a high priority given to the economic dimension, which has brought several socio-environmental imbalances at different spatial and temporal scales.

There are several international agreements and conventions that emphasize the need for ecosystems and environmental protection, which are the basis of any form of life. But, in practice, the advances in this sphere have not been enough to decouple economic development and environmental harm, which is a basic requisite to meet sustainable development (Lafferty, 2004).

In the last decade, Europe has witnessed an increasing amount of environmental agreements, conventions and directives issued at international and European, which have not been accompanied by the same degree of policy implementation (Jordan, 1999). Some times, this lack of implementation is due to a certain degree of disconnection between priorities expressed at the design and at the implementation tiers.

Global environmental policies and the related institutions are born in the context of common understanding of the global problem at hand (e.g. the Convention for Climate Change). But, these sort of supra-national institutions are less aware of local problems where policies are to be implemented. On the other hand, local communities could have problems in perceiving that global problems are as important as local ones. The case of wind energy is a good example of those global/local contradictions, which are one of the main sources of conflicts in environmental policy implementation.

In the last decades, administrations are increasingly implementing environmental *governance* schemes (i.e. instruments that do not rely upon the formal sanctions and authority of the state) in order to harmonize ecological protection and economic development. According to Jordan and colleagues (2003a, 2003b) these mechanisms are still supplementing traditional environmental *government* (i.e. command-and-control mechanisms and regulation).

Some of these *governance* schemes are: market-based instruments (such as subsidies, emission charges, tax exemptions and tradable permits), voluntary agreements and eco-labelling. They are intended to foster a more environmentally friendly behaviour in the activities and investments of private investors and entrepreneurs. Currently, supra-national and national environmental policies are prone to encourage these sort of market-based schemes within the context of public policies and environmental management.

Market-based instruments rely upon a rationality that uses one measurable property (monetary) and one particular perspective (efficiency). But, in a complex world there are other important factors that must be considered as well. For instance, values such as equity and solidarity and variables such as energy and material consumption also shape and constraint socio-economic-ecological relations.

New institutionalist economists (of whose ideas I feel inclined) argue that individuals are conformed by and conform institutions[1]. They also understand rationality as something based on accordance with a set of rules, conventions and norms, that is, institutions define what is rational. So, we can talk of plural rationality (Vatn, 2005a). Different rationalities exists in different social contexts, and the economic rationality is just one way of behaving in a given institutional context (the market).

Policy instruments, as institutions, influence our preferences as well as our behaviour (Vatn, 2005b). Therefore, economic institutions (e.g. market-based mechanisms) would reinforce *economic* behaviour at the expense of other fundamental aspects of our rationalities, which could be specially misleading within the context of environmental management. Recall that the economic system is a sub-system of the social and cultural systems; all embedded in an ecological system.

Moreover, the advance of economic globalization and oil-based industrialization have important effects at different levels. Both processes homogenize lifestyles (Matutinović, 2001), decreasing social, cultural and economic diversity. But, institutional and socio-economic diversity are of fundamental importance in order to face complex problems (Ostrom et al., 1999) and for the sustainability of complex socio-economic systems (Matutinović, 2001).

Globalization also has political effects. As it becomes more intense, the number of important issues that escape the control of nation-states also increase. Local actors (e.g. municipalities, social groups, persons, among others) become interdependent with agents located far away from them, and loose self-determination. Moreover, their ability of influencing public decisions (at different tiers of governance) is lower than the capacity of other actors with higher socio-economic and political resources.

In a context where most of the developments are left to the initiative of private entrepreneurs, governments usually have the duty to evaluate the effects of these investments and projects in order to give or reject permission for their execution. But, the processes to carry out this task (for instance, the environmental impact assessment process applied worldwide) are still inappropriate to cope with complex socio-environmental choices.

The issue here is not to underestimate market-based instruments: they have probed to be useful in several situations (Sterner, 2007; Reiche and Bechberger, 2004). My concern is whether the market is able to deal with socio-environmental problems; I think it is not. So, I want to shed light on the need of developing decision-making institutions able to integrate the multiple dimensions, values and scales that characterize complex environmental problems.

New institutions and new ways of communication are needed so that to face these challenges. The promotion of trust, cooperation and reciprocity is necessary so as to complement and strengthen local institutions that protect cultural diversity (Ostrom et al., 1999). Social Multi-criteria Evaluation—SMCE—(Munda, 2004) is presented here as a proposal in this line. That is, a framework for public decision-making that integrate different and sometimes contradicting values present in society (deal with social incommensurability) and "orchestrate" non-equivalent representations from different scientific disciplines (deal with technical incommensurability).

1 "Institutions are the conventions, norms and formal rules of a society. Provide stability, expectations and meaning in a complex world –are essential to human coordination. Regularizes life, support values and form and protect interests (Vatn, 2005a)

In this context, the research question of this dissertation becomes the following: to check the obstacles when applying a theoretical framework for public decision-making (i.e. SMCE) and to learn from the experience. Then, the relevance of the thesis comes from the fact that it identifies some of the main problems found when applying SMCE and it proposes some ways of dealing with them.

It should be notice that relevance and precision are sometime contradicting features of an analysis. That is, we cannot go into deep detail in **all** the issues raised by this dissertation. For instance, additional to the possible questions about the technicalities of multi-criteria evaluation and participatory approaches, we can raise questions about the emergent properties of the decision-making processes at societal level (e.g. power imbalances, prioritization of dimensions, and so on). Therefore, this dissertation presents some general guidelines for both applying SMCE and dealing with the problems found so far. It also proposes some lines of future research in the field of public decision-making and environmental management as well.

1.2. Thesis structure

The context outlined above calls for public decision-making processes able to balance the social, economic and ecological dimensions, and to deal with conflicting interests and priorities expressed at different scales.

This dissertation deals with the issue of public decision-making, and specially with the application of SMCE as an integrative decision-making process. SMCE combines public involvement and multi-criteria evaluation. It offers a powerful framework so as to practice multi/inter disciplinary work[2], and to integrate scientific and traditional knowledge.

SMCE would induce a change of priorities in which public choices are based upon; shifting from the predominant economic vision to one that integrates diversity of dimensions of the real-world system we belong to.

After three years carrying out case studies in the field of environmental management, I realized that SMCE is an appropriate decision-making process to deal with the permanent conflict between contradictory and legitimate values, aims and interests held by local, national and international actors. Also, SMCE can play an important role in dealing with global and local problems and perspectives. These are key issues in the context of environmental policy implementation.

So, Chapter 2 briefly presents the theoretical foundations of SMCE as carried out in the case studies presented in this dissertation: as a combination of qualitative participatory approaches and multi-criteria evaluation. This section deals with some concepts coming from ecological economics, complex systems, post-normal science and political ecology. I will also present some considerations regarding the use of qualitative participatory approaches.

Chapter 3 exposes a case study carried out in Patagonia, Chile. This chapter is a extended version of an article titled "Social Multi-Criteria Evaluation of different development scenarios of the Aysén Region, Chile", published in 2007 in Ecological Economics (Vol. 59, pp. 157-170). It proposes the use of SMCE in order to overcome some widely recognized pitfalls of the Environmental Impact Assessment Systems (EIAS) commonly used in public decision-making.

Chapter 4 discuss the issue of renewable energy policy at a general level. It analyses the

2 *Multi* in the sense that each expert takes its part, and *Inter* in the sense that methodological choices are openly and critically discussed among disciplines (Munda, 2004)

process of problem definition (e.g. climate change) and policy design at supranational level to the policy implementation step at the local level. Also, there is a review of the main instruments used to foster renewable energies and the most common sources of conflict surrounding the implementation of windfarms. Finally, I make some remarks and propositions regarding the information previously analysed.

Chapter 5 presents the problem of locations of windfarms by means of a SMCE framework. This section tackles a case study carried out in Western Catalonia in the framework of the MCDA-RES project[3], and it offers some additional lessons regarding the application of SMCE. This chapter is an extended version of the article written as co-author with Giuseppe Munda and titled "The problem of windfarm location: A social multi-criteria evaluation framework", published in Energy Policy (Vol. 35, pp. 1564-1583).

Finally, Chapter 6 draws some learned lessons and practical recommendation on the application of a SMCE process, and it draws some lines of future research.

3 European Union research project "Development and Application of a Multi-criteria Decision Analysis software Tool for Renewable Energy sources (MCDA-RES)", Contract NNE5-2001-273.

Chapter 2
Theoretical foundations of Social Multi-Criteria Evaluation

Social Multi-Criteria Evaluation has some relationships with the concept of Ecological Economics (EE), which is a multi-disciplinary science that considers socio-economic subsystems embedded in the ecological system. EE analyses the relationships between the ecological and socio-economic systems in a broader sense (Constanza, 1989), regarding the distribution of goods and burdens across different social groups at different spatial and temporal scales (Martinez-Alier et al., 1998).

EE promotes the expansion of the analysis of human activities beyond the restricted chrematistics vision. It is based on the concepts of weak comparability of values and incommensurability, that is "the absence of a common unit of measurement across plural values" (Martinez-Alier *et al.*, 1998: p. 280). Therefore, it leads to a multi-criteria representation and evaluation of policy choices.

One can distinguish between technical and social incommensurability; the former comes from the multidimensional representation of complex systems by means of descriptive models and the last comes from the existence of diverse and legitimate values in society (Munda, 2004). In order to cope with both types of incommensurabilities, SMCE respectively relies upon the combination of multi-criteria evaluation and public participation.

EE also relies upon the concept of strong sustainability, which states that human made capital cannot substitute some sorts of natural capital. This is due basically to our incomplete knowledge of natural systems. Therefore, there are bio-physical limits to the ecological degradation produced by socio-economic activities. According to this, one should be aware that the evaluation tools must be able to manage compensation between social, economic and ecological dimensions.

Also, the foundations of SMCE are set up relying upon concepts coming from Complex Systems theory and Post-Normal Science (PNS) (See Munda, 2004).

Complex systems are those whose relevant aspects cannot be captured using a single perspective (Funtowicz *et al.*, 1999; O'Connor *et al.*, 1996); those characterized by presenting multiple identities at multiple scales, which are subject to non-equivalent descriptions (See also Giampietro, 2004).

Additionally, socio-economic systems are reflexive complex systems. These systems present awareness and purpose, and they continuously add new relevant attributes that should be considered when representing them. According to Simon (1976), one can distinguish between substantive and procedural rationality. The former is independent of the way a decision is made and refers exclusively to the results of the choice. The last refers to the process in which a decision is made.

> *"A body of theory for procedural rationality is consistent with a world in which human beings continue to think and continue to invent: a theory of substantive rationality is not"* (Simon, 1976).

Human systems are learning systems, therefore, decision-making processes shouldn't be rigid and straight forward. Contrary, they should be cyclic by nature, where generated information must be incorporated in the evaluation, distributed across involved social actors in order to stimulate social learning and empowering.

Post-normal science also deals with problem solving situations characterized by the presence of high degree of uncertainty and conflicting values. In cases where "scientists cannot provide any useful input without interacting with the rest of the society, and the rest of society cannot perform any sound decisions without interacting with scientists" (Munda, 2004; p. 663-664), PNS proposes to extend participation in decision-making process beyond traditional circles of politicians and experts (scientists). It promotes the combination of scientific and traditional knowledge in order to consider as many perspectives as possible to frame complex issues as well as to carry out the tasks of quality assurance (See Funtowicz and Ravetz, 1991, 1994).

But there are also reasons coming from **political ecology** (PE) that call for a wider inclusion of social actors within environmental decision-making processes. PE deals with environmental conflicts, which usually come from the interaction of actors holding different and contradicting meanings of nature. According to Leff (2003), different visions of nature imply different value systems that go beyond the dominant economic rationality. This last can be characterized as a dominant form of nature appropriation. Leff adopts a political perspective of nature, in which human-human and human-nature relationships are built upon power relations in the fields of knowledge, production, nature appropriation and normalization of ideas, discourses, behaviours and policies. Then, it becomes pertinent to ask, who has the power to simplify complexity by imposing a single language of valuation? (Martinez-Alier, 2005)

Political ecology explores on the issue of ecological distribution, that means, on the unequal burden of the ecological costs across diverse groups in society. This discipline critiques current forms of production and consumption and western lifestyles that put our relationship with the biosphere in a dangerous situation, asking for important transformations within the industrial and market society.

According to this vision, current environmental problems (climate change, biodiversity loss, water scarcity) are political because relationships between humans and nature are determined by different forms of social organization (Liepzig quoted in Alimonda, 2002). Then, it is necessary to think about democracy and environmental justice in order to widen and complement human and citizens rights (Alimonda, 2002). This implies to open environmental decision-making processes in order to be as inclusive as possible, trying to balance power relations in order to promote what Leff (2003) calls differentiate sustainable societies.

2.1. Social Multi-Criteria Evaluation

Complex environmental problems (i.e. those characterized by the presence of uncertain outcomes, conflict of values, multiple spatial and temporal scales, and non-equivalent descriptions of them) call for integrative methodologies in order to capture their diversity of relevant aspects.

Social Multi-Criteria Evaluation (SMCE) (Munda, 2004) is proposed as a decision-making process within the field of public policies and environmental management. As said before, SMCE combines participatory and scientific approaches within the fieldwork of multi-criteria evaluation. Public involvement is aimed at incorporating social diversity, expressed as values, interests and objectives across different social actors (that is, *social incommensurability*), into decision-making processes. Thus, considering the political and social framework in which evaluations and decisions are made.

On the other hand, the structure offered by multi-criteria evaluation facilitates scientific multi/inter-disciplinary work needed to appraise the multiple-scale/multiple-identities feature of complex real-world systems (*technical incommensurability*). That is, to do an integrated evaluation of the possible impacts of social decisions considering the: socio-economic, ecological, cultural, political and technical dimensions *simultaneously*. Which is a missing feature of the current environmental impact assessment systems applied globally (See Gamboa, 2006).

In short, "SMCE is *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 rod)" (Munda, 2004; p. 671).

A theoretical representation of a SMCE scheme is presented in Figure 1. The process is outlined in a step-by-step structure to facilitate its comprehension. But in real cases some of the steps overlap each other, and a cyclical and reflexive procedure is always advisable.

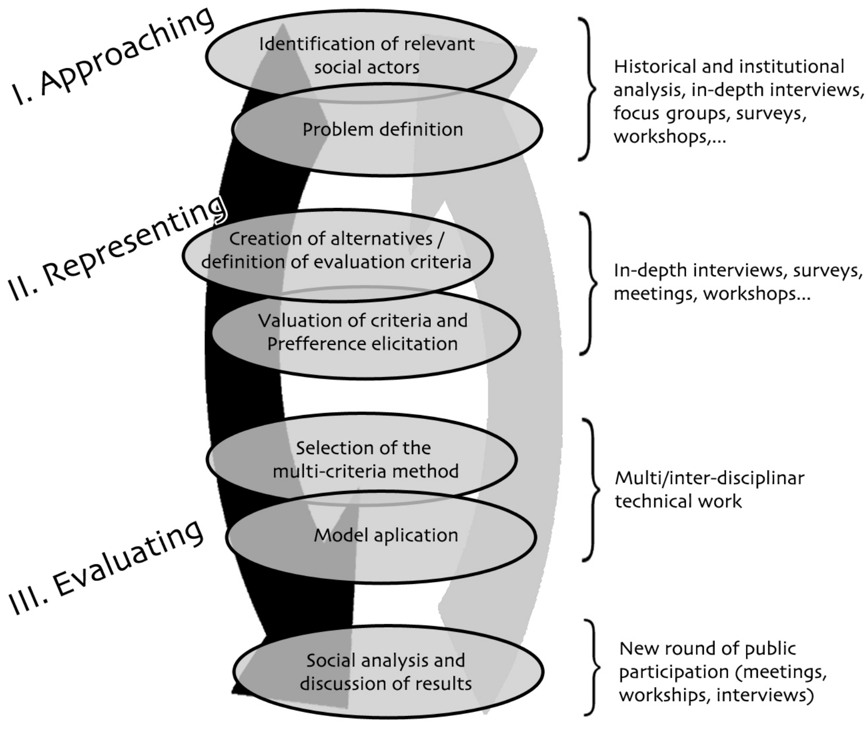

Figure 1: Theoretical Social Multi-Criteria Evaluation scheme

The first step, the *approaching phase*, involves realizing a historical and institutional analysis —a review of administrative and legislative documents, newspapers, technical reports, historical documents, and so on—in order to identify relevant social actors, their interests and aims, and the relationships between them.

It also gives the analyst independent sources of knowledge about the situation. This sort of objective information about behaviours and relationships is needed to complement inherent subjectivity of qualitative methods.[4]

It is worth noting that the analysis of the newspapers should be carried out in a critical way. One should consider the underlying opinion of the journalists as well as the unequal distribution of resources across the social actors. For example, one of the mayors involved in the case study presented in Chapter 5 said that *the opponents to the windfarms are few, but they are noisy!*. On the other hand, energy companies have much more economic resources to afford advertising and publicity to counteract this opposition.

As well, different participatory approaches are carried out (e.g. focus groups, in–depth interviews and meetings) in order to define the problem at hand from the different (*technical* and *social*) perspectives.

In-depth interviews are also aimed at knowing needs, values, interests, objectives and expectations of the interviewees, as well as to understand their relationships with other actors. It is important to note that, one is able to identify discourses emerging during the interview. The interviewees interpret the questions, and they answer with what they consider is the relevant information. Their responses are filtered by their ability and willingness to transmit this information. Therefore, the information collected by means of in-depth interviews should be contrasted with the behaviour and actions of the social actors, in order to identify the motivations underlying discourses.

Focus groups are useful to generate discussion and exchange opinions among participants. This is a good opportunity to look for intermediate viewpoints to reach consensus. But, it is also a good opportunity to manage conflicts in order to provoke the expression of opinions in a transparent way.

In the next step, the *representing phase*, the problem previously defined is translated into a multi-criteria structure, which is conceived as a set of alternatives compared under several criteria (see below). Alternatives and criteria are built relying upon the information gathered in the previous step trying to include different world-views.

The definition and valuation of criteria is a multi/inter-disciplinary task, understood as a technical translation of the social actors' perceptions and aims (Munda, 2004). So, the direction of the criteria (either maximize or minimize) would depend on the objectives that the criterion is representing[5]. For instance, as we will see in the windfarms case study, the negative visual impact of the windfarms is considered higher when the facility is bigger. This is because this criterion represent the objectives of the groups opposing the windfarms.

One should note that, in a SCME framework, criteria and criterion scores are not determined directly by social actors. The impact matrix (see next sub-section) is a result of a technical translation operationalized by the scientific team. Even if the criteria are exactly the ones agreed with the social actors the determination of the criterion scores is independent of their preferences. For example, an interest group can accept the use of a criterion measuring the effects of the various alternatives on the employment, but the determination of the figure cannot be (at least completely) controlled by them. This is the main reason why to combine a social impact matrix with the technical impact matrix is highly recommended

4 It is worth-noting that people who have written reviewed documents are not necessary *objective* in front of the situation under study. The issue here is that these are indirect sources of information, which complement information coming directly from the involved social actors.

5 These criteria appraise the impacts of the different alternatives either directly by means of natural or constructed criteria, or indirectly by means of *proxy* indicators. Natural criteria are those whose unit of measurement are derived directly from the definition of the indicator (e.g. deforestation is measured by means of hectares of forest lost), and constructed indicators are those which use subjective scales to evaluate the degree in which objectives are met (e.g. Impact over local culture could be low, more or less low, high and so on). Proxy indicators are those indirectly related with the objective to be pursued (e.g. Impact on human health is measured by the atmospheric concentration of pollutants)

(Munda, 2005a).[6]

According to the characteristics of the problem at hand—types of criteria elucidated (qualitative or quantitative), use of weights, presence of uncertainties —the appropriate multi-criteria technique is selected. This introduces the *evaluating phase*, in which the multi-criteria model is applied in order to obtain technical and social rankings of alternatives. This phase also include the social analysis and discussion of the results of the assessment.

The whole process and the information generated should be adequately and carefully communicated to the different social actors for their analysis and feedback. In this way, we can re-define or re-frame the problem (if necessary)[7].

2.1.1. Qualitative participatory approaches

The advantages of public Involvement in environmental management would be, at least, four: It strengths the practice of democracy by means of allowing participants to practice the right of influencing decisions that will affect them; it also contributes to better appraise socio-environmental complexity by means of incorporating different perspectives to the problem definition; it would promote higher public acceptance of decisions adopted (legitimacy) and it would boost social learning needed to deal with complex problems we face now and in the future (Mostert, 2005; Guimaraes Pereira and O'Connor, 1999).

Public participation has proved to have an important influence in the promotion and adoption of environmental policy. For instance, changing the behaviour of private companies by means of international campaigns (see Shaw, 2004). According to her, this sort of campaigns create new spaces for decision-making, in which local, regional and international agents reconfigure their roles and are able to generate new environmental norms.

In Catalonia for example, the high opposition to the Catalonian Energy Plan, and specially to the construction of windfarms, lead to the Catalonian government to declare a windfarms moratorium and to review the plan. As of 2005, the plan was relaunched including some comments on the importance of regarding local public opinion and to consider special characteristics of the territory.

The participatory approaches applied in both case studies presented in this dissertation pertain to the category of qualitative (deliberative) methodologies—in-depth interviews, focus groups and meetings—. These techniques give the participants—social actors and analysts—time to think, to learn and to create relevant knowledge for decision making in complex situations (Tábara, 2003; O'Neill, 2001).

Qualitative participatory techniques, like in-depth interviews, are useful to identify the underlying values and aims of the different social actors involved in the situation, giving the analysts the opportunity to understand the meaning of the answers and why people answer in a given way (O'Neill, 2001).

Ravetz (1971) distinguish between *practical* and *technical problems*. Practical problems are those related to the diversity of values and aims present in society (for instance, the wish of a fair distribution of incomes or a healthy environment), and technical problems are those related with the technical performance of options oriented to tackle the formers.

This dissertation presents two case studies dealing with technical problems: the evaluations

6 See Bouyssou (1990) on the concept of a "consistent family of criteria".

7 It is worth-noting that constant interaction among the actors involved (including researchers) should be present at every stage of the process, in order to allow for a continuous testing of the assumptions made, as well as to foster *social learning*.

of the construction of an aluminium smelter plant and of windfarm locations. But, qualitative research carried out in both cases reveals some underlying (practical) problems, such as the definition of the development path of the territories under study.

Qualitative participatory approaches allow to know motives, interests and objectives, and therefore they would help to solve practical problems rather than just solve technical problems. By means of these methodologies one can identify underlying problems and conflicts, discover their roots and look for consensus/compromise choices.

Consensus could be a desired outcome of participatory decision-making processes. But, the unavoidable existence of conflict calls for methodologies capable of managing conflict in order, for example, to avoid strategic behaviour of some actors that could hide private interests under public ones in order to benefit them from the process [8](See van den Hove, 2006).

Socio-environmental conflicts would indicate the need of adjusting socio-economic relationships that lead to unequal distribution of economic and environmental services and burdens. Therefore, developing environmental decision-making processes aimed at managing the conflict would be more appropriate than avoiding it.

However, there is an interesting discussion about the appropriateness of deliberative institutions within the field of environmental management. Some critics of this kind of social research tools are their lack of statistical meaning, hence their lack of legitimacy in decision-making processes, and some problems of representation within these approaches.

On the other side, situations of high uncertainty, value conflict, effects on multiple temporal and spatial scales and non-equivalent descriptions of the same phenomena require deliberation in order to create relevant knowledge to make decisions; we need time to interpret and explain positions, to discover the roots of the conflict in order to look for and to construct consensus/compromise choices.

The position adopted in this dissertation is the last, where participation would integrate and be representative of the different values and discourses present in society rather than trying to be statistically representative of society's structure (Roca and Gamboa, 2007).[9]

Moreover, qualitative (deliberative) approaches can incorporate not-represented or under-represented minority voices. That is, to widen the range of representation of the current political system (i.e. liberal democracy). This doesn't mean that social actors within majorities should be excluded from these sort of qualitative methodologies, rather different values, interests and objectives should be balanced in order to generate a productive exchange of contradicting opinions (quality of deliberation).

Still, qualitative methodologies lack statistical representativeness. The problem is then how to define the participants whose interests, priorities, objectives and worries demand adequate representation or who are relevant to the decision (i.e. promote social cohesion). I think that one way out to this problem is to make the processes of decision as inclusive as possible and characterized by being open to interested people.

In this regard, environmental decision-making processes are regarded as fair when a wide range of actors have the possibility to participate (representative); are able to initiate discussion and participate in it (right to voice); and where participants are able to influence decisions (consideration of opinions), and are not just used as a source of justification (Smith

8 For instance, one can argue in favour of wind energy presenting it as a clean source of energy, but the underlying dominant motivation could be the economic benefits from the rent of the land.

9 See Munda (2004) for a discussion on the differences between Stakeholder Multi-Criteria Decision Aid (Banville et al., 1998) and Social Multi-Criteria Evaluation.

and McDonough, 2001).

Other authors argue that human dignity should be balanced with environmental problems, so principles of social justice should be regarded: such as ***i)*** complete participation, ***ii)*** self-representation and autonomy and ***iii)*** self-determination (Brechin et al., 2002).

Participatory approaches should be aimed at balancing the distribution of power across actors, in order to avoid more powerful actors imposing their imperatives on others with less resources.

2.1.2. Multi-criteria evaluation

A multi-criteria structure consists in a set of alternatives conforming a decision space, which are evaluated under several criteria. Table 1 shows a problem structured in a a a A multi-criteria fashion: with *n* possible actions a_j (j = 1, 2, ..., n) and *m* relevant evaluation criteria g_i (i = 1, 2,..., m).

Criteria are at least partially contradictory, that means that one alternative can be the best under one criterion, but not necessarily under the rest of the criteria.

Table 1: Multi-criteria impact matrix

Criteria	***Alternatives***			
	A_1	A_2	-	A_n
g_1	g_1 (A_1)	g_1 (A_2)	-	g_1 (A_n)
g_2	g_2 (A_1)	-	-	-
-	-	-	-	-
-	-	-	-	-
g_m	g_m (A_1)	g_m (A_2)	-	g_m (A_n)

There are several multi-criteria models, each one with its advantages and disadvantages: the lexicographic model, for instance, consists in applying criteria one-by-one to the set of alternatives, eliminating those options that don't fulfil the limit established by the applied criterion. The procedures continue until all selected criteria have been considered and/or until one alternative is selected.

Another sort of multi-criteria method is the *ideal point* approach. The idea is to find or to generate alternatives as close as possible to the ideal point: the alternative that makes discrepancies disappear. Another approach is to find the *anti-ideal point*, so defensible options should be as far as possible from the *anti-ideal point*.

Other methods are based on linear aggregation of criterion scores, which is done after a transformation of the performances by means of utility or value functions (See for instance, Keeney and Raifa, 1976). These methods are completely compensatory.

There are also the outranking methods (Roy, 1990), which are based on the concept of partial comparability. That is, the preferences between two alternatives can be modelled by means of binary relationships: indifference, strict preference, weak preference and incomparability. These models do pair-wise comparisons of alternatives in order establish whether one alternative is *at least as good as* the other, according to most of the criteria. In order to do so, it is taken into account some of or all the following information:

- The number of criteria in favour of one alternative,
- The degree of importance of each criterion,
- The intensity of preference.
- The (binary) relations between the alternatives

The desirable features of a multi-criteria model in the public policy domain are discussed in Janssen and Munda (1999), Munda (2004) and Munda (2005a). In short, the model has to be as simple as possible to guarantee transparency. Non-compensation is desired to avoid that very good performances in some dimensions— for instance the economic one— overcome bad results in other dimensions— for instance ecological or social ones—, which could be important for some social groups.

Compensation refers to the possibility that very good performances in some criteria can offset bad performances in other criteria. A Non-compensatory method doesn't allow such a counterbalance between very good and bad performances.

In public policy problems it is useful to use indifference and preference thresholds[10], which imply considering intensity of preference, and the use of weights as importance coefficients is also desired. But the mix of intensity of preference and weights leads to compensation and trade-off between criteria[11]. Weights as importance coefficients are used with ordinal criterion scores to avoid compensatory aggregation procedures, a desired feature if we want to apply the *Strong Sustainability* principle based on *weak comparability of values* (for a discussion on these concepts see Martinez-Alier *et al.*, 1998).

In methods using ordinal criterion scoring, and thus weights as important coefficients, the contribution of any criterion to the overall performance of an alternative does not depend on the intensity of preference. On the other side, in compensatory methods, the contribution of any criterion to the overall performance of an alternative is proportional to the intensity of preference.

For instance, when comparing two alternatives with a compensatory method, the contribution of the criterion Cost of implementation will not be the same if ***i)*** cost of alternative A=100 € and cost of alternative B=10 € or ***ii)*** cost of alternative A=100 € and cost of alternative B=50 €. The contribution of this criterion is higher in the case ***I)***. When comparing both alternatives with a non-compensatory method, the contribution of this criterion to the overall performance of the alternatives is the same in both cases .

Moreover, within the SMCE framework the evaluation methodology should be coherent with the expected features of public involvement (improvement of democracy, appraisal of socio-environmental complexity, promotion of public acceptance of decisions and boost social learning).

Multi-criteria evaluation methods foster the practice of democracy by means of considering different criteria in the evaluation with limited or no compensation between them; it is an adequate framework to appraise complexity by means of considering several dimensions without reducing the effects of the alternatives to a single unit of measurement; and it serves as a communication tool boosting social learning.

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10 The indifference threshold is the maximum difference between the criterion scores of two alternatives that makes no difference between them (under that criterion). The preference threshold is the minimum difference between the performances of two alternatives in one criterion that makes one option preferred instead of the other.

11 On the one side, weights as importance coefficients reflect the relative *importance*— given by the decision-maker, the analyst or the social actor— of one criterion in relation to the others. On the other hand, weights as trade-off reflect the *substitution rate* among criteria.

Next Chapter presents a case study in the Patagonia, Chile. It describes a SMCE process ,and compares it with the current environmental impact assessment system applied worldwide.

Chapter 3
Social multi-criteria evaluation of different development scenarios of the Aysén region, Chile[12]

3.1. Introduction

In 1994, the Chilean government launched the Chilean Environmental Act, Law No. 19.300, in order to create an institutional framework to rule, in environmental terms, the introduction or development of public and private investment projects or activities. This law sets up, among other things, the Environmental Impact Assessment system (EIAS), and the National Environmental Commission (CONAMA) and its regional offices (COREMAs). Within the EIAS, the promoter of a project or activity (for instance, an aluminium smelter plant) is compelled by law to submit an Environmental Impact Study (EISt) of the projected plan so as to get governmental approval[13].

The CONAMA or its regional office implements and coordinates the EIAS. Several governmental offices review and comment the EISt. The COREMA/CONAMA collects the comments of these sectoral offices and the concerns of the citizens and social organizations in order to do a project-level environmental impact assessment of the proposed plan. The result of this evaluation could be either the permission, the conditioned permission or the rejection of the plan.

This EISt must describe in detail the characteristics of the project; presenting evidence to predict, to identify and to interpret its environmental impacts; and explaining the actions to avoid/minimize its adverse effects (Government of Chile, 1994).

After the EISt submission, it follows a period of time in which the proponent should answer the doubts and questions raised by the government and the public, in order to complement the evaluation. Then, the Environmental Commission will approve or reject the implementation of the project, and, in case of implementation, it follows the monitoring phase (For more details see De la Maza, 2005).

This kind of project-level EIAS are broadly established all around the globe, and they have been born due to the necessity of addressing the socio-ecological impacts of human (economic) activities. However, this evaluation tool, even though it takes into account the impacts on several dimensions, as showed some deficiencies deemed to be improved (See for instance, De la Maza, 2000; Steinemann, 2001; Zubair, 2001; Bruhn-Tysk and Eklund, 2002; Wang et al., 2003; El-Fadl and El-Fadel, 2004; Alshuwaikhat, 2005; Hartley and Word, 2005). To overcome some recognized shortfalls of the current EIAS, this chapter proposes some structural changes in the process. Basically, to change the role of public participation and the implementation of multi-criteria evaluation framework.

In order to do so, a Social Multi-Criteria Evaluation (SMCE) framework is suggested. SMCE is also aimed to do an integrated evaluation of the possible impacts of political decisions, but considering the socio-economic, ecological, cultural, political and technical dimensions *simultaneously*. SMCE uses information coming from scientific practices as well as

12 This chapter is the basis of the article with the same title published in Ecological Economics 59, pp. 157-170
13 According to the characteristics of the projects and the level of environmental impacts, the proponent could just submit an Environmental Impact Declaration of its project.

information produced by means of a sociological research process (traditional knowledge).

This chapter shows the application of a SMCE process to a real case study. The procedure is proposed as an alternative decision-making process to the current EIAS. The chapter describes the general frameworks— problem structuring and evaluation of alternatives— of the SMCE and EIAS processes. Finally, it analyses and compares both decision-making processes under various perspectives: the process, the management of uncertainty and the integration tool (i.e. environmental impact study vs. multi-criteria analysis).

This case study bases its structure on two previous experiences presented in De Marchi *et al.* (2000) and Martí (2001).

3.2. Social research in a SMCE

3.2.1. The Aysén Region: introducing the context

This section presents the main results of the first step of a SMCE, that is, the historical, institutional and biophysical analysis of the region.

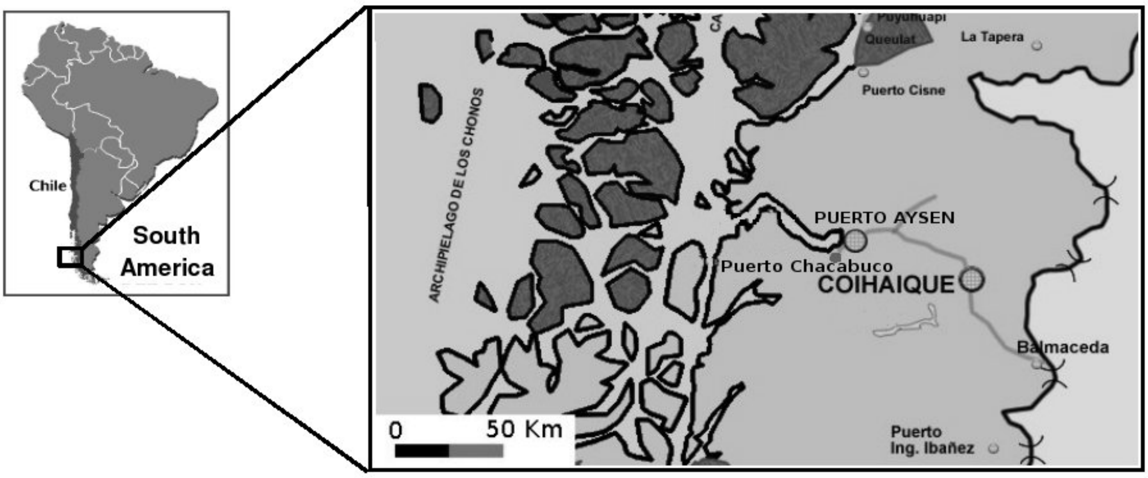


Figure 2: The Aysén Region

The Aysén Region, located in the Chilean Patagonia (see Figure 2), is a young region in socio-economic and environmental terms. An adverse weather and a long distance from the more populated urban centres characterize this region. Its land of 11 millions of hectares is inhabited by 90 thousands of people, whose settlement began at the beginning of the XX^{th} century.

Table 2 briefly describes the processes of settlement and development of the Aysén Region. The table presents the history of the region divided in three periods: from settlement to the 50's, the second half of the XXth century and the current situation. It also presents the social and economic dynamics of the area, and the public policies implemented in the region.

Table 2: The Aysén Region: Its settlement and development

	Settlement **(From later XIX century to first half of XX century)**	**Development** **(Second half of XX century)**	**Current situation** **(2003)**
SOCIETY	There were two parallel settlement processes in the Aysén Region: the so-called "spontaneous" and "programmed" migration flows. These migration flows has shaped the regional society. The spontaneous migration brought people from: the northern region of Chiloé and from Argentina. The formers were looking for better opportunities and the lasts were expelled from Argentina. At the same time, the Chilean government tried to incorporate the region to the national activity through a programmed settlement. Some commercial societies received big land extensions in order to develop the livestock activities. In exchange, those societies had to invest in some infrastructures and to pay the transportation of workers and their families. Most of those commercial societies could not afford the government's conditions and left the region. The families that remained in the region joined the other colonists and together started to shape the regional cultural identity.	In the beginning of the 50's, Puerto Aysén was the main economic center of the region and many services were established there: the post and telegraph office, the public sickbay, the custom-house, the agriculture governmental office, and the maritime sub-delegation. But two episodes changed the situation: the change of the location of the port from Puerto Aysén to Puerto Chacabuco at the end of the 50's and the decentralization process later on. As of 1974, Coyhaique was declared the regional capital (it was dictatorship times and the regional headquarters were there) and mosts of public offices and civil servants moved to Coyhaique. This changed the dynamics of the two cities. Civil servants earn a 105% of over wage, which has propelled the economy of Coyhaique. On the other hand, the inhabitants of Puerto Aysén work mainly in the fishing and aquaculture industry, which are export oriented. People say that these industries pay salaries that are not enough to afford the regional living cost.	From the 1960's rural population has started to migrate to the city. Currently, 80% of the regional population is urban. In social terms, people living under the poverty line has decreased 50%. But, the cost of life – in terms of electricity, water and transport prices – remains one of the highest at national scale (CEPAL/LPES/CORFO, 2002), Moreover, as of 1996, the richest 20% of the population was 9 times wealthier than the poorest 20% of the population. As of 2000, the this difference raised to 12 times. These inequalities are higher in Puerto Aysén rather than in Coyhaique. The unemployment index is one of the lower at national level. However, it is important to note that 23% of the jobs are temporal and the non-qualified characteristic of the required labor affect salary levels and schooling. Some other regional statistics indicate the need to give more attention to schooling at lower and upper levels, overcome the deficit of medical specialties and decentralizing the health sector, and adapting housing to climate conditions. Nevertheless, there are satisfying levels of urban and rural electrification, telephone system, potable water and sewer systems.
PUBLIC POLICIES	Public policies were aimed at: ordering the land possession process, consolidating the regional settlement and annexing the regional economy to the national context. The bankruptcies of most of the commercial societies and the ecological damage in the region (deforestation and big fires) are two consequences of public policies under lack of both information and experience.	The central government promoted new development plans. It moved more public employees to the region. One of the main objectives of the dictatorship in this region was to improve the connection of this zone with the rest of the country. The *Carretera Austral* (*Austral road*) is the most important and costly work in the region. It was constructed between 1976 and 1996, and the main workforce came from the military service.	The Regional Government and the Planning and Coordination Regional Secretariat (SEGEPLAN) are carrying out a Territorial Ordering Program. This plan is inserted in the Regional Development Strategies 2000-2006. The program tries to orient the regional private and public investment policy. It also tries to resolve land-use conflicts by means of public participation and coordination among economic sectors. The proposal of land-uses is based on the (in)compatibility of different economic activities currently developed on the territory

	Settlement (From later XIX century to first half of XX century)	Development (Second half of XX century)	Current situation (2003)
ECONOMY	The livestock sector was the motor of the economy, but ignorance and undiscriminated exploitation of natural resources characterized their behavior: three millions of hectares were burned in order to clear land for the development of this activity. Forestry addressed its production mainly for local consumption, But Cypress was indiscriminately extracted for exporting. Subsistence agriculture was practiced in temperate zones (like lake's shores), and fishing and mining started to be practiced.	Stockbreeding started to coexist with agriculture and craft-fishing (both for subsistence). The government promoted forestry in order to repair the damages caused by the fire. The undiscriminated forest clearing was one of the main causes of the accumulation of sediments of the Aysén river. Which, in turn, fostered the change of the location of the port to Puerto Chacabuco. The fist tourist project is built in Laguna San Rafael, and the economic diversification started to consolidate with a mining project and the arrival of some traders. Besides, fishing and livestock sectors begun to industrialize their activity by means of constructing a preserving seafood plant, a slaughterhouse and a dairy.	The regional economy has a gross regional product (GRP) of 400 millions of dollars, which represents 0.5% of the GNP in 1998. In economic terms, aquaculture activity has grown impressively the last decades. Aquaculture is the basis of the fishing sector, which has grown 1.738,6% between 1985 and 1997. Tourism sector also shows promising perspectives for the future. Its development relies upon fly-fishing, eco-tourism and canals navigation. The temporal character of jobs and the concentration of income are the main critics on this activity. Other economic activities promoted by the local government are those related with clean food production.

Source: Own elaboration based on the historical and institutional analysis.

Nowadays, the population lives mostly in Coyhaique (the regional capital) and Puerto Aysén. The former has half of the regional inhabitants and the public services are its main activity, which give an important impulse to the city's economy. 21 thousand of people inhabit Puerto Aysén. The principal activities are the industrial and craft fishing, and the salmon-farming industry. The cities are separated 60 kilometres from each other, and people perceive strong inequalities in the standards of living (much higher in the regional capital).

Figure 3: Puerto Aysén (A) and Coyhaique (B)

In 2001, the Canadian mining company Noranda submitted to the Regional Environmental Commission (COREMA) an EISt of an aluminium smelter plant project in Chacabuco bay, the main maritime entry to the region and the regional operation centre of the aquaculture industry (see Figure 4), starting a two years EIAS embedded in an intense environmental conflict.

The following section presents a brief description of the project and the conflict around it, in other words, a summary of the collected information by means of the institutional analysis.

3.2.2. The Alumysa project in the Chilean EIAS

Alumysa is a project of 2.700 millions of dollars of investment. It includes the construction of one of the biggest aluminium smelter plant in the world, three hydroelectric power plants, 80 kilometres of electric power lines, 95 kilometres of roads and one port in Chacabuco bay, among others infrastructures (see Figure 4).

After the submission of the Alumysa's EISt to COREMA, a 60 days public participation process took place. More than 600 citizens expressed their doubts and observations about the project to COREMA. The regional environmental office functions as a coordinator of the 33 regional and national public services and other external technical advisers analysing the EISt. The doubts and observations gathered in the process have to be answered by Noranda, following the second stage of the EIA. Usually, after this second phase the government may ask for new amendments to the EISt, or it may give a verdict about the project's submission.

Figure 4: Puerto Chacabuco: Planned location for the main infrastructure of the Alumysa project

We can find several opinions of the Alumysa project. The environmentalist group argues either the incompatibility of the project with the current regional economic activities and their will of having a different lifestyle than the developed in the big national urban centres. The salmon-farming entrepreneurs, who do not oppose the project itself, but would prefer it to have another location. Some citizens groups give their unconditional support to the project, expecting better jobs and salaries. These and other positions are reflected in Table 1 and 7.

3.2.3. Identifying social actors' needs and expectations through participatory approaches

This section gives an overview of the three social research methodologies undertaken, i.e., the second step of this SMCE. These approaches were focused in analysing the **needs** and **expectations** present in the region, to generate possible future scenarios and the evaluation criteria.

a) In-depth interviews

The aim of these experiences is to complement the information obtained by the historical and institutional analysis, and to recognize social actors not considered yet. 25 people of different social, economic, technical and political sectors were interviewed (See Box 2). The selection of the interviewees relies upon the results of the historical and institutional analysis, and also in the information collected during the interview process itself.

In-depth interviews had the following structure (See also Box 1):

i. Description of the biophysical and socio-economic contexts, and the relationships between social actors.

ii. Description of the future projections of the region and the requirements to reach it.

iii. Whom the different possible futures would affect.

The open structure of the interviews is aimed at allowing people to freely express their opinions. The gathered information is used as a feedback to the participative processes coming later, in order to discuss, modify and specify it.

Box 1: Questions of the in-depth interviews

System description and knowledge

- How would you describe the economic, social and environmental regional situation?
- Who are the main actors supporting the region and promoting its development?
- Who are the socio-economic and institutional actors operating in the region?

To generate and evaluate development alternatives

- How would you like to see the region in 15 years?
- What do you think it needs to be done in the social, economic and environmental fields?
- What kinds of projects are needed to be implemented?
- Which kind of criteria do we have to use in order to evaluate alternatives?
- Which dimension (economic, social or environmental) is more important? And the second?
- What do you think about the actual economic alternatives (Alumysa, tourism, aquaculture…)
- What do you think about compatibility between alternatives?

Evaluation of the activities impact over social actors

- How is the impact of the activities over different social actors?
- How do the different activities impact on your life?

b) Focus groups

The main objectives of these discussion spaces were to promote reflection about the future of the region and to learn about the regional socio-economic and ecological contexts. Other aims of these meetings were to validate and to complement the opinions gathered during the previous stage.

About 20 people have participated in three focus groups: one with institutional actors (mainly from the local government) in Coyhaique, and two with socio-economic actors, one in Coyhaique and the other one in Puerto Aysén.

The groups of between 5 and 8 people were given a presentation on the aims and methodologies of the study. It followed a summary of the opinions collected previously. Then, people were invited to exchange opinions in order to build a general vision of the region.

c) Young people have something to say

One workshop with students between 14 and 18 years old took place in Coyhaique. The objective of this activity are twofold: to collect opinions about the current regional situation and to take into consideration one part of the population that is normally not invited/considered in public decision processes. Moreover, they will face the future consequences of current decisions.

This activity was carried out in three steps:

i. Introduction of some economic concepts commonly used, such as value added, gross national product, economic growth and so on,

ii. The group was split in three sub-groups, and were asked to develop future scenarios of the region based on three specific pre-assumption: an industrial development of Aysén, a strictly environmentally regulated development, and a development based on an intermediate path.

iii. Presentation of the results of the groups by means of writings and drawings, and discussion about these possible scenarios.

The above-mentioned methodologies allowed identifying several social actors involved in the conflict and their positions (see Table 3, Table 4 and Table 27).

Box 2: Interviewees

Governmental institutions

- Regional Director of CONAF (Forest National Corporation).
- Mayor of Coyhaique
- Public official of the Environmental Office, Municipality of Coyhaique.
- Councillor of the Municipality of Puerto Aysén
- Councillor of the Municipality of Coyhaique
- SECPLAC (Planning and Cooperation Communal Secretary's Office), Puerto Aysén
- Governmental official in charge of the Land-use planning program

Social movements

- Representative of the Communal Union of Puerto Aysén
- Representative of the Communal Union of Coyhaique
- Representative of the Trade Union of Temporary Women Workers
- Representatives of the Civic Committee for the Sustainable Development of Puerto Aysén and its Surroundings
- Regional Director of Codeff (Forest and Fauna Defence Corporation)

Economic sectors

- Representative of the Regional Tourism Chamber
- Representative of SalmonChile
- Representative of the Commerce Chamber of Coyhaique
- Representative of the Commerce Chamber of Puerto Aysén
- Consultant of the craft-fishing sector
- Representative of the Association of Craftsmen/Craftswomen, Coyhaique
- Representative of FAGA (Association of Farmers and Stockbreeders of Aysén)

Others

- Representative of the Association of Doctors
- Representative of the Regional Teachers Association

Once the biophysical environment and the socio-economic context of the region has been analysed, the next step is to assess potential outcomes of public decisions and actions. In this case, it follows the creation of three possible future scenarios, and their comparison under a set of evaluation criteria (technical evaluation) and under the social actors' perceptions (social evaluation).

Table 3: Social actors involved in the conflict and their positions

Sector	*Social Actors*
INSTITUTIONAL	**CONAMA – COREMA (National – Regional).** Public services coordination in the EIAP. **Public services (National - Regional). R**egarding its "technical" functions (evaluation of the project), they are not allowed to express opinions about the project and its implications. **Municipality of Puerto Aysén (Communal).** The mayor says that even if the majority of the population is in favour of the project, he gives his support depending on its socio-economic impact. **Municipality of Coyhaique (Communal).** There is no official position on the project, but the mayor says that the biggest regional resource, the water and its hydroelectric power has to be used for the industry needs. **Parliamentarians (National).** Two senator and one parliamentary are in opposition of the project. And the other parliamentary is in favour. But it has to be noted that, at the beginning of the conflict, Senator A. Zaldivar was recognized by many actors as the political sponsor of Alumysa project. But he changed his position in favour of the salmon farming sector. It can be said that all the parliamentarians are looking for the best way to reach economic growth.
SOCIAL	**Alliance for Aysén Reservoir of Life** (International) and **Citizen Committee for Aysén Reservoir of Life** (Regional). Their opinion is that Alumysa will strongly impact the region, in social, environmental and economic terms. Being Aysén one of the purest regions in the world, with its recent social and geo-biological formation, the 600 thousands tons of waste produced a year and an EIA that does not reflect all the potential impacts, it is difficult to say yes to such a project. They also argue that an industrialization plan like Alumysa is incompatible with the Regional Development Strategies 2000-2006. **Civic Committee for the Sustainable Development of Puerto Aysén and its Surroundings** (Communal). They support similar ideas than the previous coalition, and they have appealed to the court for protecting the national goods of public use affected by Alumysa. **Communal Unions of Puerto Aysén and Coyhaique** (Communal). The communitarian organizations have not given support to Alumysa, there is the intention to constitute a coalition to do so. **Population of Puerto Aysén and Coyhaique** (Communal). Some communal leaders have said that the majority of the population is in favour of Alumysa. Mainly people coming from low income levels. In their view, the project represents better job and salary opportunities. On the other hand, some people say that this is "bread for today, hunger for tomorrow".
ECONOMIC	**Proyecto Alumysa Ltda. (International)** The general manager answers to the critics that the project is not incompatible with the rest of regional activities, and that it is proved by the EIA that the emissions will be under the levels allowed by the environmental legislation. Also the industry will bring economic growth, with a better life quality at a lower cost, more jobs and infrastructure to a neglected region. **SOFOFA – Manufacturing Promotion Society (National).** The private entity says that the Chilean economic model is based on the private initiative in a free market, and in this situation they refuse the salmon farming position asking for exclusivity. **Salmon and Trout Producers Association of Chile - SalmonChile (National).** They say that the incompatibility between both sectors is in Puerto Chacabuco bay. Because the emissions and contamination (principally Fluorine) will affect the water where the salmon farming industry operates, damaging its production and image. **Regional Tourism Chamber (Regional).** They say that the big negative impacts are not well considered in the EIA, and the compensation and restoration plans are not equivalent to those impacts. The clean image of the region will be damaged, affecting the tourism industry as well. **Regional Commerce Chamber (Regional).** They basically support Alumysa for the big impulse over the commercial activity the project will bring (thanks to the immigration and purchasing power growth). **Chilean Construction Chamber (National).** The Alumysa project is an opportunity that the region can not lose. This sector has shown its interest over the productive infrastructure investment of 900 millions of dollars. And disregard the worry about the environmental consequences.

Sector	Social Actors
TECHNICAL	**Consulting Group, Mining Centre, Catholic University of Chile (National).** This organism concludes that the EIA needs additional information like possible synergies between different project's components; accumulative effects after 50 operation years; mitigation, elimination, minimization and compensation plans in more detail; why it does not use the best available technology; etc.

Note: In brackets it is said the scale at least each organization could have influence or bargaining power.

3.3. Multi-criteria evaluation in a SMCE context

Understanding *evaluation* as the combination of *representation, assessment* and *quality check* connected to a given policy problem in relation to a given objective (Munda, 2004: p. 15), any multi-criteria model has to be considered as a helpful tool in the representation and assessment steps, and not as the tool to reach the *optimal* solution.

The way the problem is structured is therefore very important, because it will determine the final results. In this analysis, the identified needs and expectations of the involved social actors (See Table 3) are the basis of both scenarios and evaluation criteria. In this way, one of the aims of the process is to avoid a technocratic approach, as well as trying to respond to the citizens' necessities.

This exercise may involve several ***subjectivities***, but it has to be reminded that one of the main aims of the SMCE is to promote discussion, negotiation and social learning, considering several viewpoints. Thus, transparency in presenting the underlying assumptions in the scenarios and criteria definition and valuation is an essential requisite, and the problem structuring must be open to be modified.

3.3.1. Future scenarios

All social actors perceive that Alumysa can drastically influence the future development of the region. At the same time, there is contradictory information about the impacts of the implementation of the plan that makes the adoption of a decision more difficult[14].

Then, three future scenarios on the regional future are built in order to tackle the uncertain consequences of: ***a)*** to continue with the current activities and trends, ***b)*** to construct the industrial complex in Chacabuco bay, or ***c)*** to change Alumysa's location at least 100 kilometres to the south-west.

The scenarios are projected for the next ten years, basically because of the available information on the activities' estimates, and also to avoid uncertainties associated with long-term predictions. The whole period was divided in two phases, five years to construct the Alumysa's infrastructures and the first five years of its operation. This task is mainly done relying upon Gallopin *et al.* (1997)'s guidelines for scenario construction.

Table 4 presents an overview of the scenarios.

14 On the one hand, the Alumysa's EIA says that the environmental impact of the Fluorine emissions will be low, because they won't reach the limits allowed by the Swiss environmental laws (In Chile the Fluorine emissions are not regulated, so that, the evaluation for the possible impacts of the Fluorine emissions in the Alumysa's EIA is based on the Swiss law. It is important to note that in Switzerland there aren't aluminium smelter plant as big as Alumysa, and this law establishes the limits according to the production levels). On the other hand, a study required to *Grupo Ambiental Consultores* by SalmonChile stands that the projected emission levels will produce incompatibility between the aluminium plant and the salmon farming activities, due basically to the Fluorine emissions levels.

Table 4: Overview of the scenarios

	Scenario E1	*Scenario E2*	*Scenario E3*
Basis for the scenario construction	· Regional Development Strategies 2000-2006 (SERPLAC, 2000) · Preliminary results of the Territorial Ordering Program · Projections of the enterprises acting in the region · Information obtained in the participatory phase	· Preliminary results of the Territorial Ordering Program · Alumysa's EIA · Information obtained in the participatory phase	· Preliminary results of the Territorial Ordering Program · Projections of the enterprises acting in the region · Alumysa's EIA · Information obtained in the participatory phase
Description	Business as Usual, with high development of the fishing sector, especially aquaculture, with a growth rate of 10% in the next 15 years (50% of the production comes from Aysén commune). Optimistic projections for fly fishing, canals navigation and eco-tourism. Mostly in Coyhaique and Puerto Aysén surroundings, and promising perspectives for clean food production. Craft fishing is limited by the quota restriction as well as mining by high transport and energy costs (something that has characterized this activity the last years).	Construction of Alumysa project in Chacabuco Bay, 15 kilometres from Puerto Aysén. From the fifth year, it is considered a complete displacement of the salmon farming and processing activities from the surroundings of the plant will take place [A]. Possible impact over Chacabuco bay as the main tourist maritime entrance to the region. Also, some tourist zones will be flooded. Craft fishing could see two of the four regional fleets affected by the construction of the Alumysa pier in Cuervo River outlet, one of the main fish recruitment points (*Merluza Australis*). Reduction in electricity costs and port infrastructure could impel the mining activity. Construction and commerce a favoured by the reduction in transport costs and population rise.	This is a combination of the previous ones. Construction of Alumysa 100 kilometres to the South-West of Chacabuco Bay. In this way, the salmon farming activity remain as today [B]. Fly-fishing and eco-tourism can be affected in the flooded areas, but also the project might provoke damage on the image of the region (purity). Craft fishing could see two of the four regional fleets affected by the construction of the Alumysa pier in Cuervo River outlet, one of the main fish recruitment points (*Merluza Australis*). Construction and commerce would be impelled, but less than in scenario E2, due to the far location of the plant. And mining could get the unused electric power capacity of Alumysa.
Economic activities evolution			
Aquaculture	↑↑	↓	↑
Tourism	↑↑	↓	↑
Forestry	↑	↑	↑
Agriculture	↑↑	↑	↑
Stock breeding	↑↑	↑	↑
Craft fishing	→	↓	↓
Mining	→	↑↑	↑
Commerce	→	↑↑	↑
Construction	→	↑↑	↑

	Scenario E1	Scenario E2	Scenario E3
Jobs characteristics	- Aquaculture sector will create near 20.000 jobs in ten years (75% in the Aysén commune) - Mostly seasonal and unstable (from tourism and aquaculture) - Medium/Low qualification required. - Low/medium salaries considering the high cost of life in the region.	- High amount of jobs in the Alumysa construction phase (up to 8.000 jobs in the 36th month). People from the region would occupied nearly 20% of them [C]. - 1.100 permanent jobs are offered in the operation phase, and people from outside the region would take almost 70% of the jobs (CH2MHILL, 2001). - Medium/High qualified jobs in general.	- Possible labour migration from the salmon farming sector to a better waged work (construction and commerce) - Alumysa jobs remains as scenario E2. - Low, Medium and High qualified jobs in general.
Salaries	→	↑	↑
Population evolution	↑	↑↑↑	↑↑
Supporters	· Alliance for Aysén · Citizen committee · Civic committee · SalmonChile · Regional Tourism Chamber	· Municipality of Puerto Aysén · Municipality of Coyhaique · Communal unions · SOFOFA (Industrial Promoting Society) · Regional Commerce Chamber · Chilean Construction Chamber	· Municipality of Puerto Aysén · Municipality of Coyhaique · Communal unions · SOFOFA (Industrial Promoting Society) · SalmonChile · Regional Commerce Chamber · Chilean Construction Chamber

↑ Increasing trend → Constant trend ↓ Decreasing trend

Note: The number of arrows indicates the intensity of the trend.

[A] Representatives of the salmon-farming sector. Personal communications

[B] Rodrigo Infante, General Manager of Asociación de la Industria del Salmón de Chile A.G. (Chilean Salmon Farming Industry Association-SalmonChile), to the newspaper El Divisadero. October 30th, 2002.

[C] Representatives of the construction sector. Personal communications

3.3.2. Eliciting evaluation criteria from regional Needs and Expectations

The evaluation criteria have been derived from the identified *needs* and *expectations* of the different socio-economic and institutional actors.

One of the most interesting things was the learning process experimented in the identification of these social needs and expectations. For example, *increasing the regional population* was initially seen as a means to *reduce the costs of electricity and drinkable water*. But through several discussions this necessity turned out to the need of *reducing the cost of life*, through a better *income distribution*. Furthermore, low regional population could be also seen as a strength point promoting, for instance, tourism in a territory with low anthropogenic intervention.

Table 5 shows the selected criteria, the related needs and expectations, and a brief explanation of the index/indicator to measure each of them. As it can be seen, qualitative evaluations are predominant, which is a rule rather than an exception in evaluating problems concerning socio-economic and physical planning (Nijkamp et al. (1990) quoted in Munda et al. (1994)).

Table 5: Evaluation criteria

Dimension	***Criteria***	***Needs and expectation***	***Index/Indicator***
Economic	Economic development	• To increase the regional wealth • Attract more public and private investment	Qualitative evaluation based on the net present value of the added value produced in the next 10 years by the main activities in each scenario (Alumysa project, salmon farming and tourism sectors)
	Employment	• Income stability • Jobs for regional inhabitants	Qualitative evaluation based on the amount of monthly jobs offered by the main activities in each scenario (Alumysa project, salmon farming and tourism sectors).
	External dependency of the regional economy	• Independence of external changes • To allow everybody's activity (synergy)	Ordinal evaluation based on: the number of economic activities using local raw materials, the number of activities depending on exports and the ownership of those activities in each scenario, and the number of hampered activities in the same categories.

Dimension	Criteria	Needs and expectation	Index/Indicator
Social	Impact over local culture	• To promote higher appreciation of the region by its inhabitants • To maintain rural population • To use regional resources	Qualitative evaluation based on: the rural-urban migration and the explosive immigration to the region promoted by the activities belonging to each scenario.
	Quality of jobs	• To improve wages (qualified labour) • To promote the installation of education centres • To have stable jobs • To reduce seasonality	Ordinal evaluation based on: the stability, the seasonality and the required qualification of the jobs created.
	Income distribution	• To reduce the cost of life • To get better wages in Puerto Aysén • To improve the quality of life	Ordinal evaluation based on the analysis of the possible trend of the ratio of average income received by the richest quintile to that received by the poorest quintile.
Environmental	Environmental pollution	• Protect some economic activities (i.e. clean production) • Use resources in a sustainable way • Protect the clean environment.	Ordinal evaluation of the atmospheric and aquatic pollution, taking into consideration the relative amount of pollutants, the pollutants characteristics and the capacity of the environment to absorb them.
	Landscape impact	• Protect tourism activity • Improve quality of life	Ordinal evaluation of the amount of actuations in different types of landscapes, classified by their visual fragility and quality.
	Forest lost	• Stop soil erosion • Protect native forest • Recover degraded soils	Surface of forest lost caused by the construction of roads and electric power lines, and the flooded areas.

Source: Own elaboration

It follows the criterion scoring process. Next section presents the procedure of constructing the impact matrix (Table 25), which contains the performances of the scenarios under the selected criteria.

3.3.3. Valuation of criteria

The type of criteria (qualitative or quantitative) is highly related to the available information about the impacts. Therefore, the criteria valuation exercise must be done according to the degree of uncertainty in the effects of the alternatives. A clear example of that is the valuation of the *Income Distribution* criterion. Firstly, it was thought to obtain the regional salaries structure for the different scenarios. To do this, it is necessary to make several assumptions, like the percentage represented by regional workers in the construction of Alumysa, the jobs qualification level, the salary policies in the economic sectors promoted by Alumysa, and so on. Moreover, it is necessary to know the new salary levels and the production policies in the salmon-farming industry. All those presumptions produce "hard" numbers but plenty of uncertainties and values. Because of that, it was decided to do a qualitative evaluation based upon the analysis of the possible trends of the ratio between the incomes of the economically richer and poorer quintile of the population (Q5/Q1).

The same applies to the *Regional gross product* and the *Number of jobs* criteria. Similar assumptions are also required to forecast the uncertain contribution of the other economic sectors, whose evolution is projected in qualitative terms (see Table 4). To value these criteria the main activities of each scenario are taken into account, and their performances are translated to qualitative evaluations. The qualitative evaluation is then intended to deal with this kind of uncertainties in the multi-criteria evaluation.

The method and the numbers underlying the qualitative valuations might be presented to the involved social actors within the decision-making process, in order to promote transparency and quality check.

The following sections present the main results of the criterion scoring process.

a) Economic growth

The participation of the Aysén region in the Gross National Product is about 0,4%. The objective of national and local authorities is to raise this contribution in order to increase wealth and improve the quality of life. Also, regional wealth is necessary in order to increase the autonomy of the region, which has been heavily subsidised.

In order to value this criterion, it is considered the contribution of tourism, salmon farming and Alumysa activities. Unfortunately, there is no information about the projections of other activities such as construction, commerce or craft-fishing. So, if we want to consider these sectors in the calculation of the gross regional product, then we should do several assumptions that increase the uncertainty in the obtained values.

In any case, the economic impact of those activities is evaluated under the criterion *regional economic independence*.

Due to the available information of the economic activities, the value added for the first period (2003-2008) is calculated by means of the method of the rent, which considers the salaries, the profits and the depreciation of equipments.

$$AV = S + P + D$$

where:

VA:= Value added

S:= Salaries

P:= Profit (including direct taxes)

D:= Depreciation

The contribution to the regional gross product for the second period (2009-2013) is obtained by adding the value added by each activity. That is, the value of the outputs minus the value of the inputs that are bought from other companies.

In the case of tourism, we know that at national level the value added of the tourist sector is around 80% of the spendings of tourists (SERNATUR, 1999). We use this value in order to estimate the value added of the regional tourism sector.

Table 6: Contribution to the Gross Regional Product of the main economic activities in the Aysén region (thousands of dollars of 2000)

	Period 2004-2008	*Period 2009-2013*
Scenario E1	**~917.000**	**~1.756.000**
Tourism	162.500	250.400
Salmon farming	754.500	1.505.000
Alumysa	0	0
Scenario E2	**~1.416.000**	**~1.500.000**
Tourism	88.000	86.800
Salmon farming	755.500	0
Alumysa	572.000	1.416.000
Scenario E3	**~1.635.000**	**~3.010.000**
Tourism	88.000	86.800
Salmon farming	755.500	1.506.000
Alumysa	791.800	1.416.000

Source: Own elaboration based on Gamboa (2003)

As mentioned above, this criterion is translated in qualitative evaluations due to the uncertainties involved in the criterion scores. Table 7 presents the figures used in order to estimate the qualitative criterion scores of the contribution to the Regional gross product. The nine qualitative categories are those included in NAIADE, the chosen multi-criteria method. They go from Excellent to Extremely bad. Since it's necessary to establish the correspondences between the scenario performances and the qualitative categories, the transformation is based on the assumption that the current trend (scenario E1) is Moderate, and a score equal to zero is Extremely bad. In this way, the situations that contribute to the regional gross product at least the double of the current trend are valued as Excellent.

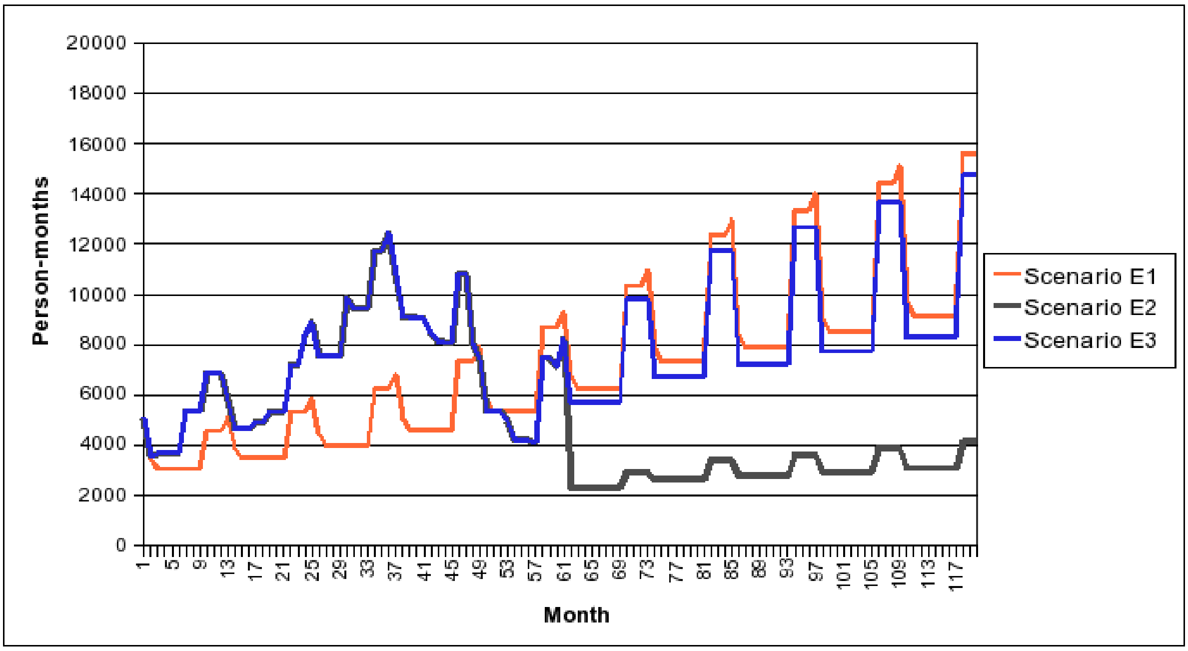
Table 7: Data for the qualitative valuations

	2004-2008 period				*2009-2013 period*			
	Reference	*E1*	*E2*	*E3*	*Reference*	*E1*	*E2*	*E3*
Projected contribution of the salmon-farming, tourism and Alumysa activities to the Gross Regional Product [*Millions of US$*]	750-920	~917	~1.416	~1.635	1.400-1.800	~1.757	~1.503	~3.010
Economic growth	Mod.	Mod.	Very Good	Exc.	Mod.	Mod.	Mod.	Exc.

Source: Gamboa (2007)

b) Employment

This criterion considers the direct jobs created by the different activities. Graphic 1 plots the amount of jobs to be created by Alumysa and by the tourism and salmon farming sectors in the following ten years in each scenario.



Graphic 1: Amount of projected jobs to be created by Alumysa, tourism and salmon farming sectors

The variations of the projected jobs are due to the seasonality of some activities and also due to the temporality of some offered jobs. One alternative of dealing with this issue is to consider only the permanent jobs created. But, according to the declarations of some actors, non-permanent jobs are also important in order to promote immigration to the region, among other reasons. So, we consider the area under the curve in order to include all offered jobs in the evaluation.

Table 8: Total number of offered by the Alumysa project and the tourism and salmon farming sectors (jobs·month).

	Period 2004-2008	*Period 2009-2013*
Scenario E1	**~326.000**	**~653.000**
Tourism	122.000	185.000
Salmon farming	204.000	468.000
Alumysa	0	0
Scenario E2	**~501.000**	**~269.000**
Tourism	80.000	90.000
Salmon farming	204.000	113.000
Alumysa	217.000	66.000
Scenario E3	**~374.000**	**~632.000**
Tourism	84.000	98.000
Salmon farming	204.000	468.000
Alumysa	286.000	66.000

Source: Own elaboration based on Gamboa (2003)

As in the case of the contribution to the regional gross product, the amount of offered jobs are translated into qualitative criteria. The transformation is also based on the assumption that the current trend (scenario E1) is Moderate, and a score equal to zero is Extremely bad. Table 9 shows this transformation.

Table 9: Data for the qualitative valuations

	2004-2008 period				*2009-2013 period*			
	Reference	***E1***	***E2***	***E3***	***Reference***	***E1***	***E2***	***E3***
Addition of the projected amount of monthly jobs offered by the salmon-farming, tourism and Alumysa activities, and the related indirect jobs. [*Thousands of Month-worker*]	340-430	~428	~603	~676	710-890	~887	~656	~1.196
Number of Jobs Created	Mod.	Mod.	Good	Very Good	Mod.	Mod.	+/- Bad	Good

Source: Gamboa (2007)

c) Regional economic dependence

Chile is an export oriented economy, and the main economic activities considered in this case are not different in this respect. Then, either the origin of the raw materials for the different activities in the region and the destination of the regional production seem an adequate basis for the evaluation of this criterion. When both the origin of the raw material and the destination of the regional production are outside the region, then the dependency of the regional economy increases. Table 10 describes the sub-criteria guiding the evaluation.

Table 10: Criteria for evaluating regional economic dependence

Criteria	*Positive impact on dependency*	*Negative impact on dependency*
Origin of the inputs	• It uses raw materials and inputs from the region	• It uses raw materials and inputs from abroad
Product destination	• Regional demand	• Products for exporting

It can be said that scenario E3 is the best alternative in both periods due to the higher diversity of economic activities in the region. So, it remains to compare scenarios E1 and E2.

According to the characteristics of the proposed economic activities, the regional economy is more dependant in scenario E2 than in E1. This is due to the fact that in scenario E2 most of the activities are around the mining sector, specially around the Alumysa project. In this last case, the raw materials would be brought from South-Africa and the production is for exporting.

The case of the salmon farming industry is quite similar, but the fish eggs and the young fishes are increasingly produced in Chile. Moreover, it is expected that the salmon farming industry will not affect other economic activities as Alumysa would do.

Table 11: Total number of offered by the Alumysa project and the tourism and salmon farming sectors (jobs-month)

	Period 2004-2008	***Period 2009-2013***
Scenario E1	Second	Second
Scenario E2	Third	Third
Scenario E3	First	First

Source: Own elaboration based on Gamboa (2003)

d) Impact over local culture

One of the outcomes of the sociological research is a description of a set of social practices and habits that are appreciated by regional people (See Gamboa, 2003). And migration movements, which are expected in the region, could affect some of these local customs.

Table 12 lists some of these practices, which are grouped under two categories. The first column of the table indicates these groups of local social practices positively valued by the people. The second column lists the sort of potential migration movements that would affect these local customs, and column three lists some practices potentially affected by migration movements.

Table 12: Sub-criteria for evaluating the impact over the local culture

Group of practices	***Criteria/Indicator***	***Potential effects on***
Traditional productive systems	**Rural-urban migration**	• Impact over the traditional familiar work systems and on the traditional knowledge • Impact over the traditional economic activities • ...
Perceptions, rhythms and social practices	**Explosive migration to the region**	• Impact on the perception of security • Impact on tempo-spatial perceptions (e.g. *"who is in a hurry loose his/her time"* is a common local saying) • Impact over social practices such as expressions of solidarity, greeting and so on. • ...

Source: Gamboa (2003)

The evaluation of the scenarios is based on the following (realistic) assumptions:

- High rates of rural-urban migration would negatively affect traditional productive systems and vice-versa
- An explosive migration to the region would negatively impact the perceptions, rhythms and social practices of people (basically due to the arrival of a large number of unknown people, which could hinder trust among them)

Table 13 shows the attributes of the migration movements in the different scenarios. This evaluation is based on the characteristics and the dynamics of the economic activities projected in each scenario.

Table 13: Characteristics of the migration movements in each scenario

	Period 2004-2008			*Period 2009-2013*		
	Scenario E1	***Scenario E2***	***Scenario E3***	***Scenario E1***	***Scenario E2***	***Scenario E3***
Rural-urban migration	More or less low	Very high	Very high	Moderate	High	More or less high
Explosive migration	More or less low	Very High	High	Moderate	More or less high	High

Source: Own elaboration based on Gamboa (2003)

and Table 14 presents the evaluation of the different scenarios under this criterion, which is based on the information contained in Table 13.

Table 14: Impact over local culture

	Period 2004-2008	***Period 2009-2013***
Scenario E1	More or less low	Moderate
Scenario E2	Very high	More or less high
Scenario E3	High	More or less high

Source: Own elaboration based on Gamboa (2003)

e) Quality of jobs

According to the information collected during the participatory activities, the quality of the jobs in this regional context depends on their stability, seasonality and required qualification (salary levels).

Stability refers to the stability of job and not to the stability of the worker in his/her position. For instance, a temporal job that is open every year is a stable job. On the other hand, seasonal jobs are those that do not last all the year around. These last sort of jobs can be created every year (stable) or can be created only for one season/year.

It is considered that the jobs are better when stability is high, the seasonality is low and the required qualification is high (better salaries).

The sub-criteria are evaluated as follows:

- Stability. Qualitative evaluation based on an analysis of Graphic 1.
- Seasonality. Average of the annual percentages of permanent jobs in relation to the total amount of jobs created. So, more permanent jobs in relation to the total amount of jobs created each year implies lower seasonality.
- Qualification. Number of qualified jobs as a percentage of the total amount of jobs created.

Table 15 presents the sub-criterion scores for each scenario.

Stability

Graphic 1 shows how scenarios E2 and E3 create a big amount of temporal jobs for the period 2004-2008. Scenario E1, on the other hand, create stable jobs but seasonal (i.e. Jobs that not disappear).

It is worth noting the precarious conditions of most of the workers in the salmon farming sector: lack of permanent contracts, lack of social security system, low salaries, among other.

In the tourism sector most of the jobs are stable (but seasonal), due to the projections of the activity and because these jobs require experience and certain skills.

For the period 2009-2013, scenario E1 has the same characteristics than the previous period. Scenario E2 offers very stable jobs (basically the 1.100 jobs of Alumysa), and scenario E3 is an intermediate point between the two others

Seasonality

From the data behind Graphic 1 one can obtain the percentage of stable jobs with respect to the total amount of jobs offered in each scenario.

Qualification

The percentage of the qualified jobs offered in each scenario.

According with SERNATUR (1999) about 90% of the workers in the tourism sector were qualified. I use this figure for the next 10 years.

According (Molinet et al., 2001: 42), 15% of the workers in the salmon farming sector require certain skills. But in the period 2009-2013 scenario E2 this percentage will decrease due to the removal of the processing plants from Chacabuco bay.

In the case of Alumysa, its environmental impact assessment indicates the total amount of skilled workers to be hired.

Table 15 presents the evaluation of the scenarios under the three sub-criteria of jobs quality (See also Appendix A for more information on the amount of jobs created by the main economic activities of each scenario).

Table 15: Evaluation of the stability, seasonality and required qualification of the jobs offered by the main economic activities in each scenario

	Period 2004-2008			***Period 2009-2013***		
	Scenario E1	***Scenario E2***	***Scenario E3***	***Scenario E1***	***Scenario E2***	***Scenario E3***
Stability	Good	Very bad	Very bad	Good	Very good	Good
Seasonality	84%	80%	80%	81%	91%	87%%
Qualification	40%	63%	49%	31%	61%	53%

Source: Own elaboration based on Gamboa (2003)

The evaluation of the scenarios comes from a multi-criteria analysis considering the above-mentioned sub-criteria, which gives the following results (Table 16)

Table 16: Impact over local culture

	Period 2004-2008	***Period 2009-2013***
Scenario E1	First	Third
Scenario E2	First	First
Scenario E3	Third	Second

Source: Own elaboration based on Gamboa (2003)

f) Income distribution

The high cost of life is one of the main problems that the inhabitants of the Aysén region are facing. One way of dealing with this problem is to raise the income of poorer people.

According to Contreras (1999), the behaviour of the richest quintile explains the high degree of inequality that Chile presents. The richest quintile have an average income much more higher than the rest of society, and no such a differences exist between the other four quintiles.

Two indicators of income inequality are the GINI index and the relationship between the income of the richer quintile over the poorer quintile (Q5/Q1). GINI does not adequately capture the changes of the incomes of the richer and the poorer people, so the evaluation of the income distribution is done in a qualitative way and based on the analysis of the possible trends of the relationship Q5/Q1.

Table 17: income by economic sector. Chile, year 2000

Economic sector	*Average income [Dollars of 2000]*
Agriculture and fishing	510 (a)
Mining	929
Electricity, water and gas	974
Industry	429
Construction	332
Commerce	377
Transport and communications	493
Financial services	916
Social services	532

Source: Own elaboration based on information from the National Statistics Institute of Chile.
Notes: (a) According to the gathered information, the salaries of non-qualified workers in the salmon farming sector are around U$260 (dollars of 2000). Non qualified workers are the majority in this sector.

Table 18 presents the evaluation of the scenarios under the income distribution criterion. This evaluation is based upon the information presented in Table 17 and the possible future trends of the economic sectors in the region (see Table 4. See also Appendix A).

Table 18: Income distribution

	Period 2004-2008	*Period 2009-2013*
Scenario E1	Third	Second
Scenario E2	Second	Third
Scenario E3	First	First

Source: Own elaboration based on Gamboa (2003)

g) Environmental pollution

A big proportion of the population manifest their concerns about the emissions of contaminants of the salmon farming sector and of the Alumysa project.

This evaluation considers only the atmospheric pollutants. The contamination of the water bodies will be equally important in all the scenarios (See Appendix A). Table 19 shows the emissions of atmospheric pollutants.

Table 19: Atmospheric pollutants

	Period 2004-2008			Period 2009-2013		
	SO_2	PM10	HF	SO_2	PM10	HF
Scenario E1	> 0	> 0	0	> 0	> 0	0
Scenario E2	>> 0	784-852	0	> 3.485	5.420	1.540
Scenario E3	>> 0	> 784-852	0	> 3.485	5.420	1.540

Source: Own elaboration based on CH2MHILL (2001) and Gamboa (2003)

But the impacts of pollution depends on the characteristics of the environment and on the effects of the pollutants on the ecological and human health. So, according to the analysis presented in Appendix B, the evaluation is as follows (see Table 20)

Table 20: Environmental pollution

	Period 2004-2008	Period 2009-2013
Scenario E1	First	First
Scenario E2	Second	Third
Scenario E3	Second	Second

Source: Own elaboration based on Gamboa (2003)

h) Landscape impact

The different scenarios consider several actions that will produce a landscape affection: the installation of salmon cages, the construction of the industrial complex, the dams and so on.

The qualitative evaluation of this criterion is based upon both the visual quality and the visual fragility of the affected zones. This is an appropriate evaluation methodology for large impact areas within a land-use planning context (MOPT, 2000).

Table 21: Landscape classification

Class	Visual quality	Visual Fragility	Observations
Class 1	High	High	Conservation priority
Class 2	High	Low	Appropriate for promoting activities that require visual quality and that cause low landscape affection
Class 3	Medium or High	Variable	Can be incorporated to the previous ones in some cases
Class 4	Low	Medium or High	Can be incorporated in the Class 5
Class 5	Low	Low	Appropriate for developing unpleasant activities or activities with high landscape impact

Source: MOPT, 2000.

Table 22 presents the amount of target sites for constructions or activities classified by the classes defined in Table 21, which is used so as to carry out the ordinal evaluation of the scenarios presented in Table 23.

Table 22: Amount of infrastructure developments in different classes of landscapes

	Period 2004-2008					Period 2009-2013				
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 1	Class 2	Class 3	Class 4	Class 5
Scenario E1	1	2	1	-	-	1	2	1		-
Scenario E2	3	3	2	1	-	3	6	2	1	-
Scenario E3	1	3	3	1	-	2	6	3	1	-

Source: Gamboa (2003)

Table 23: Landscape impact

	Period 2004-2008	Period 2009-2013
Scenario E1	First	First
Scenario E2	Third	Third
Scenario E3	Second	Second

Source: Own elaboration based on Gamboa (2003)

i) Forest lost

Currently, the huge area of degraded soil and soils susceptible to erosion is one of the most important problems in the region. This fact is corroborated by the consulted experts, and by the governmental programs aimed at reforesting and recuperating the soil in the region.

Table 24 shows the expected forest lost in each scenario. These figures consider the deforestation produced by the construction of roads, electric power lines and infrastructures, and also the flooded area for the dams.

Table 24: Forest lost [hectares]

	Period 2004-2008	Period 2009-2013
Scenario E1	0	0
Scenario E2	~20.100	~20.300
Scenario E3	~20.800	~21.000

Source: Own elaboration based on Gamboa (2007)

NAIADE (the selected multi-criteria model for this evaluation) requires the definition of indifference and preference thresholds for quantitative criteria. In this case, the definition of these thresholds is based on both the reforested area and the surface of soil recuperated during the last years.

The results of governmental programs for soil recuperation are the following: The Aysén commune has recuperated 203 hectares in 1998 to 2.690 hectares in 2002, with an average of 1.411 hectares per year. The Coyhaique commune has recuperated 1.260 hectares in 1998 to 9.540 hectares in 2002. The average is 5.970 hectares per year.

On the other hand, and during the period 1997-2002, the annual average of lands submitted for reforestation is about 7.900 hectares in Coyhaique and 2.020 hectares in Aysén.

That is, about 20 thousands of hectares are recuperated every year through these governmental programs. Then, we define the following indifference and preference thresholds for the use of NAIADE:

- *Much Better:6.000 ha*
- *Better: 5.000 ha*
- *Almost equal: 2.000 ha*
- *Equal: 1.000 ha*

3.3.4. The multi-criteria structure

The impact matrix (Table 25) shows that between 2004 and 2008 scenario E3 would have better performance in economic terms due to the activity the construction of Alumysa may bring. Scenario E2 fails in the External dependency of the regional economy. These scenarios are highly dependent on the variations of global markets.

Table 25: Impact matrix

Criteria	Unit	Direc-tion	2004-2008 period			2009-2013 period		
			E1	E2	E3	E1	E2	E3
Economic development	Qualitative		Mod.	V. Good	Excellent	Mod.	Mod.	Excellent
Employment	Qualitative		Mod.	Good	V. Good	Mod	+/- Bad	Good
Regional economy external dependency	Ordinal		Second	Third	First	Second	Third	First
Impact over local culture	Qualitative	Min.	+/- Low	V. High	High	Mod.	+/- High	+/- High
Jobs quality	Ordinal		First	First	Third	Third	First	Second
Income distribution	Ordinal		Third	Second	First	Second	Third	First
Environmental pollution	Ordinal		First	Second	Second	First	Third	Second
Landscape impact	Ordinal		First	Third	Second	First	Third	Second
Forests lost	Hectares	Min.	0	~20.100	~20.800	0	~20.300	~21.000

Source: Reviewed and modified from Gamboa (2003)

In social terms, Scenario E1 seems better, but it has a poor *Income distribution* score, something that has been remarked by many regional actors, and maybe is one of the production factors that allows the salmon-farming sector competing so well in the international arena.

Environmentally speaking, it is clear that from the *Forest lost* and *Landscape visual impact* points of view Scenario E1 performs better. Even if the three scenarios would produce high amounts of releases to the aquatic environment derived from the salmon feeding (for instance antibiotics, phosphorus and nitrogen), the Fluorine emissions of the industrial activity are those that make the difference. The same kind of analysis for the second period of five years can be done in order to identify the relative impacts of the alternatives.

The kind of analysis done in the previous paragraphs would be useful to centre the discussion about what is important for the social actors and what is relevant to make the decision. It also would improve transparency by means of making visible the prevailing criteria when the decision is made.

3.3.5. The Multi-criteria Evaluation Model in SMCE: its requisites.

Several multi-criteria methods partially fulfil the desired attributes in the context of public policies. Here, the discrete multi-criteria model **NAIADE** (**N**ovel **A**pproach to **I**mprecise **A**ssessment and **D**ecision **E**nvironments. Munda, 1995) is used because it manages **mix information** (qualitative and quantitative), its algorithm takes into account **indifference and preference thresholds**, and it allows to decide the **degree of compensation** in the criteria aggregation (which permits to do a sensitivity analysis in this regard).

The steps of this technical evaluation are:

i. Construction of the impact matrix (see Table 25).

ii. Pair wise comparison by means of preference relationships. Indifference and preference thresholds have to be defined for this task.

iii. Criteria aggregation procedure. NAIADE uses the number of criteria in favour of each alternative instead of another, and the intensity of preference.

iv. Obtaining the ranking of alternatives.

More information about specific features of NAIADE can be found in Munda (1995) and JRC (1996).

It is important to highlight that several factors influence the rankings of alternatives: the quality of the information and data used to value criteria, the criteria or indicators chosen for the evaluation, the indicator direction (to maximize or minimize), and the criteria aggregation method (mathematical model). In other words, the **results of the multi-criteria analysis depend on the problem structuring process and its outcomes.**

3.3.6. The technical evaluation

As mentioned above, NAIADE model requires the definition of the preference and indifference thresholds for quantitative criteria in order to carry out the criteria aggregation. This is one of the main difficulties in the process: condensing in one number the limits between what is socially preferred and what is not is a complex task.

In this case, only the *forest lost* criterion is valued in quantitative terms, which thresholds are defined according to the reforestation rates of the last 5 years.

Table 26 presents the results obtained by means of applying NAIADE model with different degrees of compensation. Scenario E1 ranks first in the former period. It would cause less environmental and social impacts than the others, even if the jobs qualification and salary levels remain low. Scenario E3 has some advantages in socio-economic terms, which makes it raises with medium degree of compensation.

The position of scenarios E1 and E3 switch in the second period, due basically to the socio-economic development that the coexistence of industrial activities would bring. But it would require assuming the impacts of the explosive immigration during the construction period and the considerable environmental harms that would hinder the quality of life.

This technical evaluation must be contrasted against the social evaluation further on, in order to help in finding the compromise option.

Table 26: Results of the multi-criteria evaluation

Degree of compensation	Minimum compensation	Medium compensation	Maximum compensation
Period 2004-2008	E1 E3 E2	E1 E3 E2	E1 E3 E2
Period 2009-1013	E1 E3 E2	E1 E3 E2	E3 E2 E1

Source: Own elaboration based on the sensitivity analysis presented in Table 83 and Table 84 in Appendix A.

3.3.7. The social evaluation

This part of the evaluation explores the possible coalitions that could arise among the social actors. The model starts from the evaluation that every social actor gives to each scenario (see Table 27). The *equity matrix* is built based on the information collected in the institutional analysis and on the participation process and.

Table 27: Equity matrix

Social actors	***Scenario E1***	***Scenario E2***	***Scenario E3***
Puerto Aysén Municipality	+/- Good	Good	Good
Coyhaique Municipality	+/- Good	Good	Good
Alliance for Aysén Reserve of Life	Very Good	Very Bad	Very Bad
Citizen Committee to Defend Aysén Reserve of Life	Good	Extremely Bad	Extremely Bad
Civic Committee for Aysén and its Surroundings Sustainable Dev.	Good	Extremely Bad	Extremely Bad
Aysén and Coyhaique Communal Unions	Moderate	Very Good	Good
Alumysa Project	Very Bad	Excellent	Moderate
SOFOFA (Industry chamber)	+/- Good	Very Good	Good
SalmonChile	Excellent	Very Bad	Good
Regional Tourism Chamber	Very Good	Extremely Bad	Very Bad
Regional Commerce Chamber	Moderate	Very Good	Good
Chilean Construction Chamber	Moderate	Excellent	Excellent

Source: Gamboa (2003)

a) Coalition formation analysis

NAIADE has an interesting coalition formation analysis module. The software obtains a *coalition formation Dendrogram* (Figure 5) based on the *distance* between the actors' interests, which are reflected in the *Equity matrix* (Table 27). The Dendrogram shows the possible coalitions between the different interest groups, and the user can access to the rankings of alternatives for every coalition (see Table 28).[15]

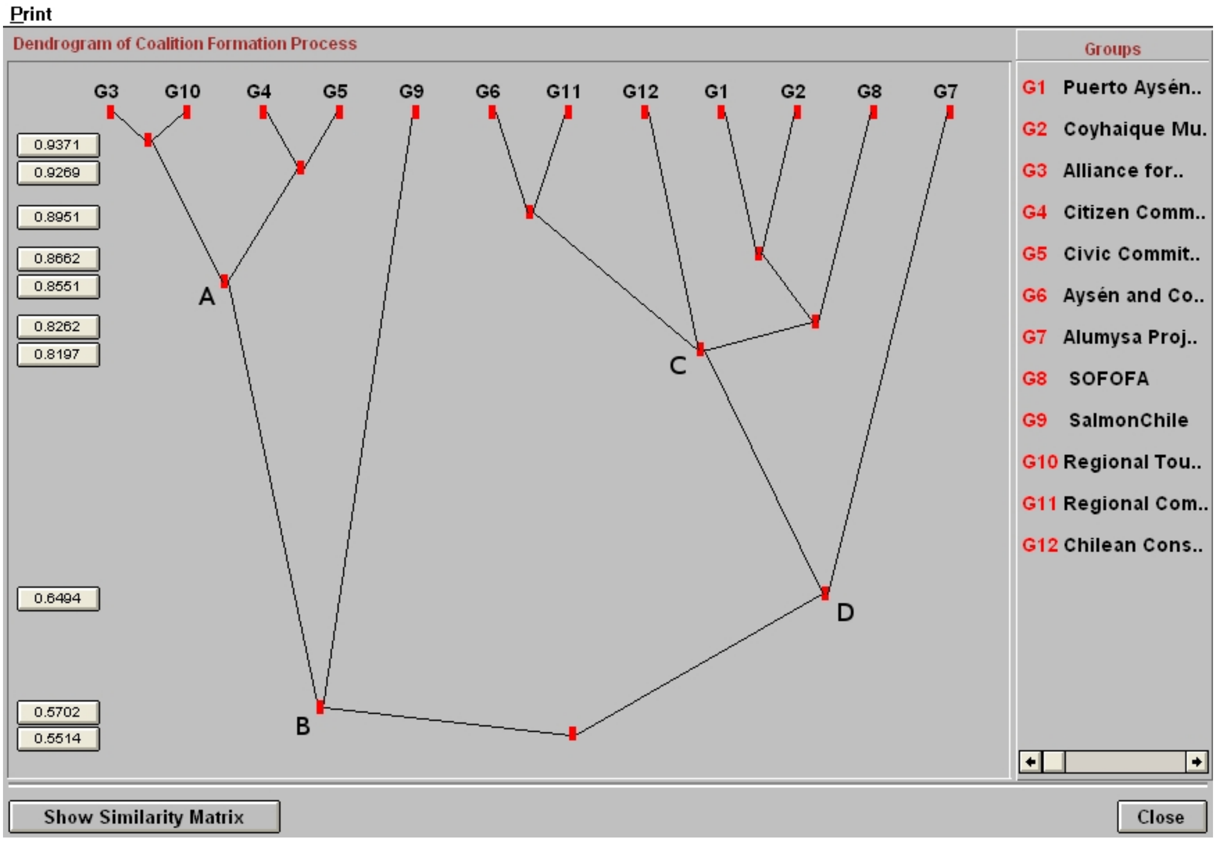


Figure 5: Dendrogram of potential coalitions

The modelling results (Figure 5) show that there is a high credibility level of coalition formation (~0.86. Point A in Figure 5) between the Alliance for Aysén Reserve of Life, the Tourism Regional Chamber, the Citizen Committee and the Civic Committee. This is due to the fact that they have common interest and aims regarding the activities that must be developed in the region. Behind the coalition there is the idea that a clean environment is needed for the activities they support and to reach a better quality of life.

It is interesting to see how SalmonChile (salmon farming industry) joins this group with a lower credibility level (~0.56. Point B in Figure 5). Presumably, the explanation is that their main reason to oppose the Alumysa project is to protect the stability of their activity (they would agree with the Alumysa project if the plant is moved from Chacabuco bay, faraway from their operational centre).

Something similar happens in the Alumysa supporting side, where some institutions and groups reach high coincidence degree (~0.83. Point C in Figure 5). But at the same time, Alumysa Project joins to this coalition with a lower degree of credibility (~0.65. Point D in

15 For a detailed description of the coalition formation module of NAIADE see Munda (1995).

Figure 5). They do not perceive moving the project 100 kilometres to the south-west as a viable alternative, because it would decrease their benefits.

Table 28: Coalition rankings at 0,8325 coincidence degree

Coalitions	*G1 - G2 - G6 - G8 - G11 - G12*	*G9*	*G3 - G4 - G5 - G10*	*G7*
	E2	E1	E1	E2
Rankings	E3	E3	E3	E3
	E1	E2	E2	E1

Social groups:

G1. Municipality of Puerto Aysén	G7. Alumysa Project
G2. Municipality of Coyhaique	G8. SOFOFA
G3. Alliance for Aysén, Reservoir of Life	G9. SalmonChile
G4. Citizen Committee to Defend Aysén Reserve of Life	G10. Regional Tourism Chamber
G5. Civic Committee for Aysén and its Surroundings Sustainable	G11. Regional Commerce Chamber
G6. Aysén and Coyhaique Communal Unions	G12. Chilean Construction Chamber

Note: Some of the rankings have the same ordering, but the intensity of preference among alternatives is different.

Clearly these results do not take into consideration the personal relationships among the social actors, which could influence the possibility of forming coalitions in real-life. But the results can help everybody to know who is interacting in the conflict and which aims they have.

3.3.8. Looking for the compromise choice

The *intersection* between the technical and social evaluations can be the starting point to look for a defensible option aimed to manage/reduce conflict. In this case, scenario E3 was constructed trying to harmonise a diversity of viewpoints, but some citizens and environmentalist groups veto the implementation of the Alumysa Project regardless its location, basically because they do not share the development model Alumysa represents.

In this regard, it is worth mentioning that the evaluation process carried out by the COREMA has finished (or partially finished) when Noranda has withdrawn the project's EISt. Some weeks before, the president of Chile made some declarations about the possible incompatibility between Alumysa and other regional activities. In this sense, the salmon-farming sector played an important role thanks to their bargaining power[16]. Then, a governmental commission was created to find a new location for Alumysa (trying to avoid that this big investment leaves the country). As we can see, social aspects could not be

16 Chile is the second producer of salmon in the world, and the salmon industry is the fourth exporter sector in Chile.

separated from the technical EIAS, and processes taking into consideration this issue can be very useful in finding transparent (and hopefully more equitable) decisions, instead of technical solutions influenced by the more powerful social actors.

3.3.9. Discussion

This section discusses some deficiencies of the EIA process and how a SMCE framework can help in overcoming those identified problems of the former.

a) On the process

First, the **lack of alternatives analysis** is one of the key deficiencies in the EIA, which narrows the space to make the decision. As in Chile, several countries don't consider the comparison of options during the process (see for instance, De la Maza, 2000; Wang et al, 2003; El-Fadl and El-Fadel, 2004; Alshuwaikhat, 2005). The lexicographic model[17] characterizing this decision-making process encourages this shortfall of the EIA. In other words, an EISt— the socio-ecological assessment of impacts— is usually only submitted when the project satisfies the financial assessment of the investor.

But, even if the EISt of the project submitted for governmental permission considers the description and assessment of more than one option, the analysis would rely upon one perspective, the promoter's one. Moreover, agency agendas can bias this set of options toward the desired action (Steinemann, 2001), something that can undermine the public trust on the whole process.[18]

The appraisal of impacts is also constrained. Even if the investor takes into consideration several criteria to evaluate the effects of its project, this impact study (the EIA) is still only one picture of the situation— *a perspective relying upon set of aims defined from* ***one*** *point of view (the investors' one)*—, which is not enough to describe and represent *complex* problems (O'Connor et al., 1996; Funtowicz et al. 1999), neither to base this kind of decisions on.

On the contrary, multi-criteria evaluation is based on the analysis of several alternatives, leading, for instance, to partially implement the original submitted project, or to put into practice a different choice.

In a SMCE exercise alternatives are built taking into account the objectives of several social actors. Thus, it is expected that the *compromise solution* would have higher possibilities to fit in the local context, i.e. to respond to the problems caused by the presence of different values and objectives in society.

Secondly, as showed in section ***Social research in a SMCE*** and its sub-sections, **the influence of public involvement in the EIA is limited** to analyse and to comment the EISt. The involved social actors cannot provide knowledge in previous steps, and the 60 days of public participation established by the Chilean law can be extremely short when the EISt is as complex and large as the Alumysa's one.

Early involvement of the public in EIA processes has proved to be worthy (see for instance

17 The name *lexicographic* refers to the way in which the words are searched in a dictionary. There is a set of hierarchically ordered criteria and a set of alternatives. First, the alternatives fulfilling the first criterion (called the Dictator) are chosen. Then, the second criterion is applied to choose among the remaining alternatives. The process continues until only one alternative is selected.

18 The legislations of several countries consider the evaluation of different options in their EIA systems. But these schemes are regarded as insufficient by some authors analysing this kind of processes (see for instance Steinemann, 2001; Zubair, 2001; Bruhn-Tysk and Eklund, 2002; El-Fadl and El-Fadel, 2004; Alshuwaikhat, 2005).

Bond *et al.*, 2004, and Saarikoski, 2000), but it remains several deficiencies in how to include public concerns in the evaluation (see for instance, De la Maza, 2000; Steinemann, 2001; Zubair, 2001; Bruhn-Tysk and Eklund, 2002; Wang *et al.*, 2003; El-Fadl and El-Fadel, 2004; Alshuwaikhat, 2005; Hartley and Word, 2005). It is important to note that trained interviewers and experimented focus groups' facilitators are desirables to take as much advantage as possible of the participatory steps.

SMCE calls for public involvement along the whole decision-making process. The insights from a variety of social actors would allow performing a quality check of the problem structuring and of the information used during the evaluation. For instance, in the Alumysa's EISt there is a map indicating areas to be flooded in the Caro Lake zone, which contradicts the opinion of the people living in those valleys. The inhabitants of that zone know, from their experience in rainy episodes, that the flooding dynamics in the area are quite different than the information contained in the Alumysa's EISt. Another example is the differences in the information of the effects of the Fluorine emissions indicated in the Alumysa's EISt, compared to that given by the technical advisors of SalmonChile.

As it was said before, criteria are the technical representation of the aims of the involved social groups and institutions. Then, public involvement would also allow a quality check of the unavoidable subjectivities in the problem structuring.

The combination of participatory approaches and a multi/inter disciplinary work would permit to address the existence of *social* and *technical incommensurabilities* (Munda, 2004), and the social and technical evaluations would facilitate to better understand the sources of the conflict.

Accordingly, it is needed an institution to integrate knowledge during all the decision-making process; coordinating the generation of information from several sources and facilitating its exchange, in order to create the basis for a common understanding of the problem.

b) On the management of uncertainty

According to Funtowicz and Ravetz, "uncertainty and ignorance can no longer be expected to be conquered; instead, they must be managed for the common good" (Funtowicz and Ravetz, 1991; p. 146). In this regard, the outcomes of the Alumysa project in the social, economic and environmental dimensions are rather uncertain. Therefore, the SMCE presented in this paper has tackled these uncertainties through the evaluation of **qualitative scenarios**.

According to the Zadeh's Incompatibility Principle (Zadeh, 1973), our ability to make precise and yet relevant statements about the system diminishes as the complexity of the system increases. Thus, **qualitative and ordinal evaluation of criteria** can also play an important role in highlighting the lack of knowledge in some uncertain issues such as, for instance, the evolution of the regional structure of the salaries after the implementation of the Alumysa project.[19]

The thresholds definition for quantitative criteria is another difficulty found in this study. As mentioned above, it is very difficult to condense different visions and aims in one number expressing social preference and indifference. Thus, a sensitivity analysis is advisable to assess the robustness of the evaluation, and to appraise the influence of each criterion in the final outcome.

Qualitative valuation is another possibility to manage this problem, but making explicit the

19 This information would be needed to project or forecast the *Income distribution* in a quantitative way.

quantitative performances underlying the qualitative scores. Two examples are the evaluations of the *Gross Regional Product* and of the *Number of jobs* criteria. The translation of the quantitative scores to the qualitative scale provided in NAIADE makes possible to partially consider the intensity of preference without being forced to define thresholds.

To reduce subjectivities in deciding whether a criterion is scored in a qualitative or quantitative way can be made, for instance, under the guidance of an uncertainty classification system (see, for instance, van der Sluijs *et al.*, 2006). Figure 6 presents the Pedigree matrix for research developed by Funtowicz and Ravetz (1990). One possibility is to adapt this matrix to use it in the public policy realm. For instance, instead of considering only the consensus among scientists (last two columns), one should consider the consensus among scientists and the relevant/involved social actors. Then, we can use this table so as to decide whether to use qualitative or quantitative criterion scoring as

Score	**Theoretical Structure**	**Data input**	**Peer acceptance**	**Colleague consensus**
4	Established theory	Review	Total	All but cranks
3	Theory-based model	Historic/Field data	High	All but rebels
2	Computational model	Extrapolated	Medium	Competing schools
1	Statistical processing	Calculated	Low	Embrionic field
0	Definitions	Expert guess	None	No opinion

Figure 6: Pedigree matrix for research (Source: Funtowicz and Ravetz 1990)

Table 29: Defining the type of criterion scoring based on the Pedigree score of the available information

Pedigree score	Type of criterion scoring
4	Crisp numbers
3	Stochastic/Fuzzy numbers
2	Qualitative or Stochastic/Fuzzy numbers
1	Qualitative
0	Ordinal

c) On the integration tool

As it has been said before, SMCE is suggested as an alternative decision-making procedure to the EIA. The idea isn't to substitute the EIA from the evaluation procedure. Instead, it is stated that the multi-criteria structuring within the SMCE may play an important role as an integration framework of a diversity of approaches such as EIA, Cost-Benefit Analysis, Life Cycle Assessment, and so on. In this regard, the EISt might be considered as an input of the whole evaluation process rather than the basis for the government approval.

Additionally, the multi-criteria structure improves transparency since the impacts on several dimensions are presented together and they are not reduced to a single unit of measure. The access to the information presented here was not difficult, but it was spread among some social actors. Some of them have commented that the multi-criteria structure (the impact matrix) is a helpful tool to present an integrated picture of the impacts.

It is important to note that the multi-criteria model must be selected according to the problem at hand. NAIADE has proved its usefulness managing mix information and the different degree of uncertainty in the valuations. It doesn't deal with the ordinal scores, but they can be modelled through quantitative or qualitative evaluations. In this study, ordinal evaluations have been modelled by means of crisp numbers, and a sensitivity analysis has been carried out to verify the robustness of the results.

3.3.10. Conclusions

EIA of projects are generally used as the basis for public policy making. However, this *technical* process is embedded into a social, economic, ecological and political context that influences the final outcome. The way this case has finalized (or partially finalized) is an example of that.

Then, it seems better to accept the inseparability between the several dimensions of the system, and to construct a decision-making procedure according to which the context is taken into consideration and the social actors can be fully involved. By means of both Participatory Approaches and Multi/Inter-Disciplinary work the social and technical incommensurabilities can be tackled. SMCE framework can then act as a showcase to increase transparency in public decisions and science can be improved to better comprehend the different aspects of the problem.

In this regard, there are several sociological research methods to include social perceptions in the problem framing. The ones presented here are not a panacea; instead, they have to be adapted to the situation under study, evolving in a dynamic way and according to the socio-cultural context. This entails that the analysts have to work as integrators, gathering several visions in a critical way, transparently and serving as a communicator between society, decision makers, technicians and the academia. Furthermore, incorporating several visions in the evaluation process might help to reach sound policies.

On the technical aspects, it should be noted that a qualitative evaluation gives the opportunity to make the criterion scores calculation coherent with the level of uncertainty in the available data, increasing the transparency of the process (avoiding excessive assumptions and forecasting of data). Anyway, multi-criteria models in the public policy framework can be further improved, for instance, increasing their simplicity to gain in transparency.

Regarding the social evaluation, the coalition formation analysis can play an important role in describing the relationships among the social actors, and knowing the "distances" between their aims. But it should be remembered that real-life relationships are affected by much more factors than the *distance among objectives* the model uses for the evaluation.

In this way, the combination of the social and technical evaluations can help the decision-makers to look for a compromise solution among contrasting interests. In other words, a defensible choice aimed to reduce conflict.

Finally, by means of simultaneously considering several perspectives and dimensions, SMCE provides higher possibilities (than the kind of EIAS presented here) of preserving cultural, economic and biological diversity, which are important to reach a balance between flexibility (in order to face unknown changes in the system and sub-systems) and efficiency (in the management of the resources).

Appendix A. Calculation of criterion scores and the multi-criteria model

This appendix presents additional information about the criterion score calculation of the previous chapter and of the multi-criteria software NAIADE.

A.1. Valuation of criterion scores

a) Economic development (Added Value)

As of August 2001, the Central Bank of Chile has decided to normalize the monetary policy, setting up a yearly interest rate of 6.50%. This value is used so as to calculate the Net Present Value of the Added Value of scenario, and for the following criteria that need the calculation of the NPV.

Table 30 Presents the assumptions for the valuation of the contribution to the Gross Regional Product of each scenario.

Table 30: Assumptions for the valuation of the contribution to the Gross Regional Product of each scenario

Scenario	***Activity***	***Period 2004-2008***	***Period 2009-2013***
E1	Salmon farming	• As of 200, the salaries in this sector were about 0,191 US$/Kg of product (considering the salaries of the workers in the farming centres and in the processing plants, 25 and 75% respectively). • As of 2000, the profit of the companies were about 2,2 US$/Kg of production. • Due to technological innovation, the profit for the next 10 years would be about 2,5 US$/Kg of production. • The depreciation of the equipment and installations are about 141 US$/ton. • The operational and transportation costs are about 0,15 US$/Kg of production. • The profit, salaries and equipment depreciation are about 2,49 US$/Kg of production (including production for national consumption and for exporting).	• Young fishes and food are the raw material, which costed 0,307 US $/Kg of production in 2000 (when 39.962 tons were produced). • The cost of feeding is between 0,95 and 1 US$/Kg of production. • The food conversion factor is between 1,35 and 1,2 Kg of food by every Kg of produced biomass. It is considered that in the next 10 years this factor will reach the levels of Norway, that is between 1,2 and 1,1 Kg of food by Kg of biomass. • As of 2000, the average price of the fish for export was 4,53 US$/Kg. • Exports are between 88 and 91% of the regional production, and the rest is for regional/national consumption, whose price is about 2 US$/Kg.

	Tourism	• In this case, the expenditures of the national and international tourists that visit the region are the basis for the calculation. At national level, these expenditures represented in 1996 the 79% of the added value produced by the tourism sector in Chile (SERNATUR, 1996). These values are extrapolated for the region.
		• Additional information needed for the calculation are:
		  • Tourists that stay overnight in the XI region (1990-1999)
		  • Growth rate of international tourists arrival: 18,9% (SERNATUR, 1999).
		  • Growth rate of national tourists arrival: 13,9% (SERNATUR, 1999).
		• As of 1999, 29% of the tourists were foreigners, and 71% were Chilean. This proportion is extrapolated to 1999, when the total amount of tourists in the region were 93.083.
		• The average expenditures of international tourists is US$ 450, and of the Chilean tourists is US$ 350 (estimated from SERNATUR, 1999).
		• It is considered that the municipalities of Aysén and Coyhaique contribute with 50% of the regional added value (50% of the accommodation and most of the restaurants and cafés are there).	

E2	Salmon farming	• It holds the same conditions of scenario E1. However, the start of the works of Alumysa would produce an increase in the average salary from about 261 US $/month until about 547 US$/mes.	• The processing plant will be forced to move out of Puerto Chacabuco. • The removal of the farming centres in a radius of 20 kilometres from Alumysa would produce a reduction in the production capacity of 18.000 ton/year.
	Tourism	• The arrival of tourists will slow-down. It is assumed that it will continue at least at the national rate of 6,2%.	
	Alumysa	• During the construction stage the added value is due to the remuneration and the depreciation of the machinery, the hydro-power station and the related infrastructure. (CH2MHILL, 2001).	• The production of aluminium costs about 1.600 US$/ton produced (average value in 2000). • Raw materials cost 539 US$/ton of produced aluminium. • The production will be 440.00. ton/year.

Scenario	Activity		Period 2004-2008		Period 2009-2013
E3	Salmon farming	•	It holds the same conditions of scenario E1.		
	Tourism	•	The arrival of tourists will slow-down, but less than in scenario E2. Anyway, it is assumed that it will continue at least at the national rate of 6,2%.		
	Alumysa	•	The remunerations and depreciation of the works of the additional infrastructure (100 km of roads and electric power lines) should by added to the values obtained for scenario E2	•	It holds the same conditions of scenario E2.
		•	The added value of constructing 1 km of road is US$ 1.837, and of 1 km of electric power lines is US$ 277		

Due to the available information of the economic activities, the value added for the first period (2003-2008) is calculated by means of the method of the rent (Equation 1), which considers the salaries, the profits and the depreciation of equipments.

$$VA = S + P + D \qquad (1)$$

where:

VA:= Value added

S:= Salaries

P:= Profit (including direct taxes)

D:= Depreciation

The contribution of the main economic activities to the regional gross product for the second period (2009-2013) is the value of the outputs (production) minus the value of the inputs that are bought from other companies.

In the case of tourism, we know that at national level the value added of the tourist sector is around 80% of the spendings of tourists (SERNATUR, 1999). We use this value in order to estimate the value added of the regional tourism sector.

i. Scenario E1

Table 31: Calculation of the added value of the salmon farming activity (Period 2004-2008)

	Calculation	2004	2005	2006	2007	2008
Salmon harvest [Ton]	C	40.730	51.431	64.943	82.005	103.550
Processed salmon [Ton]	P	40.730	51.431	64.943	82.005	103.550
Exports [Ton]	E	35.512	45.201	57.505	73.126	92.950
Salaries of harvesters [MUS$/Ton]	SC = C * 0,048	1.943	2.460	3.106	3.922	4.953
Salaries of processing workers [MUS $/Ton]	SP = P * 0.143	5.844	9.839	12.424	15.689	19.810
Depreciation of harvest equipment [MUS$/Ton]	DPC = C * 0,101	4.114	5.194	6.559	8.283	10.459
Depreciation of processing equipment [MUS$/Ton]	DPP = P * 0,04	1.629	2.057	2.598	3.280	4.142
Profit [MUS$/Ton]	B	88.311	110.804	142.056	182.007	233.055
Salaries (S), Depreciation (DP) and Profit (B) [MUS$]	(SC+SP) + (DPC+DPP) + B	107.936	138.039	176.446	225.432	287.889
NPV		**MUS$ 754.482**				

Source: Own elaboration based upon information from SalmonChile and from in-depth interviews.

Table 32: Calculation of the Net Present Value of the salmon farming activity (Period 2009-2013)

Item	Calculations	2009	2010	2011	2012	2013
Projected production [Ton]	P	130.756	165.109	179.437	195.010	211.933
Projected exports [Ton]	E	118.100	150.000	163.174	177.503	193.089
Food cost [US$/Kg]	A	0,975	0,975	0,975	0,975	0,975
Food conversion factor [Kg food/Kg production]	CA	1,2	1,19	1,17	1,16	1,15
Young fish cost [US$/Kg production]	CS	0,307	0,307	0,307	0,307	0,307
Raw material cost (young fish and food) [MUS $]	C=(A*CA+CS)*P	192.309	240.151	258.077	277.304	302.959
National sales [MUS$]	A=(P-E)*2	25.311	30.217	32.527	35.013	37.689
International sales [MUS$]	B=E*4,53	534.994	679.500	739.178	804.089	874.691
Added value [MUS$]	(A + B) - C	367.995	469.566	513.628	561.797	609.421
NPV		**MUS$ 1.506.102**				

Source: Own elaboration based upon information from SalmonChile and from in-depth interviews.

Table 33: Calculation of the added value of tourism (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
National tourists		125.800	143.286	163.203	185.888	211.727
Expenditures of national tourists [MUS$]	CCh	44.030	50.150	57.121	65.061	74.104
International tourists		65.252	77.585	92.248	109.683	130.413
Expenditures of international tourists [MUS$]	CEx	29.363	34.913	41.512	49.357	58.686
Total expenditures of tourists [MUS$]	C=CCh+CEx	73.393	85.063	98.633	114.418	132.790
AV of the Aysén region [MUS$]	A=C*0,79	57.978	67.196	77.916	90.386	104.899
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0,5	28.989	33.598	38.958	45.193	52.449
NPV		**MUS$ 162.504**				

Source: Own elaboration

Table 34: Calculation of the added value of tourism (Period 2009-2013)

Item	Calculations	2009	2010	2011	2012	2013
National tourists		241.157	274.678	312.858	356.345	405.877
Expenditures of national tourists [MUS$]	CCh	84.405	96.137	109.500	124.721	142.057
International tourists		155.061	184.368	219.213	260.645	309.906
Expenditures of international tourists [MUS$]	Cex	69.778	82.966	98.646	117.290	139.458
Total expenditures of tourists [MUS$]	C= CCh+Cex	154.183	179.103	208.146	242.011	281.515
AV of the Aysén region [MUS$]	A=C*0.79	121.798	141.483	164.427	191.178	222.385
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0.5	60.899	70.742	82.213	95.589	111.192
NPV		**MUS$ 250.402**				

Source: Own elaboration

ii. Scenario E2

Table 35: Calculation of the added value of Alumysa (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
Remunerations [MUS$]	C	64.490	74.113	140.004	111.341	17.860
Depreciation equipment [MUS$]	D	43.410	49.972	94.430	75.472	12.226
Added Value [MUS$]	C + D	107.900	124.086	234.434	186.812	30.086
NPV		**MUS$ 571.964**				

Source: Own elaboration based on CH2MHILL (2001)

Table 36: Calculation of the added value of Alumysa (Period 2009-2013)

Item	Units	Valor
Aluminium production	Ton/year	440.000
Cost	US$/Ton	1.600
Cost raw materials	US$/ton of production	539
Added value	MUS$/year	466.840
NPV	**MUS$**	**1.415.996**

Source: Own elaboration based on CH2MHILL (2001)

Table 37: Calculation of the added value of the salmon farming activity (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
Salmon harvest [Ton]	C [Ton]	40.730	51.431	64.943	82.005	103.550
Processed salmon [Ton]	P [Ton]	40.730	51.431	64.943	82.005	103.550
Exports [Ton]	E [Ton]	35.512	45.201	57.505	73.126	92.950
Salaries of harvesters [MUS$/Ton]	SC = C * 0,1	4.073	5.143	6.494	8.201	10.355
Salaries of processing workers [MUS $/Ton]	SP = P * 0,3	12.219	15.429	19482	24.603	31.065
Depreciation of harvest equipment [MUS$/Ton]	DPC = C * 0,101	4.114	5.194	6.559	8.283	10.459
Depreciation of processing equipment [MUS$/Ton]	DPP = P * 0,04	1.629	2.057	2.598	3.280	4.142
Profit [MUS$/Ton]	B	79.947	102.696	131.818	169.079	216.730
Salaries (S), Depreciation (DP) and Profit (B) [MUS$]	(SC+SP) + (DPC+DPP) + B	108.091	138.235	176.694	225.744	288.283
NPV		**MUS$ 755.534**				

Source: Own elaboration based upon information from SalmonChile and from in-depth interviews.

Table 38: Calculation of the added value of tourism (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
National tourists		88.651	94.148	99.985	106.184	112.767
Expenditures of national tourists [MUS$]	CCh	31.028	32.952	34.995	37.164	39.469
International tourists		37.094	39.394	41.837	44.430	47.185
Expenditures of international tourists [MUS$]	Cex	16.692	17.727	18.826	19.994	21.233
Total expenditures of tourists [MUS$]	C= CCh+Cex	47.720	50.679	53.821	57.158	60.702
AV of the Aysén region [MUS$]	A=C*0.79	37.697	40.034	42.516	45.152	47.952
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0.5	18.849	20.017	21.258	22.576	23.976
NPV		**MUS$ 87.994**				

Source: Own elaboration

Table 39: Calculation of the added value of tourism (Period 2009-2013)

		2009	2010	2011	2012	2013
National tourists		119.759	127.184	135.069	143.444	152.337
Expenditures of national tourists [MUS$]	CCh	41.916	44.514	47.274	50.205	53.318
International tourists		50.111	53.217	56.517	60.021	63.742
Expenditures of international tourists [MUS$]	CEx	22.550	23.948	25.433	27.009	28.684
Total expenditures of tourists [MUS$]	C= CCh+Cex	64.465	68.462	72.707	77.215	82.002
AV of the Aysén region [MUS$]	A=C*0.79	50.925	54.082	57.435	60.996	64.778
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0.5	25.462	27.041	28.718	30.498	32.389
NPV		**MUS$ 86.761**				

Source: Own elaboration

iii. Scenario E3

Table 40: Calculation of the added value of the construction of additional roads for scenario E2 (Period 2004-2008)

Roads' length	55 km				
	2004	**2005**	**2006**	**2007**	**2008**
Remunerations cost [MUS$]	46.488	12.062	6.232	-	-
Depreciation equipment [MUS$]	32.541	8.443	4.362	-	-
Total	79.029	20.505	10.594	-	-
NPV	**MUS$ 101.054**				

Source: Own elaboration based on CH2MHILL (2001)

Table 41: Calculation of the added value of the construction of additional electric power lines for scenario E2 (Period 2004-2008)

Electric power lines length	79 km				
	2004	**2005**	**2006**	**2007**	**2008**
Remunerations cost [MUS$]	2.353	10.709	1.476	-	-
Depreciation equipment [MUS$]	1.647	7.496	1.033	-	-
Total	4.000	18.205	2.509	-	-
NPV	**MUS$ 21.884**				

Source: Own elaboration based on CH2MHILL (2001)

Table 42: Calculation of the added value of the construction of additional roads for scenario E3 (Period 2004-2008)

Roads' length	155 km				
	2004	**2005**	**2006**	**2007**	**2008**
Remunerations cost [MUS$]	131.011	33.993	17.562	-	-
Depreciation equipment [MUS$]	91.708	23.795	12.293	-	-
Total	222.719	57.788	29.855	-	-
NPV	**MUS$ 284.790**				

Source: Own elaboration based on CH2MHILL (2001)

Table 43: Calculation of the added value of the construction of additional electric power lines for scenario E3 (Period 2004-2008)

Electric power lines length	179 km				
	2004	**2005**	**2006**	**2007**	**2008**
Remunerations cost [MUS$]	5.332	24.264	3.345	-	-
Depreciation equipment [MUS$]	3.732	16.985	2.342	-	-
Total	9.064	51.249	5.687		
NPV	**MUS$ 49.586**				

Source: Own elaboration based on CH2MHILL (2001)

Table 44: Calculation of the added value of Alumysa (Period 2009-2013)

Item	*Unit*	*Value*
Aluminium production	Ton/year	440.000
Cost	US$/Ton	1.600
Cost raw materials	US$/ton of production	539
Added value	MUS$/year	466.840
NPV	**MUS$**	**1.415.996**

Source: Own elaboration based on CH2MHILL (2001)

Table 45: Calculation of the added value of the salmon farming activity (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
Salmon harvest [Ton]	C [Ton]	40.730	51.431	64.943	82.005	103.550
Processed salmon [Ton]	P [Ton]	40.730	51.431	64.943	82.005	103.550
Exports [Ton]	E [Ton]	35.512	45.201	57.505	73.126	92.950
Salaries of harvesters [MUS$/Ton]	SC = C * 0,1	4.073	5.143	6.494	8.201	10.355
Salaries of processing workers [MUS $/Ton]	SP = P * 0,3	12.219	15.429	19482	24.603	31.065
Depreciation of harvest equipment [MUS$/Ton]	DPC = C * 0,101	4.114	5.194	6.559	8.283	10.459
Depreciation of processing equipment [MUS$/Ton]	DPP = P * 0,04	1.629	2.057	2.598	3.280	4.142
Profit [MUS$/Ton]	B	79.947	102.696	131.818	169.079	216.730
Salaries (S), Depreciation (DP) and Profit (B) [MUS$]	(SC+SP) + (DPC+DPP) + B	108.091	138.235	176.694	225.744	288.283
NPV		**MUS$ 755.534**				

Source: Own elaboration based upon information from SalmonChile and from in-depth interviews.

Table 46: Calculation of the added value of the salmon farming activity (Period 2009-2013)

Item	Calculations	2009	2010	2011	2012	2013
Projected production [Ton]	P	130.756	165.109	179.437	195.010	211.933
Projected exports [Ton]	E	118.100	150.000	163.174	177.503	193.089
Food cost [US$/Kg]	A	0,975	0,975	0,975	0,975	0,975
Food conversion factor [Kg food/Kg production]	CA	1,2	1,19	1,17	1,16	1,15
Young fish cost [US$/Kg production]	CS	0,307	0,307	0,307	0,307	0,307
Raw material cost (young fish and food) [MUS$]	C=(A*CA+CS)*P	192.309	240.151	258.077	277.304	302.959
National sales [MUS$]	A=(P-E)*2	25.311	30.217	32.527	35.013	37.689
International sales [MUS$]	B=E*4,53	534.994	679.500	739.178	804.089	874.691
Added value [MUS$]	(A + B) – C	367.995	469.566	513.628	561.797	609.421
NPV		MUS$ 1.506.102				

Source: Own elaboration based upon information from SalmonChile and from in-depth interviews.

Table 47: Calculation of the added value of tourism (Period 2004-2008)

Item	Calculations	2004	2005	2006	2007	2008
National tourists		88.651	94.148	99.985	106.184	112.767
Expenditures of national tourists [MUS$]	CCh	31.028	32.952	34.995	37.164	39.469
International tourists		37.094	39.394	41.837	44.430	47.185
Expenditures of international tourists [MUS$]	Cex	16.692	17.727	18.826	19.994	21.233
Total expenditures of tourists [MUS$]	C= CCh+Cex	47.720	50.679	53.821	57.158	60.702
AV of the Aysén region [MUS$]	A=C*0.79	37.697	40.034	42.516	45.152	47.952
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0.5	18.849	20.017	21.258	22.576	23.976
NPV		**MUS$ 87.994**				

Source: Own elaboration

Table 48: Calculation of the added value of tourism (Period 2009-2013)

Item	*Calculations*	*2009*	*2010*	*2011*	*2012*	*2013*
National tourists		119.759	127.184	135.069	143.444	152.337
Expenditures of national tourists [MUS$]	CCh	41.916	44.514	47.274	50.205	53.318
International tourists		50.111	53.217	56.517	60.021	63.742
Expenditures of international tourists [MUS$]	CEx	22.550	23.948	25.433	27.009	28.684
Total expenditures of tourists [MUS$]	C= CCh+Cex	64.465	68.462	72.707	77.215	82.002
AV of the Aysén region [MUS$]	A=C*0.79	50.925	54.082	57.435	60.996	64.778
AV of the municipalities of Aysén and Coyhaique [MUS$]	VA=A*0.5	25.462	27.041	28.718	30.498	32.389
NPV		**MUS$ 86.761**				

Source: Own elaboration

b) Employment

i. Scenario E1

Table 49: Jobs offered by the salmon farming activity (Period 2004-2013)

Year	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Jobs	4.969	6.275	7.923	10.005	12.633	15.952	20.143	21.891	23.791	25.856

Source: Own elaboration based upon information from SalmonChile. These figures consider a constant production rate of 16,4 ton/year/worker.

Table 50: Estimated productivity

Item	*2000*	*Harvest*	*Processing*	*2010*	*Harvest*	*Processing*
Production [Ton/year]	28.117	28.117	28.117	165.109	165.109	165.109
Jobs	1.715	463	1.252	7.265	1.961	5.303
Productivity [Ton/worker/year]	16,4	60,7	22,5	22,7	84,2	31,1

Source: Own elaboration based upon information collected from in-depth interviews, from SalmonChile and Molinet et al. (2001)

Table 51:Projected jobs in the salmon farming activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Production [Ton]	P	40.730	51.431	64.943	82.005	103.550
Productivity in harvest [Ton/worker]	PC	69,2	71,5	73,9	76,3	78,9
Workers for harvest [workers]	EC=P/PC	594	723	880	1.074	1.311
Productivity in processing [Ton/worker]	PP	25,6	26,5	27,4	28,3	29,2
Worker for processing [workers]	EP=P/PP	1.607	1.956	2.382	2.906	3.549
Jobs	E=EC+EP	2.202	2.678	3.263	3.980	4.860
Total jobs	**12 * ΣE**	**203.796**				

Source: Own elaboration based on information from SalmonChile.

Table 52:Projected jobs in the salmon farming activity (Period 2009-2013)

Item	*Calculations*	*2009*	*2010*	*2011*	*2012*	*2013*
Production [Ton]	P	130.756	165.109	179.437	195.010	211.933
Productivity in harvest [Ton/worker]	PC	81,5	84,2	84,2	84,2	84,2
Workers for harvest [workers]	EC=P/PC	1.603	1.961	2.131	2.316	2.517
Productivity in processing [Ton/worker]	PP	30,2	31,2	31,2	31,2	31,2
Worker for processing [workers]	EP=P/PP	4.338	5.309	5.770	6.270	6.815
Jobs	E=EC+EP	5.941	7.270	7.901	8.586	9.332
Total jobs	**12 * ΣE**	**468.355**				

Source: Own elaboration based on information from SalmonChile.

Table 53:Projected jobs in the tourism activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Average monthly jobs (regional)	ER	3.431	3.728	4.050	4.400	4.781
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	1.716	1.864	2.025	2.200	2.391
Total jobs	**12 * ΣE**	**122.352**				

Source: Own elaboration considering a yearly growth rate of 8.62% in jobs creation

Table 54:Projected jobs in the tourism activity (Period 2004-2008)

Item	*Calculations*	*2009*	*2010*	*2011*	*2012*	*2013*
Average monthly jobs (regional)	ER	5.193	5.641	6.127	6.655	7.229
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	2.597	2.821	3.064	3.328	3.615
Total jobs	**12 * ΣE**	**185.100**				

Source: Own elaboration considering a yearly growth rate of 8.62% in jobs creation

ii. Scenario E2

Table 55:Projected jobs in the Alumysa project (Period 2004-2008)

Month	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*Year 1*
Jobs	1.851	1.851	1.958	1.958	1.958	1.958	3.627	3.627	3.627	3.627	3.627	3.627	**33.296**

Month	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*Year 2*
Jobs	2.568	2.568	2.568	2.568	2.810	2.810	3.238	3.238	3.238	3.238	3.238	4.428	**36.510**

Month	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*Year 3*
Jobs	4.954	5.007	5.007	5.007	5.007	7.340	6.899	6.899	6.914	6.932	6.936	7.653	**74.555**

Month	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*Year 4*
Jobs	6.025	6.025	6.021	5.996	5.977	5.377	5.035	5.035	4.990	4.990	4.990	2.232	**62.693**

Month	*49*	*50*	*51*	*52*	*53*	*54*	*55*	*56*	*57*	*58*	*59*	*60*	*Year 5*
Jobs	1.590	1.590	1.590	1.590	1.209	434	434	434	350	350	350	0	**9.921**

Source: CH2MHILL (2001)

During the production phase Alumysa will offer 1.100 permanent jobs per month, that is, 66.000 jobs during the 5 years between 2008 and 2013.

Table 56:Projected jobs in the salmon farming activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Production [Ton]	P	40.730	51.431	64.943	82.005	103.550
Productivity in harvest [Ton/worker]	PC	69,2	71,5	73,9	76,3	78,9
Workers for harvest [workers]	EC=P/PC	594	723	880	1.074	1.311
Productivity in processing [Ton/worker]	PP	25,6	26,5	27,4	28,3	29,2
Worker for processing [workers]	EP=P/PP	1.607	1.956	2.382	2.906	3.549
Jobs	E=EC+EP	2.202	2.678	3.263	3.980	4.860
Total jobs	**12 * ΣE**	**203.796**				

Source: Own elaboration based on information from SalmonChile.

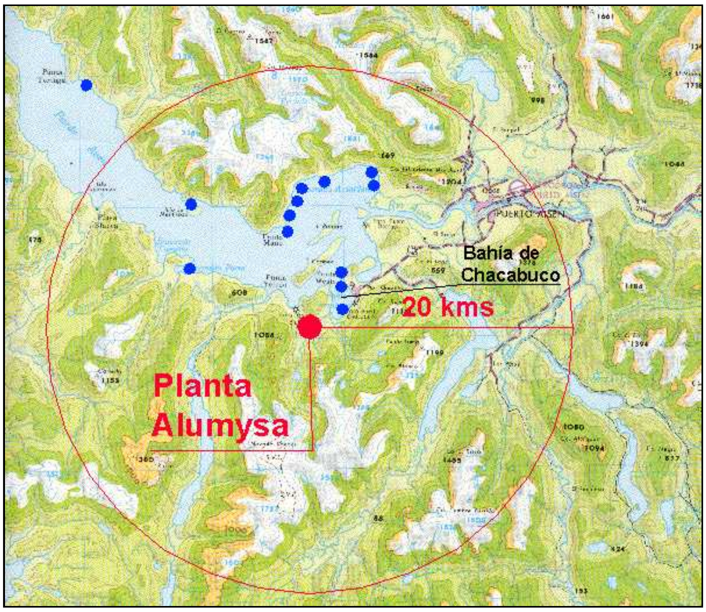


Figure 7: Salmon farming centres within a radius of 20 km around Alumysa (Source: GAC, 2002)

Figure 7 shows 12 farming centres within the radius of 20 kilometres around Alumysa. Considering that these centres have an average productivity of 1.500 ton/year[20], the removal of these centres will imply a decrease of 18.000 ton/year, near 50% of the regional production in 2000.

Table 57:Projected jobs in the salmon farming activity (Period 2009-2013)

Item	*Calculations*	*2009*	*2010*	*2011*	*2012*	*2013*
Production projected by SalmonChile[Ton]	P	130.756	165.109	179.437	195.010	211.933
Corrected projection [Ton]	PE=P-18.000	112.756	147.109	161.437	177.010	193.933
Productivity in harvest [Ton/worker]	PC	81,5	84,2	84,2	84,2	84,2
Harvester workers [amount of workers]	EC=PE/PC	1.382	1.747	1.917	2.102	2.303
Jobs	E	1.382	1.747	1.917	2.102	2.303
Total jobs	**12 * ΣE**	**113.423 [Month-worker]**				

Source: Own elaboration based on information from SalmonChile.

Table 58:Projected jobs in the tourism activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Average monthly jobs (regional)	ER	2.551	2.613	2.675	2.739	2.805
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	1.276	1.307	1.338	1.370	1.403
Total jobs	**12 * ΣE**	**80.328**				

Source: Own elaboration considering a yearly growth rate of 2,4% in jobs creation.

Table 59:Projected jobs in the tourism activity (Period 2009-2013)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Average monthly jobs (regional)	ER	2.872	2.941	3.012	3.084	3.158
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	1.436	1.471	1.506	1.542	1.579
Total jobs	**12 * ΣE**	**90.408**				

Source: Own elaboration considering a yearly growth rate of 2,4% in jobs creation.

20 Pesca Chile has 12 farming centres with a total capacity of 16.000 ton/year, and Friosur has 4 farming centres with an overall production capacity of 7.000 ton/year.

iii. Scenario E3

This scenario consider 155 km of roads instead of the 55 km of scenario E2. Then, the number of jobs created would be 94.031 (=155/55*33.582 jobs). It also consider 179 km of electric power lines instead of the 79 km of scenario E2, and the created jobs would be 15.768 (=179/79*6.950 jobs).

Therefore, the total amount of jobs offered by Alumysa during the period 2004-2008 would be 286.449.

As in scenario E2, Alumysa will offer 66.000 jobs during the operation of the plant.

Table 60:Projected jobs in the salmon farming activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Production [Ton]	P	40.730	51.431	64.943	82.005	103.550
Productivity in harvest [Ton/worker]	PC	69,2	71,5	73,9	76,3	78,9
Workers for harvest [workers]	EC=P/PC	594	723	880	1.074	1.311
Productivity in processing [Ton/worker]	PP	25,6	26,5	27,4	28,3	29,2
Worker for processing [workers]	EP=P/PP	1.607	1.956	2.382	2.906	3.549
Jobs	E=EC+EP	2.202	2.678	3.263	3.980	4.860
Total jobs	**12 * ΣE**	**203.796**				

Source: Own elaboration based on information from SalmonChile.

Table 61:Projected jobs in the salmon farming activity (Period 2009-2013)

Item	*Calculations*	*2009*	*2010*	*2011*	*2012*	*2013*
Production [Ton]	P	130.756	165.109	179.437	195.010	211.933
Productivity in harvest [Ton/worker]	PC	81,5	84,2	84,2	84,2	84,2
Workers for harvest [workers]	EC=P/PC	1.603	1.961	2.131	2.316	2.517
Productivity in processing [Ton/worker]	PP	30,2	31,2	31,2	31,2	31,2
Worker for processing [workers]	EP=P/PP	4.338	5.309	5.770	6.270	6.815
Jobs	E=EC+EP	5.941	7.270	7.901	8.586	9.332
Total jobs	**12 * ΣE**	**468.355**				

Source: Own elaboration based on information from SalmonChile.

Table 62:Projected jobs in the tourism activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Average monthly jobs (regional)	ER	2.640	2.722	2.806	2.893	2.983
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	1.320	1.361	1.403	1.447	1.492
Total jobs	**12 * ΣE**	**84.276**				

Source: Own elaboration considering a yearly growth rate of 3,1% in jobs creation.

Table 63:Projected jobs in the tourism activity (Period 2004-2008)

Item	*Calculations*	*2004*	*2005*	*2006*	*2007*	*2008*
Average monthly jobs (regional)	ER	3.076	3.171	3.269	3.370	3.475
Average monthly jobs (Aysén and Coyhaique)	E=ER*0,5	1.538	1.586	1.635	1.685	1.738
Total jobs	**12 * ΣE**	**98.184**				

Source: Own elaboration considering a yearly growth rate of 3,1% in jobs creation.

c) Impact over local culture

Table 64: Evaluation of the impact over the local culture scenario E1

Criterion	*Scenario E1*	*Impact*
Rural-urban migration	Period 2004-2008 • The growth of the salmon farming activity will require more labour, which would promote the migration to Puerto Aysén. • In the tourism sector, the promoted activities are eco-tourism and agro-tourism, whose practice consider the involvement of the local population. These last can increase their income and quality of life by staying in the rural area.	More or less low
	Period 2009-2013 • The salmon farming activity will increase its labour demand even more	Moderate
Explosive migration to the region	Period 2004-2008 • The jobs will increase gradually, which would imply a gradual migration to the region as well.	More or less low
	Period 2009-2013 • The development of the salmon farming industry would imply the development of the related economic activities, which will attract new population to the region.	Moderate

Source: Own elaboration

Table 65: Evaluation of the impact over the local culture scenario E2

Criterion	*Scenario E2*	*Impact*
Rural-urban migration	Period 2004-2008 • The effect of the salmon farming activity is similar than the previous scenario, but only in the construction phase of Alumysa. After that, the processing plant will be removed from the Chacabuco bay, and also some farming centres. • Alumysa will offer a big amount of jobs for the construction phase, which will be better paid than the current activities in the area. This will foster the rural-urban migration. • Alumysa project will flood around 10.000 hectares of land. Some of this land is already inhabited and used by some people who lives there.	Very high
	Period 2009-2013 • Alumysa has offered a job to the people who has to leave their land due to the flooding. This means the abandonment of traditional activities, affecting the familiar system of work, the lost of traditional knowledge ad the undervaluation of the local culture.	High
Explosive migration to the region	Period 2004-2008 • It is estimated that around 15 thousands of people would arrive at Puerto Aysén (workers and their families). • The salmon farming activity would attract people only in this period, as equal as in the scenario E1.	Very high
	Period 2009-2013 • Around 700 workers (with their families) from outside the region will arrive at Puerto Aysén to work in Alumysa.	More or less high

Source: Own elaboration

Table 66: Evaluation of the impact over the local culture scenario E3

Criterion	*Scenario E3*	*Impact*
Rural-urban migration	Period 2004-2008 • In this scenario the effects of Alumysa would be lower due to its location. But, we have to consider that the effects of the salmon farming activity would be as in scenario E1. • Alumysa project needs to flood around 10.000 hectares of land. Some of this land is already inhabited and used by some people who lives there.	Very high
	Period 2009-2013 • New activities, related with the operation of Alumysa, will develop in the area. But, the location of Alumysa would reduce its impacts compared with scenario E2 • Alumysa project will flood around 10.000 hectares of land. Some of this land is already inhabited and used by some people who lives there.	More or less high
Explosive migration to the region	Period 2004-2008 • The jobs in the salmon farming sector will increase gradually, which would imply a gradual migration to the region as well. • The accommodations of the workers of Alumysa will not be in Puerto Aysén, so there less people will come to the city.	High
	Period 2009-2013 • The development of the salmon farming industry would imply the development of the related economic activities, which will attract new population to the region. • Around 700 workers (with their families) from outside the region will arrive at Puerto Aysén to work in Alumysa.	High

Source: Own elaboration

d) Amount and Quality of jobs

Table 67: Scenario E1

Sector/Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Salmon farming	3216	1695	1695	1695	1695	1695	1695	1695	1695	3216	3216	3216	3216	2062	2062	2062	2062	2062	2062	2062
Tourism	1752	1752	1327	1327	1327	1327	1327	1327	1327	1327	1327	1327	1827	1827	1385	1385	1385	1385	1385	1385
	4968	3447	3022	3022	3022	3022	3022	3022	3022	4543	4543	4543	5043	3889	3446	3446	3446	3446	3446	3446
Seasonality												84%								
Skilled tourism	1577	1577	1195	1195	1195	1195	1195	1195	1195	1195	1195	1195	1645	1645	1246	1246	1246	1246	1246	1246
Skilled salmon farming	482	254	254	254	254	254	254	254	254	482	482	482	482	309	309	309	309	309	309	309
	2059	1831	1449	1449	1449	1449	1449	1449	1449	1677	1677	1677	2127	1954	1555	1555	1555	1555	1555	1555
	41%	53%	48%	48%	48%	48%	48%	48%	48%	37%	37%	37%	42%	50%	45%	45%	45%	45%	45%	45%

Sector/Month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Salmon farming	2062	3912	3912	3912	3912	2511	2511	2511	2511	2511	2511	2511	2511	4766	4766	4766	4766	3063	3063	3063
Tourism	1385	1385	1385	1385	1906	1906	1444	1444	1444	1444	1444	1444	1444	1444	1444	1444	1988	1988	1506	1506
	3446	5297	5297	5297	5818	4417	3956	3956	3956	3956	3956	3956	3956	6210	6210	6210	6754	5051	4569	4569
Seasonality				84%												84%				
Skilled tourism	1246	1246	1246	1246	1715	1715	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1789	1789	1356	1356
Skilled salmon	309	587	587	587	587	377	377	377	377	377	377	377	377	715	715	715	715	459	459	459

Sector/Month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
farming																				
	1555	1833	1833	1833	2302	2092	1676	1676	1676	1676	1676	1676	1676	2015	2015	2015	2504	2249	1815	1815
	45%	35%	35%	35%	40%	47%	42%	42%	42%	42%	42%	42%	42%	32%	32%	32%	37%	45%	40%	40%

Sector/Month	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Salmon farming	3063	3063	3063	3063	3063	5813	5813	5813	5813	3740	3740	3740	3740	3740	3740	3740	3740	7098	7098	7098
Tourism	1506	1506	1506	1506	1506	1506	1506	1506	2073	2073	1571	1571	1571	1571	1571	1571	1571	1571	1571	1571
	4569	4569	4569	4569	4569	7319	7319	7319	7887	5814	5311	5311	5311	5311	5311	5311	5311	8669	8669	8669
Seasonality								83%												83%
Skilled tourism	1356	1356	1356	1356	1356	1356	1356	1356	1866	1866	1414	1414	1414	1414	1414	1414	1414	1414	1414	1414
Skilled salmon farming	459	459	459	459	459	872	872	872	872	561	561	561	561	561	561	561	561	1065	1065	1065
	1815	1815	1815	1815	1815	2228	2228	2228	2738	2427	1975	1975	1975	1975	1975	1975	1975	2479	2479	2479
	40%	40%	40%	40%	40%	30%	30%	30%	35%	42%	37%	37%	37%	37%	37%	37%	37%	29%	29%	29%

Sector/Month	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Salmon farming	7098	4573	4573	4573	4573	4573	4573	4573	4573	8678	8678	8678	8678	5595	5595	5595	5595	5595	5595	5595
Tourism	2163	2163	1639	1639	1639	1639	1639	1639	1639	1639	1639	1639	2256	2256	1709	1709	1709	1709	1709	1709
	9261	6735	6211	6211	6211	6211	6211	6211	6211	10316	10316	10316	10933	7851	7304	7304	7304	7304	7304	7304
Seasonality												82%								
Skilled tourism	1946	1946	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	2030	2030	1538	1538	1538	1538	1538	1538
Skilled salmon farming	1065	686	686	686	686	686	686	686	686	1302	1302	1302	1302	839	839	839	839	839	839	839
	3011	2632	2161	2161	2161	2161	2161	2161	2161	2776	2776	2776	3332	2869	2377	2377	2377	2377	2377	2377
	33%	39%	35%	35%	35%	35%	35%	35%	35%	27%	27%	27%	30%	37%	33%	33%	33%	33%	33%	33%

Sector/Month	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Salmon farming	5595	10619	10619	10619	10619	6081	6081	6081	6081	6081	6081	6081	6081	11540	11540	11540	11540	6609	6609	6609
Tourism	1709	1709	1709	1709	2353	2353	1782	1782	1782	1782	1782	1782	1782	1782	1782	1782	2454	2454	1859	1859
	7304	12328	12328	12328	12971	8434	7863	7863	7863	7863	7863	7863	7863	13323	13323	13323	13994	9062	8468	8468
Seasonality				82%												81%				
Skilled tourism	1538	1538	1538	1538	2117	2117	1604	1604	1604	1604	1604	1604	1604	1604	1604	1604	2208	2208	1673	1673
Skilled salmon farming	839	1593	1593	1593	1593	912	912	912	912	912	912	912	912	1731	1731	1731	1731	991	991	991

	2377	3131	3131	3131	3710	3029	2516	2516	2516	2516	2516	2516	2516	3335	3335	3335	3939	3200	2665	2665
	33%	25%	25%	25%	29%	36%	32%	32%	32%	32%	32%	32%	32%	25%	25%	25%	28%	35%	31%	31%

Sector/Month	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Salmon farming	6609	6609	6609	6609	6609	12542	12542	12542	12542	7182	7182	7182	7182	7182	7182	7182	7182	13630	13630	13630
Tourism	1859	1859	1859	1859	1859	1859	1859	1859	2559	2559	1939	1939	1939	1939	1939	1939	1939	1939	1939	1939
	8468	8468	8468	8468	8468	14401	14401	14401	15101	9742	9121	9121	9121	9121	9121	9121	9121	15569	15569	15569
Seasonality								81%												81%
Skilled tourism	1673	1673	1673	1673	1673	1673	1673	1673	2303	2303	1745	1745	1745	1745	1745	1745	1745	1745	1745	1745
Skilled salmon farming	991	991	991	991	991	1881	1881	1881	1881	1077	1077	1077	1077	1077	1077	1077	1077	2045	2045	2045
	2665	2665	2665	2665	2665	3554	3554	3554	4185	3381	2822	2822	2822	2822	2822	2822	2822	3790	3790	3790
	31%	31%	31%	31%	31%	25%	25%	25%	28%	35%	31%	31%	31%	31%	31%	31%	31%	24%	24%	24%

Table 68: Scenario E2

Sector/Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Tourism	1598	1598	1211	1211	1211	1211	1211	1211	1211	1211	1211	1211	1637	1637	1240	1240	1240	1240	1240	1240
Alumysa	1851	1851	1958	1958	1958	1958	3627	3627	3627	3627	3627	3627	2568	2568	2568	2568	2810	2810	3238	3238
Salmon farming	1676	945	945	945	945	945	945	945	945	1676	1676	1676	1676	1149	1149	1149	1149	1149	1149	1149
	5125	4394	4114	4114	4114	4114	5783	5783	5783	6514	6514	6514	5880	5354	4957	4957	5199	5199	5627	5627
Seasonality												79%								
Not skilled Alumysa	338	338	338	338	338	338	816	816	816	816	816	816	512	512	512	512	579	579	617	617
Skilled Alumysa	1513	1513	1620	1620	1620	1620	2811	2811	2811	2811	2811	2811	2056	2056	2056	2056	2231	2231	2621	2621
Skilled salmon farming	251	142	142	142	142	142	142	142	142	251	251	251	251	172	172	172	172	172	172	172
Skilled tourism	1438	1438	1090	1090	1090	1090	1090	1090	1090	1090	1090	1090	1473	1473	1116	1116	1116	1116	1116	1116
	3203	3093	2852	2852	2852	2852	4043	4043	4043	4152	4152	4152	3780	3701	3344	3344	3519	3519	3909	3909
	62%	70%	69%	69%	69%	69%	70%	70%	70%	64%	64%	64%	64%	69%	67%	67%	68%	68%	69%	69%

Sector/Month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Tourism	1240	1240	1240	1240	1676	1676	1270	1270	1270	1270	1270	1270	1270	1270	1270	1270	1716	1716	1300	1300
Alumysa	3238	3238	3238	4428	4954	5007	5007	5007	5007	7340	6899	6899	6914	6932	6936	7653	6025	6025	6021	5996
Salmon farming	1149	2039	2039	2039	2039	1400	1400	1400	1400	1400	1400	1400	1400	2484	2484	2484	2484	1708	1708	1708
	5627	6517	6517	7707	8668	8083	7677	7677	7677	10010	9569	9569	9584	10685	10689	11406	10225	9449	9029	9004
Seasonality				86%												83%				

Sector/Month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Not skilled Alumysa	617	617	617	946	926	951	951	951	951	1633	1466	1466	1481	1486	1486	1490	1211	1211	1211	1186
Skilled Alumysa	2621	2621	2621	3482	4028	4056	4056	4056	4056	5707	5433	5433	5433	5446	5450	6163	4814	4814	4810	4810
Skilled salmon farming	172	306	306	306	306	210	210	210	210	210	210	210	210	373	373	373	373	256	256	256
Skilled tourism	1116	1116	1116	1116	1508	1508	1143	1143	1143	1143	1143	1143	1143	1143	1143	1143	1544	1544	1170	1170
	3909	4043	4043	4904	5842	5774	5409	5409	5409	7060	6786	6786	6786	6961	6965	7678	6731	6615	6236	6236
	69%	62%	62%	64%	67%	71%	70%	70%	70%	71%	71%	71%	71%	65%	65%	67%	66%	70%	69%	69%

Sector/Month	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Tourism	1300	1300	1300	1300	1300	1300	1300	1300	1757	1757	1331	1331	1331	1331	1331	1331	1331	1331	1331	1331
Alumysa	5977	5377	5035	5035	4990	4990	4990	2232	1590	1590	1590	1590	1209	434	434	434	350	350	350	0
Salmon farming	1708	1708	1708	1708	1708	3030	3030	3030	3030	2086	2086	2086	2086	2086	2086	2086	2086	3700	3700	3700
	8985	8385	8043	8043	7998	9320	9320	6562	6377	5433	5007	5007	4626	3851	3851	3851	3767	5381	5381	5031
Seasonality								75%												79%
Not skilled Alumysa	1186	1040	1045	1045	1020	1020	1020	399	344	344	344	344	320	96	96	96	91	91	91	0
Skilled Alumysa	4791	4337	3990	3990	3970	3970	3970	1833	1246	1246	1246	1246	889	338	338	338	259	259	259	0
Skilled salmon farming	256	256	256	256	256	454	454	454	454	313	313	313	313	313	313	313	313	555	555	555
Skilled tourism	1170	1170	1170	1170	1170	1170	1170	1170	1582	1582	1198	1198	1198	1198	1198	1198	1198	1198	1198	1198
	6217	5763	5416	5416	5396	5595	5595	3458	3282	3140	2757	2757	2400	1849	1849	1849	1770	2012	2012	1753
	69%	69%	67%	67%	67%	60%	60%	53%	51%	58%	55%	55%	52%	48%	48%	48%	47%	37%	37%	35%

Sector/Month	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Tourism	1775	1775	1345	1345	1345	1345	1345	1345	1345	1345	1345	1345	1793	1793	1358	1358	1358	1358	1358	1358
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon farming	7097	1175	1175	1175	1175	1175	1175	1175	1175	1797	1797	1797	1797	1485	1485	1485	1485	1485	1485	1485
	9972	4050	3619	3619	3619	3619	3619	3619	3619	4241	4241	4241	4689	4378	3943	3943	3943	3943	3943	3943
Seasonality												83%								
Not skilled Alumysa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Skilled salmon farming	1065	176	176	176	176	176	176	176	176	269	269	269	269	223	223	223	223	223	223	223
Skilled tourism	1597	1597	1210	1210	1210	1210	1210	1210	1210	1210	1210	1210	1613	1613	1222	1222	1222	1222	1222	1222
	3762	2874	2486	2486	2486	2486	2486	2486	2486	2580	2580	2580	2983	2936	2545	2545	2545	2545	2545	2545
	38%	71%	69%	69%	69%	69%	69%	69%	69%	61%	61%	61%	64%	67%	65%	65%	65%	65%	65%	65%

Sector/Month	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Tourism	1358	1358	1358	1358	1811	1811	1372	1372	1372	1372	1372	1372	1372	1372	1372	1372	1829	1829	1385	1385
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon farming	1485	2271	2271	2271	2271	1630	1630	1630	1630	1630	1630	1630	1630	2493	2493	2493	2493	1787	1787	1787
	3943	4729	4729	4729	5182	4540	4101	4101	4101	4101	4101	4101	4101	4964	4964	4964	5421	4716	4272	4272
Seasonality				93%												92%				
Not skilled Alumysa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Skilled salmon farming	223	341	341	341	341	244	244	244	244	244	244	244	244	374	374	374	374	268	268	268
Skilled tourism	1222	1222	1222	1222	1629	1629	1235	1235	1235	1235	1235	1235	1235	1235	1235	1235	1646	1646	1247	1247
	2545	2663	2663	2663	3070	2974	2579	2579	2579	2579	2579	2579	2579	2708	2708	2708	3120	3014	2615	2615
	65%	56%	56%	56%	59%	66%	63%	63%	63%	63%	63%	63%	63%	55%	55%	55%	58%	64%	61%	61%

Sector/Month	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Tourism	1385	1385	1385	1385	1385	1385	1385	1385	1847	1847	1399	1399	1399	1399	1399	1399	1399	1399	1399	1399
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon farming	1787	1787	1787	1787	1787	2733	2733	2733	2733	1958	1958	1958	1958	1958	1958	1958	1958	2994	2994	2994
	4272	4272	4272	4272	4272	5218	5218	5218	5680	4905	4457	4457	4457	4457	4457	4457	4457	5494	5494	5494
Seasonality								92%												92%
Not skilled Alumysa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Skilled salmon farming	268	268	268	268	268	410	410	410	410	294	294	294	294	294	294	294	294	449	449	449
Skilled tourism	1247	1247	1247	1247	1247	1247	1247	1247	1662	1662	1259	1259	1259	1259	1259	1259	1259	1259	1259	1259
	2615	2615	2615	2615	2615	2757	2757	2757	3172	3056	2653	2653	2653	2653	2653	2653	2653	2809	2809	2809
	61%	61%	61%	61%	61%	53%	53%	53%	56%	62%	60%	60%	60%	60%	60%	60%	60%	51%	51%	51%

Table 69: Scenario E3

Sector/Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Tourism	1598	1598	1211	1211	1211	1211	1211	1211	1211	1211	1211	1211	1637	1637	1240	1240	1240	1240	1240	1240
Alumysa	1851	1851	1958	1958	1958	1958	3627	3627	3627	3627	3627	3627	2568	2568	2568	2568	2810	2810	3238	3238
Salmon farming	1676	945	945	945	945	945	945	945	945	1676	1676	1676	1676	1149	1149	1149	1149	1149	1149	1149
	5125	4394	4114	4114	4114	4114	5783	5783	5783	6514	6514	6514	5880	5354	4957	4957	5199	5199	5627	5627
Seasonality												79%								

Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	251	142	142	142	142	142	142	142	142	251	251	251	251	172	172	172	172	172	172	172
Skilled salmon farming	1438	1438	1090	1090	1090	1090	1090	1090	1090	1090	1090	1090	1473	1473	1116	1116	1116	1116	1116	1116
Skilled tourism	3203	3093	2745	2745	2745	2745	2745	2745	2745	2854	2854	2854	3237	3158	2801	2801	2801	2801	2801	2801
	62%	70%	67%	67%	67%	67%	47%	47%	47%	44%	44%	44%	55%	59%	57%	57%	54%	54%	50%	50%

Sector/Month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Tourism	1240	1240	1240	1240	1676	1676	1270	1270	1270	1270	1270	1270	1270	1270	1270	1270	1716	1716	1300	1300
Alumysa	3238	3238	3238	4428	4954	5007	5007	5007	5007	7340	6899	6899	6914	6932	6936	7653	6025	6025	6021	5996
Salmon farming	1149	2039	2039	2039	2039	1400	1400	1400	1400	1400	1400	1400	1400	2484	2484	2484	2484	1708	1708	1708
	5627	6517	6517	7707	8668	8083	7677	7677	7677	10010	9569	9569	9584	10685	10689	11406	10225	9449	9029	9004
Seasonality				86%												83%				
Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	172	306	306	306	306	210	210	210	210	210	210	210	210	373	373	373	373	256	256	256
Skilled salmon farming	1116	1116	1116	1116	1508	1508	1143	1143	1143	1143	1143	1143	1143	1143	1143	1143	1544	1544	1170	1170
Skilled tourism	2801	2935	2935	2935	3327	3231	2866	2866	2866	2866	2866	2866	2866	3028	3028	3028	3430	3314	2939	2939
	50%	45%	45%	38%	38%	40%	37%	37%	37%	29%	30%	30%	30%	28%	28%	27%	34%	35%	33%	33%

Sector/Month	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Tourism	1300	1300	1300	1300	1300	1300	1300	1300	1757	1757	1331	1331	1331	1331	1331	1331	1331	1331	1331	1331
Alumysa	5977	5377	5035	5035	4990	4990	4990	2232	1590	1590	1590	1590	1209	434	434	434	350	350	350	0
Salmon farming	1708	1708	1708	1708	1708	3030	3030	3030	3030	2086	2086	2086	2086	2086	2086	2086	2086	3700	3700	3700
	8985	8385	8043	8043	7998	9320	9320	6562	6377	5433	5007	5007	4626	3851	3851	3851	3767	5381	5381	5031
Seasonality								75%												79%
Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	256	256	256	256	256	454	454	454	454	313	313	313	313	313	313	313	313	555	555	555
Skilled salmon farming	1170	1170	1170	1170	1170	1170	1170	1170	1582	1582	1198	1198	1198	1198	1198	1198	1198	1198	1198	1198
Skilled tourism	2939	2939	2939	2939	2939	3138	3138	3138	3549	3407	3024	3024	3024	3024	3024	3024	3024	3266	3266	3266
	33%	35%	37%	37%	37%	34%	34%	48%	56%	63%	60%	60%	65%	79%	79%	79%	80%	61%	61%	65%

Sector/Month	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Tourism	1775	1775	1345	1345	1345	1345	1345	1345	1345	1345	1345	1345	1793	1793	1358	1358	1358	1358	1358	1358
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon	3700	2550	2550	2550	2550	2550	2550	2550	2550	4523	4523	4523	4523	3120	3120	3120	3120	3120	3120	3120

Sector/Month	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
farming																				
	6574	5425	4995	4995	4995	4995	4995	4995	4995	6968	6968	6968	7415	6013	5579	5579	5579	5579	5579	5579
Seasonality												88%								
Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	555	382	382	382	382	382	382	382	382	678	678	678	678	468	468	468	468	468	468	468
Skilled salmon farming	1597	1597	1210	1210	1210	1210	1210	1210	1210	1210	1210	1210	1613	1613	1222	1222	1222	1222	1222	1222
Skilled tourism	3665	3493	3106	3106	3106	3106	3106	3106	3106	3402	3402	3402	3805	3594	3203	3203	3203	3203	3203	3203
	56%	64%	62%	62%	62%	62%	62%	62%	62%	49%	49%	49%	51%	60%	57%	57%	57%	57%	57%	57%

Sector/Month	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Tourism	1358	1358	1358	1358	1811	1811	1372	1372	1372	1372	1372	1372	1372	1372	1372	1372	1829	1829	1385	1385
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon farming	3120	5535	5535	5535	5535	3391	3391	3391	3391	3391	3391	3391	3391	6015	6015	6015	6015	3685	3685	3685
	5579	7993	7993	7993	8445	6302	5863	5863	5863	5863	5863	5863	5863	8487	8487	8487	8944	6614	6171	6171
Seasonality				88%												87%				
Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	468	830	830	830	830	509	509	509	509	509	509	509	509	902	902	902	902	553	553	553
Skilled salmon farming	1222	1222	1222	1222	1629	1629	1235	1235	1235	1235	1235	1235	1235	1235	1235	1235	1646	1646	1247	1247
Skilled tourism	3203	3566	3566	3566	3973	3651	3256	3256	3256	3256	3256	3256	3256	3650	3650	3650	4061	3712	3313	3313
	57%	45%	45%	45%	47%	58%	56%	56%	56%	56%	56%	56%	56%	43%	43%	43%	45%	56%	54%	54%

Sector/Month	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Tourism	1385	1385	1385	1385	1385	1385	1385	1385	1847	1847	1399	1399	1399	1399	1399	1399	1399	1399	1399	1399
Alumysa	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Salmon farming	3685	3685	3685	3685	3685	6537	6537	6537	6537	4005	4005	4005	4005	4005	4005	4005	4005	7105	7105	7105
	6171	6171	6171	6171	6171	9023	9023	9023	9484	6952	6505	6505	6505	6505	6505	6505	6505	9604	9604	9604
Seasonality								86%												86%
Not skilled Alumysa	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513	1513
Skilled Alumysa	553	553	553	553	553	981	981	981	981	601	601	601	601	601	601	601	601	1066	1066	1066
Skilled salmon farming	1247	1247	1247	1247	1247	1247	1247	1247	1662	1662	1259	1259	1259	1259	1259	1259	1259	1259	1259	1259
Skilled tourism	3313	3313	3313	3313	3313	3741	3741	3741	4156	3776	3373	3373	3373	3373	3373	3373	3373	3838	3838	3838
	54%	54%	54%	54%	54%	41%	41%	41%	44%	54%	52%	52%	52%	52%	52%	52%	52%	40%	40%	40%

Table 70: Evaluation of the stability, seasonality and required qualification of the jobs offered by the main economic activities in each scenario

	Period 2004-2008			***Period 2009-2013***		
	Scenario E1	***Scenario E2***	***Scenario E3***	***Scenario E1***	***Scenario E2***	***Scenario E3***
Stability	Good	Very bad	Very bad	Good	Very good	Good
Seasonality	84%	80%	80%	81%	91%	87%%
Qualification	40%	63%	49%	31%	61%	53%

Source: Own elaboration based on Gamboa (2003)

e) Income distribution

Table 71: Analysis of the effects of each scenario on the income distribution (Period 2004-2008)

Scenario	***Period 2004-2008***
E1	Salmon farming is the main economic activity n this scenario. The salaries in this sector are about 260 US$/month, and due to the high energy and transport costs in this region, an increase in the remunerations is not expected. The offered jobs in the tourism sector are mainly semi-qualified and qualified, and the growth of this activity would foster an increase in salaries in the medium socio-economic quintile. There are also some agro-tourism projects that could generate additional incomes for rural population.
E2	According to CH2MHILL (2001) the minimum wages during the construction phase are about 600 US $/month, which is higher than the maximum salaries in the construction sector in the last years. On the other hand, higher incomes in the region would foster other economic sectors such as commerce and construction (of housing, services, schools). These activities have paid better salaries than traditional activities such as fishing and salmon farming. The above mentioned situation could generate a hiring crisis within the salmon farming industry, which would put pressure on the owners and managers of the companies, leading them to increase wages (Personal communication from SalmonChile)
E3	The situation is similar then scenario E2. However, the new location of Alumysa requires more workers for the construction of additional roads and power lines, so it could be expected a slightly better situation than scenario E2. Also, the salmon farming sector could experience a hiring crisis, with positive effects on the income distribution.

Source: Own elaboration

Table 72: Analysis of the effects of each scenario on the income distribution (Period 2009-2013)

Scenario	***Period 2009-2013***
E1	The arrival of people to the region could trigger a decrease in the costs of energy and transport. This in turn, could foster an increase in the salaries of the poorer people, but this decision is up to the owners and managers of (mainly) the salmon farming companies.
E2	This period will experiment an oversupply of labour due to the end of the construction works in the Alumysa project and to the cease of the operation of the processing plants and some farming centres. This situation could lead a decrease of the salaries up to the current levels. Which means a decrease in the salaries of the poorer people. It is worth noting that construction companies from outside the region carry out most of the big works in Aysén. These companies bring up to 80% of the workers from other regions of the country, and the regional worker usually get the jobs requiring less skills. On the other side, according to CH2MHILL (2001), about 40% of the jobs will be for regional workers. They will earn at least 1.200 US$/month. These people will be then in the richer quintile, increasing the difference with the poorer quintile. Some of the workers of Alumysa coming from outside the region (about 700) will move to Aysén with their families. This situation could foster other sector such as commerce, education, health and services. But these positive impact would not counterbalance the effect of the oversupply of labour. According to this, scenario E2 is perceived worse than scenario E1.

Scenario	Period 2009-2013
E3	The new location of Alumysa would produce opposite effects than in the previous period. In the sense that the percentage of workers coming from abroad with their families will be lower, due to the distance from Puerto Aysén to the plant. Moreover, the cold weather of the Aysén region could encourage families to stay in their original paces (as in the mining sector in the north of Chile). In the fishing and salmon farming sector salaries would remain as the previous period, even though there will be an oversupply of labour due to the end of the Alumysa construction works.

Table 73: Income distribution

Scenario	Period 2004-2008	Period 2009-2013
E1	Third	Second
E2	Second	Third
E3	First	First

Source: Own elaboration based on Gamboa (2003)

f) Environmental pollution

In this section I present the assessment of the water and atmospheric contaminants. The former are not considered in the evaluation due to the fact that the three scenarios perform equally bad. But, it is valuable information of the current and future situation about the water quality of the area.

i. Aquatic pollutants

Nitrogen

Currently, the nitrogen emissions are about 33 Kg/ton of harvested salmon (Buschmann and Pizarro, 2001), which means that each ton of food produces a release of 26 Kg of nitrogen.

Table 74: Nitrogen emissions [Ton]

Scenario	2004-2008	2009-2013
E1	10.952	26.522
E2	10.952	19.892
E3	10.952	26.522

Source: Own elaboration based on food requirements in the salmon farming industry.

The figures for the period 2004-2008 in Table 33 are equivalent to the release of waste domestic water of a population of 600 thousands people.

Phosphorus

The phosphorus emissions are about 7 Kg/ ton of harvested salmon (Buschmann y Pizarro, 2001), that is, 5,5 Kg/ton of food.

Table 75: Phosphorus emissions [Ton]

Scenario	2004-2008	2009-2013
E1	2.326	5.632
E2	2.326	4.224
E3	2.326	5.632

Source: Own elaboration based on food requirements in the salmon farming industry.

The figures for the period 2004-2008 in Table 32 are equivalent to the release of waste domestic water of a population of 84 thousands people.

ii. Atmospheric pollutants

The effect of the contaminants is highly related with the characteristics of the context in which they are released, which determine the level of concentration of the pollutant (toxicity).

CH2MHILL (2001) and GAC (2002) present the results of a modelling exercise, there are not assessment for all the contaminants considered here, and in some cases the results are not comparable one each other.

Then, the evaluation is qualitative and based on the following aspects:

- Volume of the pollutants.
- Characteristics of the environment.
- Potential effects of the pollutants.

Table 31 Presents the amount of contaminant release to the atmosphere.

Table 76: Atmospheric pollutants

	Period 2004-2008			*Period 2009-2013*		
	SO_2	*PM10*	*HF*	*SO_2*	*PM10*	*HF*
Scenario E1	> 0	> 0	0	> 0	> 0	0
Scenario E2	>> 0	784-852	0	> 3.485	5.420	1.540
Scenario E3	>> 0	> 784-852	0	> 3.485	5.420	1.540

Source: Own elaboration based on CH2MHILL (2001) and Gamboa (2003)

Characteristic of the environment

- A temperate-cold rainy maritime climate characterises the impact area, with rains between 2.000 and 4.000 mm per year. This situation will favour the transfer of the pollutants from the air to the soil and water bodies.
- Average temperatures are between 10 and 13ºC in January, and between 4 and 7ºC in July. Moreover, a thermal inversion layer often takes place in winter time. This phenomena will keep the pollutants within the former 100 metres from the ground to upward. Furthermore, low temperatures would produce synergies in the impacts of the SO_2 y PM_{10}.
- South-east winds are predominant, and they take place mainly in spring and summer, while in winter predominant winds are from the north-east. This implies that, in winter, the pollution released from Chacabuco bay will go toward Puerto Aysén.
- The landscape of the area is very uneven: islands and mountains could be of 1.000 metres height, being an important screen that together with the regime of rains could avoid the arrival of the pollutants to the inhabited centres.
- Superficial water salinity of the fiord is very low. According to CH2MHILL (2001, Section G) salinity in Chacabuco bay is highly stratified. Salinity increases until 30 metres depth. Below this point salinity is homogeneous. According to GAC (2002), the low salinity of the water will be one of the main causes of low absorption of fluorine by the see.

- The temperature of the water in the Chacabuco bay is also highly stratified: Superficial temperatures are lower than 10ºC, and the presence of a thermorline impede superficial mixture.
- On the other hand, low current speeds also characterizes water dynamics of Chacabuco bay (CH2MHILL, 2001, section G).
- According to the map of soil sensitivity to acid deposition produced by the Stockholm Environmental Institute (SEI), mainly for sulphur and nitrogen), the impact area is of sensitivity 2 (1 is more sensitivity and 5 is less sensitivity).

Table 77: Evaluation of the atmospheric pollution based on the characteristics of the environment

Period	Evaluation
2004-2008	The location of Alumysa in scenario E3 will only help to mover further away the emissions during the construction of the plant (about 31 ton of PM_{10}). According to this, both scenarios E2 and E3 are equally bad
2009-2013	Regarding the potential effects of SO_2, PM_{10} and HF (fluorine), the location of Alumysa in scenario E3 will reduce the effects on the population, but also the effects of the fluorine in the marine environment (due to the higher salinity and higher marine currents in the new location). In the case of SO_2 and PM_{10}, their potential effects (e.g. acid rain) will occur in any location. But again, far away from the inhabited centres.

Source:Own elaboration

Potential effects of the pollutants

Table 78: Potential effects of the pollutants in the human and environmental health

Pollutant	***Potential effects***	***Source***
SO_2	• Acid rain, and acidification of soil and water. • Increase of water pH, which is considered as a cause of fish mortality (Mason, B.J., 1992) • Decrease in the phytoplankton, zooplankton and bentonic invertebrates diversity (Mason, B.J., 1992). With their respective impact in the food chain	Alumysa. Combustion and process.
Particulate matter PM10	• Increase in the levels of pollution of sulphur particles (included in PM_{10}) cause an increase of deaths due to heart attack (1). • Some of the components of the PM_{10} can cause lung cancer (1). • Nickel and vanadium in the PM_{10} are carcinogenic.	Alumysa. Combustion and process.

Pollutant	*Potential effects*	*Source*
Fluorine (HF)	Human health: • Almost 100% of the inhaled fluorine is absorbed and the rest 50% remains in the body (1). • Acute effects: severe irritation in internal membrane, respiratory paralysis in extreme cases (1). • Chronic effects: fluorosis, weight lost, anaemia, calcified ligament, osteoporosis fractures in old people (1). • Inhibition of immunity functions, decrease in the glucose tolerance, mutagenic effects and y genetic toxicity, stimulation of osteosarcoma cells proliferation. (2) Environmental health: • Fish death: If the level of fluorine in fresh water is above 0,2 mg/l. • Fluorine compounds could facilitate the solubility of aluminium, iron and organic matter in soil, and therefore increase its pH (Arnesen, A.K.M., 1996, Wilcke, W. et al., 2000).	Alumysa. Process.

(1) *Medical association of Chile (2002)*

(2) *Medical association of Chile (2002). These information is not used as main arguments due to the uncertainty and controversy of the results of the quoted studies.*

g) Forest lost

Table 79: Forest lost in linear infrastructure (Period 2004-2008)

Item	*Distance [Km]*	*Subjection width [m]*	*Deforested area [ha]*
New public roads	45	20	90
New private roads	9,3	20	18,6
Electric power lines	79,2	50	396
Roads to access electric towers			18
Total			**522,6**

Source: Own elaboration based on CH2MHILL (2002).

Table 80: Forest lost due to infrastructures (Period 2004-2008)

Item	*Deforested area [ha]*
Smelter plant	105
Accommodations	25
Aggregates plant	1,6
Sedimentation lake	4
Quarry	15,3
Maintenance zone	12
Cement plant	0,5
Wast disposal area	32
Trucks washing	0,3
Total	195,7

Source: Own elaboration based on CH2MHILL (2002).

Table 81: Forest lost due to flooding

	Flooded area [ha]
Cuervo river dam	12.962
Cóndor lake dam	1.296
Blanco river dam	5.166
Total	19.424

Source: Own elaboration based on CH2MHILL (2002).

Table 82: Deforested area due to the additional roads and electric power lines of scenario E3

Item	***Distance [Km]***	***Width [m]***	***Deforested area [ha]***
Public roads	155	20	310
Electric power lines	180	50	900
Total			1.210

Source: Own elaboration based on CH2MHILL (2002).

A.2. NAIADE Multi-criteria software[21]

NAIADE (**N**ovel **A**pproach to **I**mprecise **A**ssessment and **D**ecision **E**nvironments. Munda, 1995) is an outranking multi-criteria method that manages mix information; criterion scores may be expressed in crisp, stochastic, fuzzy numbers or linguistic expressions.

NAIADE is a discrete multi-criteria method (i.e. the set of alternative is finite) that does a pair-wise comparisons between alternatives in order to generate a ranking of options.

a) Definition of alternatives

The alternatives are defined by clicking on the first row of the Criteria/Alternatives or Groups/Alternatives matrix. The name and description of the alternatives proposed are simply defined (See Figure 8).

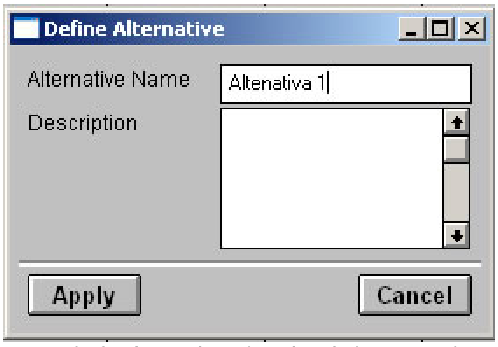


Figure 8: Dialogue box for the definition of alternatives

b) Definition of criteria

Clicking on the first column of the Criteria/Alternatives matrix (), it activates the window where the type of criterion (fuzzy, stochastic, qualitative or quantitative) and its characteristic parameters, such as the measurement units, the optimisation criterion (maximisation or minimisation) and the crossover points of its preference relations can be defined (See Figure 9).

Figure 9: Dialogue box for the definition of criteria

The crossover points of the preference relations represent the preference and indifference thresholds. They can be defined either by directly assigning it a numerical value or by moving graphically the vertical blue line. The vertical blue line represents the crossover

21 This text is based upon the NAIADE Manual – version 1.0.ENG. Joint Research Centre of the European Commission. Ispra site. Italy. 1996.

value or the point where the preference function intersects the crossover line (i.e. when it reaches the value of 0.5).

Four *preference relations* have to be defined by means of establishing two preference and two indifference thresholds (crossover points).

The *Much Better* (red) and *Better* (yellow) thresholds are the minimum difference between the performances of two alternatives that makes one option preferred instead of the other.

The *Almost Equal* (blue) and *Equal* (green) thresholds are the maximum difference between the criterion scores of two alternatives that makes almost no difference and no difference between them respectively.

The number at the end of the X axis represents the base scale value, which must be higher than the *Much Better* threshold.

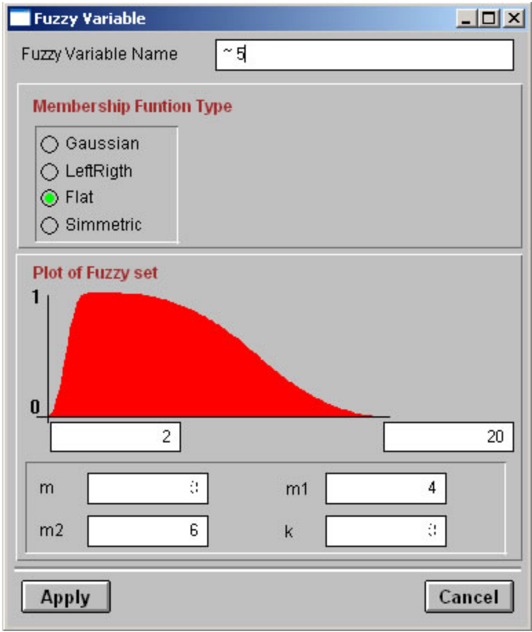


Figure 10: Dialogue box for the definition of fuzzy numbers

c) Filling the matrices

The matrices are simply filled by clicking on the cell to be defined. In the Impact matrix the types of input data depend upon the type of criteria chosen for the analysis whilst in the Equity matrix the data are always of linguistic type.

For fuzzy criteria a window is popped up from which the fuzzy set and its parameters can be defined when choosing from four possible types (see Figure 10). For stochastic criteria a window appears where the type of probability density function and its parameters can be defined (see Figure 11). Finally, when the criterion is qualitative a window appears where the user simply selects the variable (see Figure 12). The user must assign a name to the linguistic variables which will appear in the matrix. If the criterion is numerical the user can simply type the number in the corresponding box.

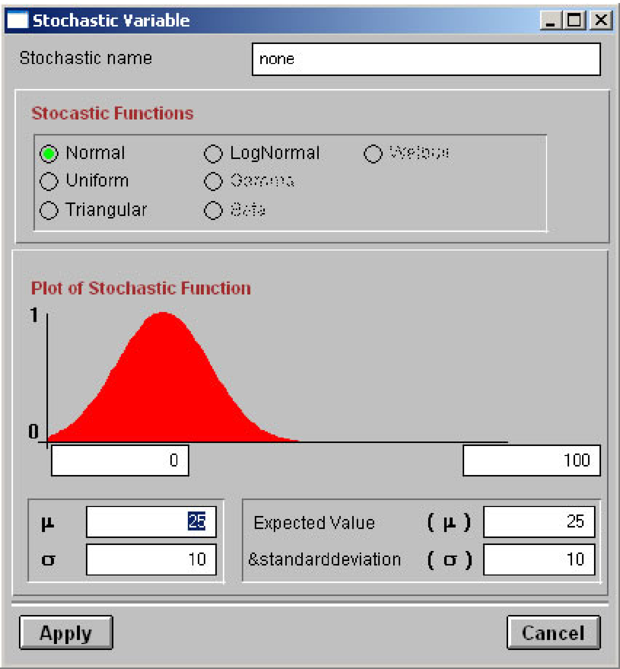


Figure 11: Dialogue box for the definition of stochastic variables

d) Running the aggregation

i. Semantic distance

In order to compare the criteria values for the alternatives, it is necessary to introduce the concept of distance. In the case of numeric evaluation, the distance is simply defined as the difference between the two numbers. In the case of fuzzy or stochastic evaluation, the concept of semantic distance is used. Semantic distance measures the distance between two functions: it takes into account the position and also the shape of the two functions (either for fuzzy membership functions or probability density functions).

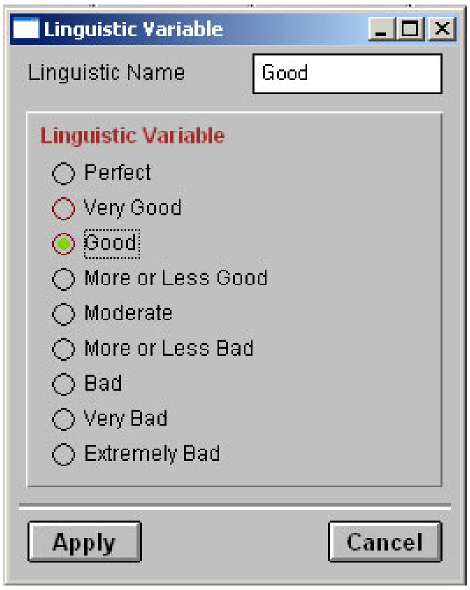


Figure 12: Dialogue box for the definition of linguistic variables

ii. Preference relations and pairwise comparisons of alternatives

Preference relationships are defined by means of six functions that allows to express (depending on the distance between alternatives), for each criteria, an index of credibility of the statements that an alternative is much better, better, approximately equal, equal, worse and much worse than another. The credibility index goes from 0 (definitely non-credible) to 1 (definitely credible) increasing monotonically within this range.

Figure 9 shows the functions that defines the preference relations *Much Better* (red) and *Better* (yellow), which are symmetrical respectively to the *Much Worse* and *Worse* preference relations (See Box 3).

iii. Criteria aggregation

The pairwise comparison of alternatives generate a set of indexes of credibility. Then, through an aggregation algorithm of the credibility indexes, NAIADE calculates a *preference intensity index* of one alternative with respect to another.

In particular the α parameter is used to express the minimum requirements on the credibility indexes. Only those criteria whose indexes are above the α threshold will be counted positively in the aggregation (See below).

In order to use information on the diversity among the assessment of the single fuzzy relations, according to each criterion, the **entropy** concept is useful. Entropy is calculated as an index varying from 0 to 1 that gives an indication of the variance of the credibility indexes that are above the threshold, and around the crossover value 0.5 (maximum fuzziness).

Box 3: Example of the determination of the index of credibility

Consider the preference relations presented in Figure 9. The red curve expresses the index of credibility that alternative A is *Much Better* than alternative B.

The threshold for the *Much Better* preference relation is set up in 10.000 €.

If the performances of alternatives A and B are 45.000 and 30.000 Euros respectively, then the the index of credibility that A is *Much Better* than B is around 0,7.

An entropy value of 0 means that all criteria give an exact indication (either definitely credible or definitely non-credible), whereas an entropy value of 1 means that all criteria give an indication biased by the maximum fuzziness (0.5).

Figure 13 shows a graphic representation of the indexes of credibility (in yellow), and of the intensity of preference index and entropy (in pink).

In this case, the horizontal red line represents the value defined by the α parameter. The indexes of credibility that are above this value will be counted positively in the aggregation.

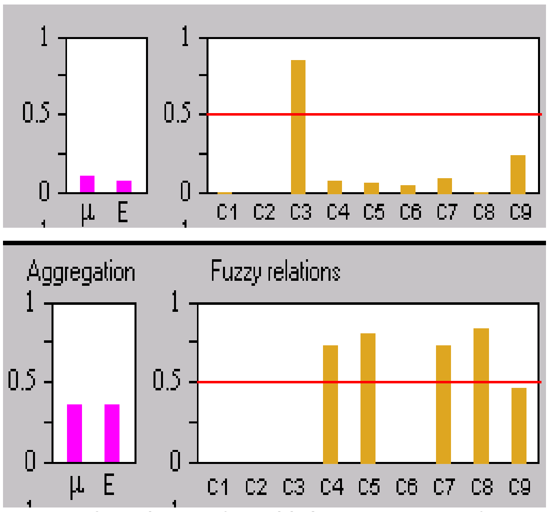


Figure 13: Indexes of credibility, intensity of preference index and entropy

iv. Rankings

The *intensity of preference* for each preference relationship (*Much Better, Better, Almost Equal, Equal, Worse* and *Much worse*) is calculated by means of aggregating the respective *indexes of credibility*.

Then, the ranking of alternatives is obtained from the intersection of two separate rankings. One of the rankings is based on the aggregation of: the intensity of *preference indexes* and the *entropy* of the *Better* and *Much better* preference relations. The other ranking is based on the aggregation of the intensity of preference indexes and the *entropy* of the *Worse* and *Much worse* preference relations.

The final ranking is a result of a sort of *each against all* competence, and mutual preference independence does not hold. Therefore, positions in the ranking may be contradictory with binary relationships between alternatives. For example, A can rank better than B in the final ranking, but B can be better than A *according to most of the criteria*.

In this regard, NAIADE uses the information provided by the preference intensity index and correspondent entropies in order to build the *degrees of truth* (τ) of the following statements:

"according to most of the criteria":

a is better than b

a and b are indifferent

a is worse than b

A.3. Results of the multi-criteria evaluation in NAIADE

Table 83: Sensitivity analysis based on the NAIADE parameters α and γ (Period 2004-2008)

Minimum requirement on the credibility indexes	**Minimum** ⟵	**Compensation**		⟶ **Maximum**
	γ=0,2	**γ=0,4**	**γ=0,6**	**γ=0,8**
α=0,1	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2
α=0,3	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2
α=0,5	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 E3 ↘ ↙ E2	E1 E3 ↘ ↙ E2
α=0,7	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 E3 ↘ ↙ E2	E1 E3 ↘ ↙ E2
α=0,9	E3 ↓ E2 ↓ E1°	E3 ↓ E2 ↓ E1	E3 ↓ E2 ↓ E1	E3 ↓ E2 ↓ E1

Table 84: Sensitivity analysis based on the NAIADE parameters α and γ (Period 2009-2013)

Minimum requirement on the credibility indexes	**Minimum** ⟵	**Compensation**		⟶ **Maximum**
	γ=0,2	**γ=0,4**	**γ=0,6**	**γ=0,8**
α=0,1	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2
α=0,3	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2
α=0,5	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 E3 ↘ ↙ E2	E1 E3 ↘ ↙ E2
α=0,7	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 E3 ↘ ↙ E2	E1 E3 ↘ ↙ E2

Minimum requirement on the credibility indexes	Minimum ← Compensation → Maximum			
	γ=0,2	**γ=0,4**	**γ=0,6**	**γ=0,8**
α**=0,9**	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2	E1 ↓ E3 ↓ E2

Chapter 4
Wind energy implementation: identifying some global/local contradictions

4.1. Introduction

Climate change is widely known as a global environmental problem, and urgent actions are needed to avoid (or reduce) potential impacts on the environment and society. These decisions should be made quickly even if socio-environmental dynamics are not fully understood. But on the other hand, the existence of contradicting and legitimate objectives in society would lead to socio-environmental conflicts in the process of choosing and implementing policies aimed at dealing with climate change.

Since the late seventies several institutions have been created in order to face this global challenge. As of 1979, the First World Conference on Climate has recognised climate change as a serious global problem. In 1992, the United Nation's Convention on Climate Change (UNFCCC) was set up, and the member states of the convention made the commitment to limit greenhouse gas emissions, carry out research activities on the issue and develop adaptation strategies.

As of 1995, the Conference of the Parties (COP) was set up as the principal authority of the Convention. In these political and technical meetings, several activities are carried out in order to shape and to specify decisions previously made by the signatory states. Within the framework of the COP meetings, signatory states of the convention review the agreement previously taken, examine new scientific information about climate change, evaluate national public policies and adopt new compromises in order to tackle this global environmental problem.

During this process, the Kyoto Protocol (1997) is the main agreement among states in order to cope with climate change. It established principles, institutions and norms in order to confront global warming. Accordingly, developed countries that corroborated the agreement have made the commitment, among other things, to cut down their GHG emissions between now and 2008-2012 by 5.2% of the figures of 1990. The European member states (EU15) have made their reduction commitment as well, but they are allowed to transfer their emissions within the *European Bubble* in order to reach the European target.

The Protocol establishes three mechanisms aimed at reducing GHG emissions in a cost-effective way. These are the Clean Development Mechanisms (CDM), a trade emissions regime and the Joint Implementation (JI)[22]. The Protocol also considers issues of funding, technology transfer and information analysis, which have been handled in the following COP meetings to define their implementation.

Additional to political commitments, technical panels have been set up as well. The Intergovernmental Panel on Climate Change (IPCC) was created in 1988, and its main duty is to evaluate the current situation and the possible socio-economic and environmental impacts of climate change. The design and recommendation of some strategies are also within its

22 It is interesting to note that dissent voices on the application of the Clean Development Mechanisms and/or the Joint Implementation are not difficult to find. These objections are based on the impacts experimented by local communities and ecosystems (See Bachram, 2004; Carbon Trade Watch, 2002).

responsibilities.

In this context, the intensive use of fossil fuels during the last decade has been assessed as one of the main culprits in the increase of the atmospheric carbon dioxide concentration[23]. So, transport and electricity sectors have been targeted for action.

It is worth-noting that, even though transport produces most of the carbon emissions, the strategies to decrease the contribution of this sector are limited: to increase vehicles efficiency, to use low carbon intensive fuels and to improve traffic planning are some of the proposed alternatives.

Within the electricity generation sector several alternatives are weighed up, and renewable energies are expected to play an important role in this regard. Among renewables, wind energy is the most developed and promoted renewable energy source in order to meet these objectives, but the construction and operation of windfarms is the last step in a *descending* chain of environmental policies that is not exempt of obstacles and problems.

Local opposition towards windfarms has been experienced across Europe and abroad, and the sources of conflict have been explained in several ways. Unsatisfactory decision-making processes around the implementation of windfarms is one of these possible explanations.

Another source of conflict is the contradictory effects that wind energy technology has at different levels. It would contribute to reduce GHG emissions and decrease fossil fuels dependency of societies, but there is contradictory evidence against renewables as an option that boost local development.

Thus, the aim of this chapter is to identify some local/global contradictions that shape decision-making process within the field of wind energy implementation. Subsequently, I explore the potential of SMCE as a decision-making process aimed at meeting objectives expressed at global and local levels, as well as a conflict management tool: two desired features if one considers the current situation regarding the exploitation of renewable energies .

This chapter is structured as follows: first, a review of supra-national and national renewable energy policies are presented, allowing for an analysis of the criteria prevailing at those tiers of governance. Then, follows a review of the main factors of opposition towards wind energy technology at the local level, thus one can look at the process aimed at meeting objectives at different layers of governance. Finally, the desired features of a decision-making process within the framework of wind energy implementation are outlined.

4.2. Renewable energy policy, from the global perspective

As of 2001, electricity produced from renewable energy sources (RES) (excluding large-scale hydro) had a share of 12,6% in Europe, and a 14,2% including large-scale hydroelectric (12,6% in 2003)[24]. According to CEC (2001), electricity produced from RES (including large-scale hydroelectric) is expected to raise up to 21% by the year 2010[25].

4.2.1. European directives and norms

At the European level, electricity generation from RES is seen as a mean to: ***i)*** assure energy

23 Also, timbering, forest fires, agriculture and land use change are regarded as other main human activities fostering global warming.
24 These data are based on Eurostat statistics and ESHA (2003)
25 It is worth-noting that large-scale hydroelectric is included in the European targets, even if these installations could be the source of important GHG emissions (Fearnside, 2004).

supply; ***ii)*** reduce GHG emissions; ***iii)*** increase competitiveness of European companies within renewable energy sector; ***iv)*** mitigate local/regional emissions; and ***v)*** improve socio-economic situation at local scale by means of promoting the creation of local employment and companies (EC, 2001; EC, 2003; CEC, 2004; CEC, 2005).

Several instruments have been developed to foster the adoption of these technologies. According to the free market spirit embodied by supra-national institutions[26], these instruments rely upon the entrepreneurs motivation to obtain economic benefits. Feed-in tariffs, green certificates schemes and tendering systems are just some examples of these schemes (see Box 4).

As of September 2001, the European Parliament and the Council of Ministers recommended ***i)*** to implement a source guaranty for electricity produced from RES, ***ii)*** to reduce administrative obstacles for renewables within the electricity sector, and ***iii)*** to facilitate renewable electricity access to transport and distribution networks in order to set up the basis for an European electricity common market, which is seen as the best way to boost the expansion of renewables (EC, 2001).

At that time, the experience on the application of economic instrument was regarded as insufficient to implement the European common market. Then, as of 2003, the European Directive 2003/54/CE established common norms for the European electricity market. It promotes market liberalization in the energy sector in order to: i) increase competence, ii) decrease GHG emissions, and iii) reduce external dependency of energy supply[27] (EC, 2003).

26 In this sense, it is important to note the *cost-effectiveness* character of the policies and mechanisms developed in international official documents, such as the Kyoto Protocol and the European Directives.

27 According to the European Green Paper (CEC, 2001), Europe run the risk of increasing its external dependency on oil and gas, up to levels over 90 and 70% respectively.

Box 4: Economic instruments to foster renewables

Feed-in tariffs consists in assuring a minimum price for electricity produced from renewables during a defined period of time. This mechanism operates by pushing the supply side increasing security of investment in the mid- and long-term.

Feed-in tariffs allow renewable technologies to compete in the electricity market by means of being as cost-efficient as the conventional energy sources used for this purpose, such as oil, natural gas, coal or hydro.

The tariffs should be applied according to the degree of development of the different technologies, and the economic assistance should be reduced in step with technological development, in order to avoid technology stagnation (Meyer, 2003; Reiche and Bechberger, 2004). Agterbosch *et al.* (2004) calls for technology-specific remuneration for green electricity, which can be reinforced applying a location differentiation of the tariffs (Reiche and Bechberger, 2004). This last possibility would increase the available territories for wind power installations.

The use of the **green certificates market** in combination with a quota system is the second most popular instrument to promote renewable electricity. In this scheme, the companies generating electricity from renewable energy sources compensate their higher costs by means of selling green certificates to their customers. The system works based on either a voluntary or obligatory green electricity consumer quota, which is proved by means of the certificates. In this way, it pulls the demand side.

This instrument could be the unfair competition among different renewable technologies, due to the fact that it promote the most cost-efficient options, leaving aside the full renewable electricity potential. So, it should be left for the most mature technologies (Meyer, 2003). In addition, the difficulties to match the supply and demand sides of green electricity may lead to fluctuations in the prices of the certificates, which provokes an uncertain situation for the investors.

Tender contracts is the instrument that follows the above-mentioned mechanisms regarding the degree of implementation at the European level (Gencat, 2005, Reiche and Bechberger, 2004, Meyer, 2003, Enzensberger *et al.*, 2002). It consists in medium/long-term contracts of renewable electricity supply defined by means of a tendering process. The electricity is supplied at the price resulting from the bid.

Again, this scheme is advised to promote the most mature technologies, due to the economic advantage these technologies present.

Tax incentives is another instrument to promote investment on renewables, and it is usually employed as a complementary policy tool (CEC, 2005).

Besides, the European Commission argues that the energy market should be compatible with the mechanisms aimed to promote renewables in the medium- and long-term. However, it again recognises the difficulties to meet an harmonization between national policies due to differences among member states. The Commission recommended cooperation among member states in order to overcome these differences and to develop support mechanisms within Europe. As well, it gives several recommendations aimed to optimize the economic instruments, and to reduce (or eliminate) administrative obstacles for implementations as well as for network access (CEC, 2004; 2005).

The last European green paper on renewable energies (CEC, 2006) presents a pessimistic scenario. Europe needs to take adequate actions in the energy sector. But currently, the mechanisms to foster the implementation of renewables have a strong inclination towards the development of the European liberalized energy market and the use of economic instruments. In practical terms, it promotes energy efficiency rather than questioning the current levels of consumption, thus avoiding to deal with some of the roots of current socio-economic and environmental problems.

4.2.2. Economic instruments for the implementation of renewables

Several authors coincide that, in practical terms, none of the economic instruments neither a combination of them has proved to be superior or more efficient in fulfilling the objective of increasing the rate of implementation of renewables within the electricity market. Their success is highly context dependent.

There is no universal bill to assure the application of renewables. The feasibility of wind energy entrepreneurs adopting wind turbines is highly influenced by the social, economic, institutional, geographical and technical conditions (Reiche and Bechberger, 2004; Agterbosch et al.,2004; Enzensberger et al., 2002). Also, policies at different scales and the global socio-economic context play an indirect role in the success of renewables (Agterbosch et al.,2004).

Different combinations of economic instruments produce a diversity of results. In Spain, for instance, the feed-in tariffs scheme is established at the state level, and the *Comunidades Autónomas*[28] have shown unequal rates of implementation of wind energy. In Navarra, for example, high degree of construction of windfarms could be explained by policies that benefit local actors rather than the effect of the feed-in tariffs scheme (Faulin et al., 2005). Navarra is characterized by the existence of communal forests, so the incomes coming from the rent of the land (where the windfarm is located) go to the administration and not to private landowners.[29]

Also, in Sweden there is the case of three neighbouring municipalities—Laholm, Halmstad and Falkenberg—that are located on the coast. Even though they have similar physical conditions (wind availability and land characteristics) and are under the same economic system of incentives, they exhibit pronounced differences in wind energy development. The territorial planning divergences between the three municipal administrations (i.e. different socio-institutional settings) explain to a great extent this phenomena (See Khan, 2003).

According to Agterbosch et al. (2004), technical (geography and technological development) and economic (investment and operation costs) conditions are the basis to develop a wind energy market. However, those factors have not got a decisive influence on wind investors as the institutional (definition of renewables, territorial planning, administrative proceedings, and national and international norms) and social (degree of cooperation between agents, and their aims, behaviour and power distribution) contexts (See also Khan, 2003; Wolksink, 2000, 2007; Söderholm *et al.*, 2005).

Besides, there still remains some doubts about the adequacy of economic instruments to promote renewables. Excessive importance given to market-based instruments, that foster economic interests in the short term, could hinder the required long term planning to adopt renewables (Meyer, 2003)[30]. So, while Europe considers the harmonization of economic instruments and the development of a common electricity market as the main strategies to promote RES, there exists a need to consider the differences between national, regional and local contexts in which policies are implemented. The point here is not to declare economic instruments as useless, but to shed light on the complex relations between the social, institutional, economic and technical dimensions of a policy implementation process, which needs multi-perspective evaluation approaches.

28 Government administrations at *national* level.
29 It would be interesting to explore the influence of the property rights setting in the high windfarms implementation rates.
30 It is interesting to highlight discussions about the coherence of these instruments with free market philosophy. The state will interfere in those systems by defining electricity prices or by deciding renewable electricity quotas (Meyer, 2003). According to this author, public funding of the former scheme could reach an unacceptable level if the participation of renewable is high enough. But it is important to shed light on the enormous subsidies energy sector based on fossil fuels have received during the last decades. These subsidies have never been considered disproportionated (See Scheer, 2000)

4.2.3. From environmental (and energy) policy design until its implementation

As we have seen, policies aimed at facing global environmental problems, such as climate change, have to descend through several tiers of governance until their implementation. In this process, several agents act at different levels and influence the process according to their interests, resources and ability to exert power. For example, during the negotiations of the European Directive on electricity produced from RES (Directive 2001/77/EC) the member states through the Council of Ministers supported the idea of including as much energy sources as possible within the definition of *renewable*. By doing this, they tried to facilitate the fulfilment of their targets on renewable electricity generation. On the other hand, the European Parliament and the Commission did not want to expand the meaning of *renewable*, acting with a supra-national vision with the objective of reaching as much renewable installed capacity as possible (Rowlands, 2005).

There are also several differences across countries, which are expressed by the wide range of renewable implementation rates as well as the acknowledged diversity of policy schemes (See for instance Reiche and Bechberger, 2004). In this context, European policies are modified in order to match them with national/local contexts, and in some cases, policies never even reach their implementation.

According to Jordan (1999), there are several reasons explaining the lack of environmental policy implementation in Europe (See Box 5). One can find deficiencies at the design phase as well as the implementation stage, and a sort of disconnection between different tiers of governance exists. While the Commission tries to extend its competences in several areas of environmental policy, it disregards the fact that policy implementation is not an imposition exercise, rather it implies formal and informal negotiation and bargaining (Jordan, 1999).

- Policies tend to have vague and/or contradictory objectives
- Issues pertinent to implementation are disregarded during the process of negotiation
- Legislation is poorly drafted and prepared
- The body responsible for proposing legislation, the Commission, is not substantially responsible for its application and implementation
- There is an absence of powerful and committed 'vested interests'
- There is too little consultation with affected parties.
- Enforcement proceedings are slow, secretive, inflexible, complex, and dominated by the states and the Commission.

The European Commission is aware that current measures aimed at promoting renewables would foster their participation up to levels between 18 and 19% in 2010 (CEC, 2004) instead of the goal of 21% set up in 2001 by the European Parliament and the Council of Ministers through the Directive 2001/77/EC.

Under this perspective and according to Eurostat's data, this means to rise renewable electricity generation from 376 TWh in 2003 to 675 TWh in 2010. The basis for this increase are wind energy, whose installed capacity should be doubled by 2010, and in the same period biomass's contribution should be multiplied by 100[31]. Additionally, EU15 has made the commitment to reduce its GHG emissions between now and 2008-2012 by 8% compared to the emission levels of 1990. As of 2003, Europe had reached a 1.7% of reduction in relation to the figures of 1990, which is considered disappointing by the European authorities. Spain is one of the worst cases: its commitment is not increasing its GHG emissions more than 15% compared to the figures of 1990. However, during 2003 its emissions were 40% over the base

31 Giampietro et al. 1997, Giampietro and Ulgati (2005) and Giampietro et al. (2006), who assess the (low) feasibility of biofuels production at large scale.

level (CEC, 2005b), and as of 2005 its emissions have incremented up to 53% above the levels of 1990 (CCOO, 2006).

RES are seen as a means to decrease GHG, decrease the dependency on fossil fuels, face the challenges of *peak oil*, among other aims. Then, the processes of implementation should regard factors unconsidered still today. Nevertheless, the major challenge is imposed by the transport sector, which is the greater contributor of CO_2 emissions.

Industrial societies have based their development mainly upon energy sources with high energy return on energy investment (EROEI[32]), that is, fossil fuels. Then, if we want to transit to renewables (e.g. biomass and wind energy), the energy sector must be able to establish a forced correspondence between its expected function and how it fits within the whole to which it pertains. That is, it must deliver the amount of energy required for societal metabolism, and fit within the constrains imposed by socio-economic structure (i.e. available human time) and environmental limits (i.e. available land). So, the feasibility of renewable energies powering current consumption trends and the desirability of doing so should be evaluated (See Giampietro et al, 2006 for a deeper discussion on this).

Additionally, human societies, among other adaptive complex systems, increase the complexity of their organization and structure in order to solve problems that put their survival at risk (e.g. shortage of energy or other important resources). Higher complexity comes together with increased maintenance costs (energy, labour, money or time) of the required new structures. Since solutions that cost less are applied at first, marginal returns to complexity decreases over time, and new changes become more difficult to implement. Therefore, the transition to energy sources of lower EROEI, such as wind energy or biofuels, would imply a restructuring of society: a process that won't be exempt of conflicts and uncertainties due to the contradictory interests in society and the political and technical limitations (Tainter et al., 2006. See also Tainter, 2001).

This calls for a consideration of a wide range of social actors within the renewables implementation domain, as well as the use of an adequate evaluation framework. So, this next section deals with different sources of resistance towards windfarms in order to see the other side of the coin, that is, local perspectives regarding wind energy. The aim of the current and the next sections is to establish the required features of a decision-making processes able to balance local and global needs.

4.3. Wind energy implementation, from the local perspective

Although wind energy has a green image, windfarm projects often find opposition to their realization. NIMBY behaviour is one of the most recurrent arguments to explain this resistance, but according to Wolsink (2000, 2006) the NIMBY concept doesn't allow to distinguish between a wide range of attitudes towards wind energy, and especially to differentiate the motivations to oppose windfarms. Resistances to these sort of installations could take at least four different types, and only one can be called NIMBY (Type I in Box 6).

Public opinion studies based on surveys have lead some authors to associate positive attitudes toward windfarms with a higher level of knowledge about this technology; people living near these installations would have more information about the operation of windfarms, and therefore, higher degree of acceptance than people living away from windfarms. But reasons of acceptance or rejection go beyond the relationship between distance and knowledge (See for example, Khron and Damborg, 1999; Söderholm et al, 2005; Wolsink 2000, 2006).

32 EROEI reflects the amount of energy produced by one unit of energy invested.

Box 6: *Types of resistance to windfarms construction (Source: Wolsink, 2000, 2006)*

I. A positive attitude towards wind power, combined with an opposition to the construction of a windfarm anywhere in one's own neighbourhood

II. A rejection of wind technology in general. Mainly based on the impacts of windfarms on scenery.

III. There is a switch from positive to negative attitude towards windfarms during the decision-making process aimed at constructing the utility.

IV. A negative attitude towards a defined windfarm project which is considered faulty.

Some public opinion studies fail in understanding public attitudes if they don't try to discover contextual and relational dimensions in which interviewees live (Schakley et al., 1996). For example, people living near nuclear power plants express confidence of both nuclear facilities and their regulations due to the unavoidable dependence on the nuclear industry (workers and their families), and not due to a higher knowledge of the characteristics of nuclear energy technology and its risks (*ibid.*).

The point here is to shed light on the fact that there exist other motivations than ignorance to oppose windfarms. So, the following sub-sections present some situations leading people to resist windfarms, which would be useful so as to avoid the pitfalls of technocratic and top-down decision-making procedures.

4.3.1. Social acceptance of windfarms

Wüstenhagen *et al.* (2007) distinguishes three dimensions of social acceptance of renewable energy innovations, namely socio-political, community and market acceptance (See Figure 14).

Socio-political acceptance refers to the social acceptance in the broadest, sense. This has to do with the acceptance of effective policies and technologies, and the creation of adequate frameworks that boost community and market acceptance.

Community acceptance refers to the attitude toward renewable energy projects by local social actors. Which are related to distributional justice and procedural justice.

Finally, market acceptance refers to the process of market adoption of an innovation. Which can be analysed from the point of view of consumers and suppliers (investors), and also from the intra-firm perspective.

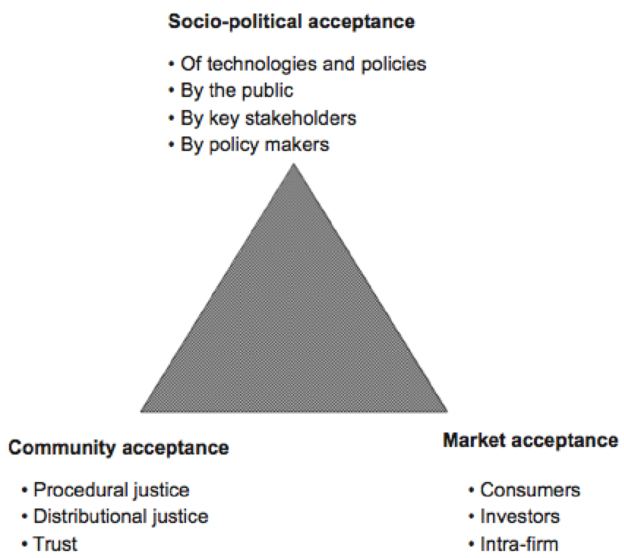


Figure 14: Dimensions of Social acceptance of renewable energy innovations (Source: Wüstenhagen et al., 2007))

The following sub-sections deal in deeper detail with issues related to local acceptance of windfarms. That is, to shed light on some of the roots of local opposition toward these facilities. Following, I propose SMCE so as to deal with the challenges related with the community acceptance dimension.

4.3.2. Impacts and perceptions at different levels

The attitudes toward wind energy can be differentiated from the attitudes towards windfarms in several ways. Public opinion towards wind energy is in general very positive; for instance, it is seen as a clean energy source that reduces GHG emissions. On the other hand, new values and worries emerge at local level that influence the opinion towards windfarms at this scale; for instance, changing landscape, impacts on birds, shadow effect, are just some local impacts raising concerns among locals, related to wind energy technology.[33]

Supra-national governmental entities argue that renewable energies would promote local development, for instance, creating local jobs and boosting regional companies. But problems perceived and experienced at local scale (such as rural-urban migration, population ageing, lack of social services, lack of communication ways, among others) are a lot more complex to tackle than assumed. For instance, technological development could hinder the creation of permanent and qualified local jobs (Faulin et al., 2005)[34].

The creation and expansion of local companies is also a complex issue. To harmonize the economics instruments and the establishment of a common energy market would cause unequal effects on small and medium investors through Europe, due, for instance, to the socio-institutional difference across European countries (see above).

Moreover, renewable energy installations are characterized by their relatively higher investment costs and lower operation costs. In general, post-investment economic instruments (e.g. feed-in tariffs, green certificates or taxes incentives) that predominate the European context would favour big companies: they can obtain bank funding more easily than small enterprises due to their ability to afford such an investments[35].

If the main economic instruments are oriented to typical market actors, the participation of local investors and cooperatives is not directly promoted[36]. Additionally, local consumers don't see any reduction in their electricity bill and they are who suffer the disadvantages of electricity generation from RES.

So, meeting national targets on the implementation of renewables doesn't necessarily lead to improve the quality of life in local communities. Moreover, due to the impossibility of favouring all sorts of entrepreneurs at the same time, the election of a defined scheme (i.e. a set of instruments) means choosing to privilege *just some* types of investors.

4.3.3. Decision-making processes for wind energy implementation

Even if some negative attitudes toward windfarms exists, the impact of this sort of attitudes in the success of the construction of windfarms has been overestimated. Rather, the sources of opposition are closer to the planning and decision-making processes related to windfarms evaluation, approval and construction. Especially, if these processes are characterized as top-down, technocratic and highly influenced by corporative elites (Wolksink, 2007).

33 It is worth noting that landscape impact is the dominant factor explaining negative attitudes toward windfarms at local scale. It has an important influence on attitude formation toward wind energy as well (Wolsink, 2006)

34 One example is the operation of windfarms owned by EHN in Spain, which is carry out in a computerized centre located in Navarra, far away from most of the the facilities owned by the company. At he time of the study presented in Gamboa and Munda (2007), windfarms create one local job every nine installed wind turbines.

35 Currently, the construction of windfarms has a cost of one million of Euros per installed megawatt, plus the costs of the connection to the net (power lines and substation).

36 More than 80% of the windfarms constructed in Spain are owned by big transnational companies. Iberdrola owns 33% of the Spanish windfarms, Acciona has a participation of 18%, Endesa 9%, and Hidrocantábrico Energía 7%. Other companies with lower participation are Gas Natural, Gamesa and the Italian UF-Enel (Asociación Empresarial Eólica, 2006).

As the reader will see in the next chapter, one of the main reasons argued by the opponents to the planned windfarms is the way the decision-making process was carried out. They perceived the process as exclusive, and the projects as an imposition from the local authorities and the energy companies. Therefore, these people ask more than just consultation, they asked for real involvement of local actors within the territorial planning process, and specifically, in the design of the projected windfarms. Moreover, it can be said that some social movements opposing those windfarms behave in a strategic way: they weren't against windfarms as such, but they express total opposition towards the projects in order to get the least amount of wind turbines constructed as possible.

Early public involvement within environmental decision-making processes should be certainly consider as a way to include as many perspectives as possible in the problem structuring as well as in the evaluation process.

4.4. Conclusions

This chapter has started delineating the objectives of supra-national institutions (e.g. the European Union) and governments with respect to renewable energies: they see electricity production from RES as a way to face climate change, to assure energy supply and also to boost economic development at local and national levels.

It showed a description of the main sources of opposition towards windfarms at the local level; outstanding issues related with decision-making processes within the framework of territorial wind energy planning as well as the local impacts of this technology (e.g., landscape affectation).

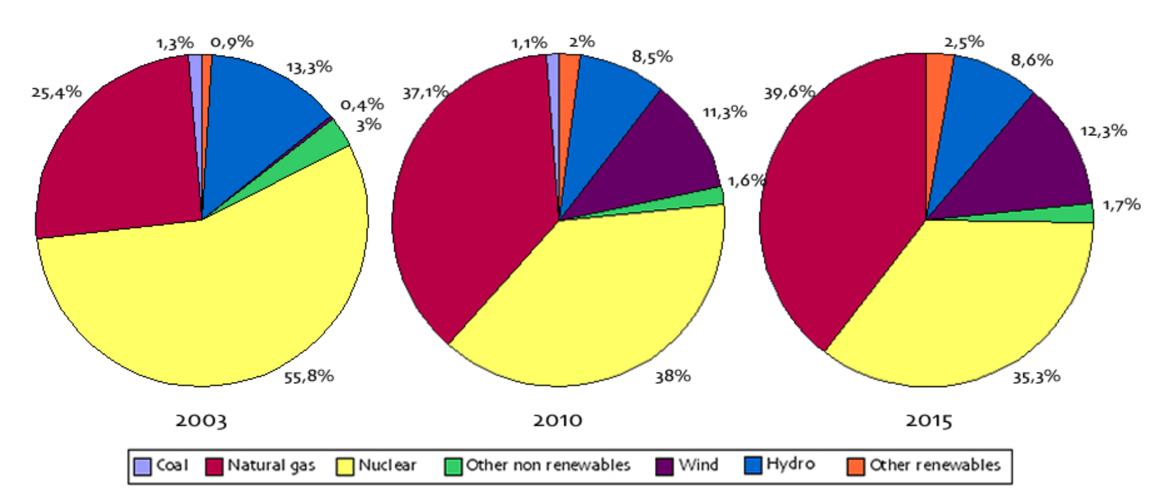
Two desired features of decision-making process within the framework of renewable energy planning and implementation are: the ability to integrate objectives expressed at global and local levels, and its potential as a conflict management tool.

Next chapter will describe a SMCE of windfarm locations in Catalonia in order to know whether this decision-making process fulfils those desired features.

Chapter 5
A Problem of Windfarm Location in Catalonia[37]

5.1. Introduction

In Catalonia, electricity produced from renewable energy sources has reached about 6.600 GWh in year 2003, representing the 14.5% of the gross electricity production. The participation of wind energy is 0,4% of the net electricity production and 2,4% within renewables[38].



Graphic 2: Participation of different energy sources in Catalonia for the years 2003, 2010 and 2015
Source: Own elaboration based on Gencat (2005)

The main energy source for electricity production is nuclear energy. It follows natural gas and hydroelectric power stations. The Catalonian government projects to maintain the production of electricity from nuclear energy within the next 15 years, which implies to decrease its participation. According to the Catalonian energy plan (Gencat, 2005), natural gas will double its contribution and wind energy will increase its share up to 8.800 Gwh in 2015 (12,3% of the electricity production in Catalonia).

As of 2004, the Catalonian Meteorological Service has made a map of wind resources of Catalonia (See Figure 15). According to this map, windy zones are located in the North-East and South of Catalonia. It also shows *off-shore* wind resources.

The previous energy plan of Catalonia (Gencat, 2001) had identified the same potential zones for windfarms, but that plan was reissued due to several reasons. Within its justifications for relaunching the plan, the Catalonian government has argued "the need of giving more prominence to the environmental criteria and of the territorial re-balance in the Catalonian energy policy" and the "non-fulfilment of the aims of the previous plan, above all the objectives regarding renewable energies implementation and energy saving and efficiency"(Gencat, 2005: p. 5).

37 This chapter is the basis of the paper "The problem of windfarm location: A social multi-criteria evaluation framework". Energy Policy 35 (2007), pp. 1564-1583. Authors: Gonzalo Gamboa and Giuseppe Munda

38 The Catalonian government considers large hydroelectric power station as renewable energy source.

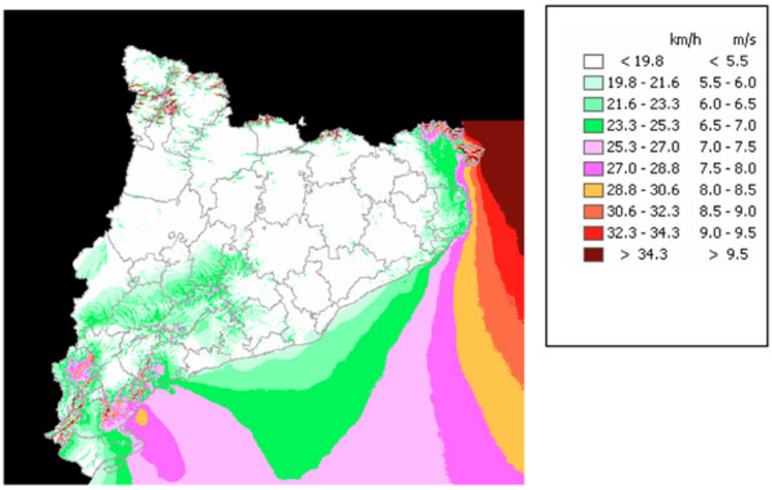


Figure 15: Map of wind resources of Catalonia
Source: Gencat (2005)

The plan identifies several barriers for wind energy development. It mainly tackles technical impediments, but it poorly deals with the obstacles related with the social acceptance of windfarms. Within the proposals of actions aimed at fostering the construction of windfarms, the plan only look for the "acceptance and support of the majority" of the inhabitants of the territory towards windfarms. The participation of these people in the process of implementation is not considered, and the plan does not specify how the concerns about windfarms will be included in these processes.

But the new energy plan does not make any change in terms of increasing the participation of local population in the land use planning. The criteria that will guide the implementation of wind energy are already defined, and it seems there is no room for change or adaptation to local realities.

If the South and South-West of Catalonia are still now the target zones for the development of windfarms (even *off-shore*) and the government does not change its *top-down* approach for the energy planning, then social conflict would not be surprising.

As a tool for conflict management, multi-criteria evaluation has demonstrated its usefulness in many environmental and energy policy/management problems (see e.g. Beinat and Nijkamp, 1998; Diakoulaki et al., 2005; Georgopoulou et al., 1998; Goumas et al., 2000; Munda, 2005a; Tzeng et al., 2005; Uemura et al., 2003). Most applications in the field of energy policy, can be classified into the following main groups (Diakoulaki et al.,2005, pp. 876-879):

1. comparative evaluation of power generation technologies,
2. selection among alternative energy plans and policies,
3. sorting out a subset of candidate energy projects,
4. sitting and dispatching decisions in the electricity sector.

Social multi-criteria evaluation can supply a powerful framework for energy policy analysis, and, in particular, it seems very relevant for tackling wind parks location problems.

Main objective of this chapter is to show the potentialities of a SMCE framework for dealing with wind park location problems. To achieve this goal a real-world problem is used. This is a location problem recently tackled in Catalonia (a Region in the North-East of Spain).

5.2. The Real-World Location Problem

The impact zone is located in the west part of the Catalonian central depression (see Figure

16) between the "comarcas" of Urgell and Conca de Barberà. The projects proposed were two: the Coma Bertran project of 11 windmills of 1.5 MW, and the Serra del Tallat project of 33 windmills of 1.5 MW. In addition, there were other two projects of 75 and 15 windmills respectively.

Figure 16. L'Urgell and Conca de Barberà Comarcas in Catalonia

Early in this location policy process, there were several positions regarding the construction of those windfarms. On one side, some people started to raise their voices against the windfarms. Firstly, they expressed their will of participating in the design of the future of their *comarcas* and, secondly, they see as territorial inequalities (mainly between the metropolitan area of Barcelona and the rest of the Region) the way Catalonia has been planning the energy production scheme.

On the other side, some municipalities and some citizens agreed with the construction of these infrastructures. They see the windfarms as a good opportunity to increase their incomes, to improve social services and to change the declining path that characterizes their territory. By developing an institutional analysis study and applying various participatory techniques the social "atmosphere" understood can be synthesized in Table 85.

Table 85. Socio-economic actors, scale of action and their positioning in relation with the windfarms.

Social actor	*Scale of action*	*Position regarding the windfarms*
Catalonian government	National	The Catalonian government has launched the Renewable energy plan for the year 2010. It projects the participation of RES to grow, from 72.2 MW to 1.073 MW of installed capacity. It has accepted the petition made by some environmental and social movements of revising the Catalonian renewable energy program. But at the same time they have the goal of increasing installed capacity of windfarms up to 3.000 MW. Then, its evaluation of the different alternatives depends mainly on the installed capacity.
Municipality of Vallbona de les Monges	Local – Province	The municipality wants the windfarms to be installed. They see the income as a good opportunity to improve some social services, and/or to create others (like elder nursing). The municipalities of Vallbona de les Monges, of Rocallaura and of Els Omells de na Gaia are negotiating as a coalition with the companies, trying to obtain equal and better retribution conditions from the promoters. They say that if the income is not enough to overcome the present social trend, then they do not want the windfarms to be constructed.
Municipality of Rocallaura	Local – Province	

Social actor	*Scale of action*	*Position regarding the windfarms*
Municipality of Els Omells de Na Gaia	Local – Province	In a similar position than the previous ones, the municipality of Els Omells de Na Gaia supports the installation of the windfarms in their own territory. The windfarms could provide economic resources for the municipality and for some members of it.
Town council of Senan	Local – Province	The town council, supported by Senan's inhabitants, is strongly opposed to the windfarms. They do not want to be surrounded by windmills, They see their welfare at risk, mainly because the *industrialization of the mountains* is viewed as a loss of quality of life and a possible destruction of tourism potentialities (e.g. forests)
President of the Consell comarcal de l'Urgell	Province - National	The president of the council has offered her mediation to reach a compromise solution. But she shares the opinion of the mayors, in the sense that more income is needed to revitalize the towns, and to offer more and better services.
Politic representatives	Province	Representatives from different political parties have signed a motion asking for a moratorium to the windfarms *Coma de Bertran* and *Serra del Tallat*. And defending the development of economic activities without interference with local initiatives.
Coordinating committee to defend the land (Urgell, Conca de Barberà, Segarra, Garrigues)	Province	They think that it is not necessary to jeopardize the future of the towns to revitalize them. They are not against wind energy, but they do not approve the way the process has been carried out, for instance, without considering the needs and problems of the local people. They think that the solution has to be discussed by all the towns involved, to avoid any town to be harmed. They act as a regional entity fighting the installation of windfarms at large scale. They support the development of activities in accordance with traditional activities, like the tourist project *Ruta del Cister*. The evaluations are directly related with the amount of windmills. Then, less windmills to be constructed means a better evaluation for them
Platform for Senan	Province	They see the projects as an undesirable gift from its neighbours. They do not share the way the process has bean carried out, and they say that to reach more equitable decisions all the involved towns have to be heard. (See Town council of Senan above)
Association of friends and neighbours of Montblanquet	Local – Province	Most of the people of this association hold a second residence. They *escape* from the city to the country side to look for a quiet place to rest. Most of them reject the planned windfarms due to their proximity to the towns (potential noise annoyance and scenic impact).
GEPEC	National	This is an environmental non-governmental organization, acting at the Catalonian level to redefine the Catalonian Energy Plan, with the participation of some social actors. They ask for a decentralized electricity production system close to the consumption places. Regarding the location of windfarms, they ask for special attention to the habitats of rare and threaten species, and to the biologic corridors. They ask also for applying the Landscape European Convention and for territorial equity.
Enegía Hidroeléctrica de Navarra (EHN)	National	The company is the promoter of one of the windfarms. They are one of the main energy producers from RES in the Spanish territory, and one of their aims is to construct windfarms as big as possible to impulse a strong change *"in the energy production culture*". The current submitted project (ST) is already in the evaluation phase, and they have spent some economic resources on it. It could be said that this alternative is perfect for them. While for other alternatives their willingness to implement them is related with the amount of installed capacity and of course with the fact that they will be the acting company
Gerrsa	National	This is the promoter of the *Coma Bertran* project. It has been impossible to organize a meeting with them due to their reluctance of talking with people external to the government. It is assumed that its situation is quite similar with EHN. They support projects in which they are involved

Once the actors' perceptions have been identified the problem has to be structured in a multi-criterion framework. This means to generate alternatives and to choose evaluation criteria. Next sections illustrate the multi-criterion process and the results obtained.

5.3. Generation of Alternatives

One of the main features of the SMCE framework is that alternatives are constructed considering information from several sources, for instance, the participatory process, the review of the projects, technical interviews, and so on. This process was carried out by the research group. It started considering the preliminary plans of the Coma Bertran (CB-Pre) and Serra del Tallat[39] (ST-Pre) projects, and the combination of both (CBST-Pre) as the three first alternatives. They are called the technocratic options, because the investors have defined them relying upon their own criteria only. Then, other three alternatives are the submitted projects (Coma Bertran (CB) and Serra del Tallat (ST)) and the their combination (CBST). We call these plans as technocratic and accepted by some part of the population, because the investors still define the alternatives based on their own criteria, but considering the worries of some social actors.

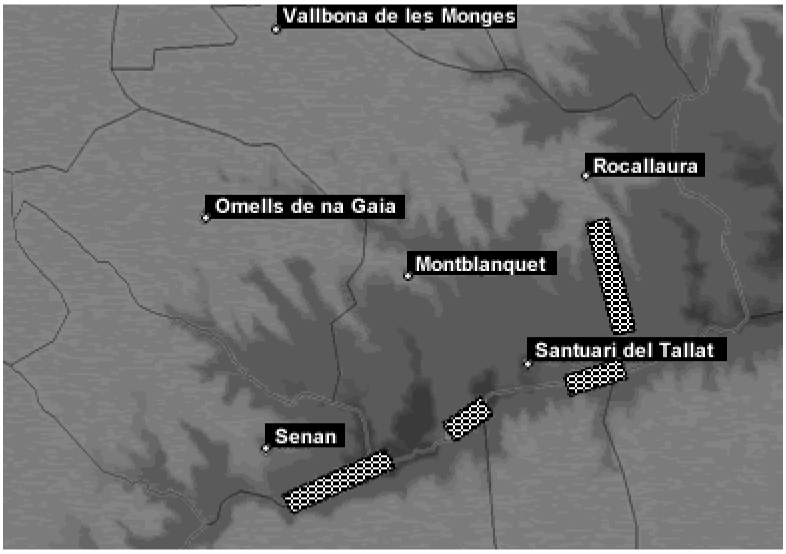


Figure 17. Technical feasibility zones (wind availability)
Source: Our own elaboration based on EHN (1999)

After this, and considering the worry of some people about the visual impact of the windfarms, new alternatives were generated, relying upon the following criteria:

i. Technical (and economic) feasibility, depending on wind availability (see Figure),

ii. To reduce the visual impact of the original proposals,[40]

Starting from the combination of the preliminary plans, two other alternatives are generated by eliminating the windmills located closer than 1.5 kilometres from the towns (Ls).

Other two alternatives are generated by redistributing windmills that are closer than 2 kilometres from the inhabited zones (Rs). The starting points are the submitted projects. We call these plans modified, because they are based on the modification of both the preliminary and the submitted projects.

Finally, there is the possibility of constructing a windfarm managed by a cooperative (e.g. local administration), and the last one is not constructing parks at all (NP). This last is the

39 Strictly speaking, the preliminary plan of the Serra del Tallat Project was not submitted for governmental evaluation, and it was got from EHN as an internal document. This study was used to identify additional windy zones for locating wind turbines.

40 It has been considered the worry of "living surrounded by windmills". On the other hand, the Danish Wind Industry stands that the windmills located further away than 500 or 1.000 meters do not produce shadow effect (i.e. to intercept sun rays).

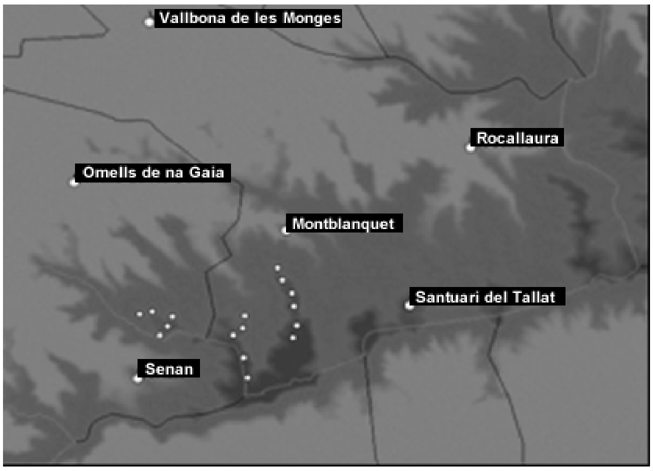
BaU situation, i.e. Business as Usual.

These 12 alternatives were submitted to further discussion with social actors and within the scientific team itself. After this further screening process only seven alternatives were left for further evaluation. The detailed description of these seven alternatives is presented in and Figure 18.

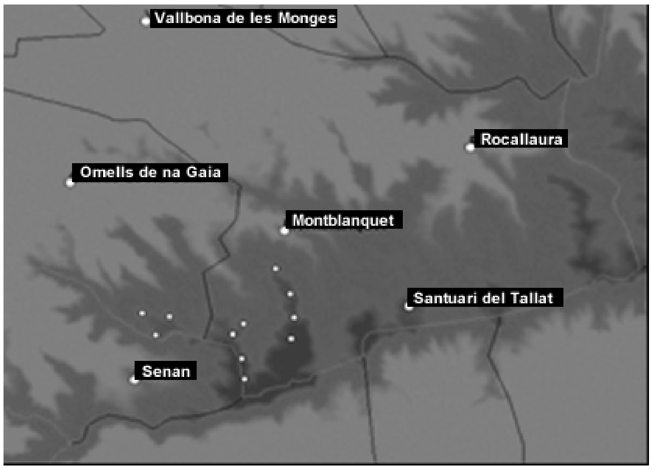
Table 86. Characteristics of the alternatives.

	Alternatives						
	Technocratic	***Technocratic and accepted by some part of the population***			***Modified***		***BaU***
Windfarms features	***CB-Pre***	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
Number of wind-mills	16	11	33	44	26	24	0
Power capacity [MW]	13,6	16,5	49,5	66	39	36	0
Rotor height [m]	55	80	80	80	80	80	80
Blades diameter [m]	58	77	77	77	77	77	77

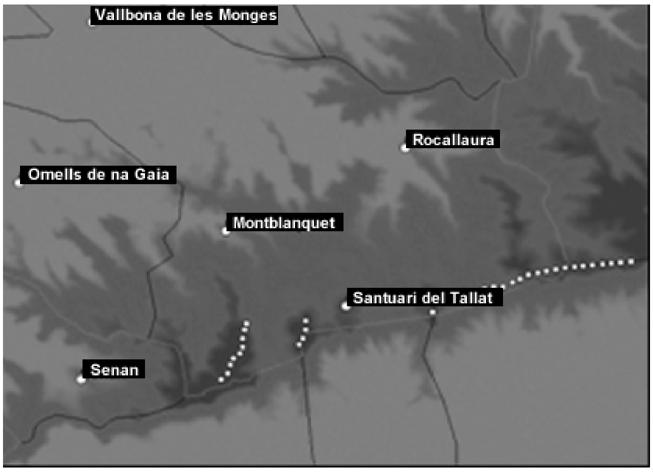
Figure 18. Location of windmills



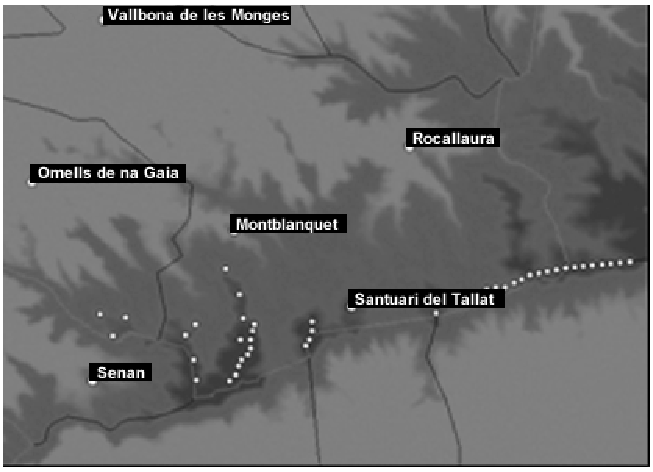
a)
CB-Pre: Coma Bertran preliminary project.



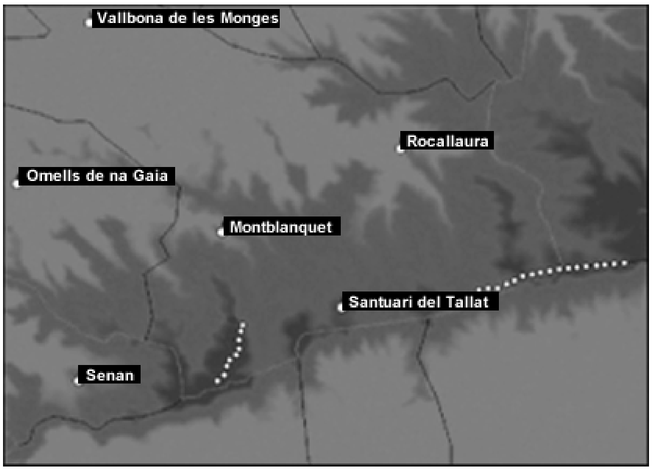
b)
CB: Coma Bertran project, submitted by Gerr Grupo Energético Siglo XXI S.A. The changes made to the preliminary plan consist in reducing the amount of windmills and increasing their capacity.



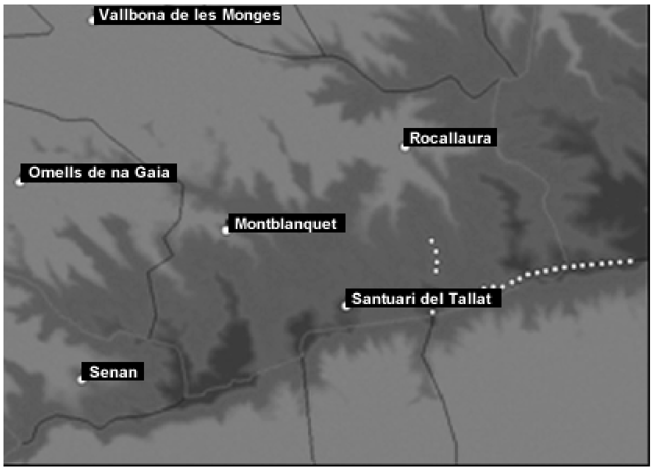
c)
ST: Serra del Tallat project, submitted by Energía Hidroeléctrica de Navarra (EHN).



d)
CBST: Combination of the CB and ST projects



e)
L: Based on CB and ST projects, this alternative considers the windmills located at least 1.5 kilometres from the inhabited centres and potential tourist attractions (Santuari *del Tallat*)



f)
R: This option tries to move the windmills away from the inhabited centres presenting higher resistance to the windfarms (*Senan* and *Montblanquet*). Some windmills have been eliminated, and others have been located in the feasibility zones of Figure .

5.4. Selection of Evaluation Criteria

Table 87 presents the evaluation criteria, which are aimed at representing the general objectives and interests of the identified social actors showed in Table 85. It is worth mentioning that the expected effects of the alternatives are not always foreseeable. There are many uncertainties in this kind of decision making process, for instance the future wind conditions (due to e.g. climate change), tourism trends, or human behaviour.

Table 87. Evaluation criteria

Dimension	***Criteria***	***Needs and expectations***	***Criterion scores***
Socio-economic	Land owners' income	• Additional incomes for the farmers. • To stabilize income • To improve quality of life • There is the worry about who is going to get the benefits, local or external owners.	Overall owner's income per year **Unit**: €/year **Direction**: Maximize
	Distribution of income	• To avoid the concentration of revenues. • To propel local development	Percentage of the local incomes related to the companies profit. **Unit**: % **Direction**: Maximize
	Municipalities' income	• To increase the municipalities' revenues • To offer more social services by the city council • To keep rural population	income of the municipalities considering: • Construction permission taxes. **Unit**: € **Direction**: Maximize • Economic activity taxes **Unit**: €/year **Direction**: Maximize
	Number of jobs	• To attract and to keep people in the region • To reactivate the economic dynamics of the region	Number of permanent jobs in the operation phase **Unit**: Number of jobs **Direction**: Maximize
	Installed capacity	• To promote a larger share of renewable energies in electricity production • To warranty economic viability	Installed capacity **Unit**: MW **Direction**: Maximize
Socio-ecological	Visual impact	• To avoid mountain industrialization • To protect tourism in the long run • To keep rural identity • To avoid land/houses' value to decrease.	Ordinal evaluation based on the overall view-shed of each windfarm **Direction**: Minimize view-shed of the windfarms
	Forest lost	• To minimize ecosystems disturbance/fragmentation • To avoid soil erosion	Total deforested area **Unit**: hectares **Direction**: Minimize
	Noise annoyance	• To protect human health • To minimize effects over fauna's habitat	Ordinal evaluation based on the sound pressure levels of the windfarms **Direction**: Minimize sound pressure levels (measured in dB(A)) in the involved villages.
	Avoided CO2 emissions	• To achieve emissions reduction commitments.	Ordinal evaluation based on the avoided CO_2 emissions of each windfarm **Direction**: Maximize avoided CO_2 emissions

Source: Own elaboration

5.5. Computing Criterion Scores

This section deals with the criterion scoring process and the construction of the impact matrices. This is done at the regional scale.

5.5.1. Land owners' income

All the chosen sites to locate windmills are private, and a common way of dealing with this situation is that the company pays a certain amount of money to the landowner for every windmill installed. This quantity is fixed around 3.000 €/windmill[41] per year. The overall income for the land owners is presented in Table 88.

Table 88. Land owners' income [€/year]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Number of windmills	16	11	33	44	26	24	-
Owners' income	48.000	33.000	99.000	132.000	78.000	72.000	-

Source: Own elaboration

5.5.2. Municipalities income

Here, an attempt to compute the impact on local administration's income due to the construction, installation and operation of windfarms is done.

The local taxation system considers three types of taxes for this situation:

- The Real Property Tax (RPT). It taxes the ownership of a real property where the windfarms are built.
- The Economic Activity Tax (EAT). It taxes the turnover of the operation of the windfarm.
- The Construction, Installation and Building work Tax (CIBT)

a) Real property tax

This is a yearly tax depending on:

- The valuation of both the land and the construction of the facilities. This is done by the General Land Registry Director's Office, and
- The taxation type on the land value, defined by each municipality.

In this case, the affected land is classified as agriculture land. But, after the construction of the windfarms the lands will be classified as goods of special characteristics. This change implies the revaluation of lands according to the following criteria (among others):

- The installed capacity of each wind turbine,
- The valuation date,
- The number of windmills in every windfarm, and
- The presence of other installations and buildings to operate the windfarm.

A higher land value product of this process implies: a) a superior taxable value, and b) a

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higher fee to be paid by the owner/tenant. In other words, it implies higher incomes to the municipalities.

To have an idea, Table 89 shows a resume of the different types of taxes in Catalonia.

Table 89. Different type of taxes in Catalonia

	Minimum share	*General share*	*Maximum share*	*Reduced share*
Urban	0,4%		1,10%	0,1 (6 years)
Rural	0,3%		0,9%	0,075 (6 years)
Special characteristics	0,4%	0,6%	1,3%	Not reduced

Nowadays, the tax shares for goods of special characteristics are 1,4% in Vallbona de les Monges and 1,3% in Els Omells de Na Gaia. However, the municipalities have the possibility of reducing the payment up to 90% of the tax amount.

The landowners are already paying this tax. Then, the additional income for the municipalities comes from the difference in applying taxes to the old and new valuation of land.

Due to the lack of information, especially regarding the difference between the current and the future land values, this tax hasn't been calculated. Anyway, according to declarations of the mayor of Vallbona de les Monges, this additional taxation has been negotiated to be paid by the companies.

b) The Economic Activity Tax

It taxes the turnover of the construction and operation of the windfarm. It is important to be noted that the companies which have a net profit lower than 1.000.000 € can be declared tax free.

For the above-mentioned reason, it is necessary to consider the net profit of the owners of the windfarms. In this case, there are two legal entities:

i. Energía Eólica de Cataluña. Energía Hidroeléctrica de Navarra (EHN) owns 100% of it. At the same time, ACCIONA has a participation of the 50% of EHN, SODENA shares 39.58% and Corporación Caja Navarra shares 10.42%.

ii. Grupo Energético XXI, S.A. shared by the business groups GAMESA and ROS ROCA.

Therefore, the economic balances of these companies have to be analysed to know whether they should or shouldn't pay this tax.

To obtain the total amount of the municipalities' income it applies the following relationship:

Minimum Fee = Installed capacity * 0,721215 €/KW (1)

Finally, the results have to be weighted according to the coefficients defined in the article 86 of the Local Treasury Law, which goes between 1.29 and 1.31. These results are presented in Table 90.

Table 90. Municipalities' income. Economic Activity Tax [€/year]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Installed capacity [MW]	13,6	16,5	49,5	66	39	36	-
Municipalities' income [€/year]	12.750	15.470	46.410	61.880	36.570	33.750	-

c) Construction, Installation and Building work Tax

According to the article 100 of the Local Treasury Law, the realization of any construction or installation needs a building work license. This tax is based on the real and effective cost of the construction, i.e. the material cost of the building work done.

This tax is defined by every municipality and it must not be higher than 4% (article 102.3 of the Local Treasury Law). The involved municipalities have established the following values:

- Omells de na Gaia: 1,5%
- Vallbona de les Monges: 2%
- Senan: 2%

The taxable base for this revenue is presented in Table 91. The calculation relies upon the information contained in the environmental impact assessments of the Coma Bertran and Serra del Tallat projects[42]:

Table 91. Municipalities' income. Construction tax [Thousands of €]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Construction costs	~3.360	~2.990	~4.360	~7.350	~3.380	~2.950	-
Municipalities' income	~67,2	~59,8	~87,2	~108,0	~67,6	~59,0	-

To obtain the aggregated annual income of the municipalities, construction taxes should be expressed as a yearly income. In order to do so, a life expectancy of 20 years is given to the projects and a discount rate of 5% (the interest rate of the European monetary policy during the second semester of 2007) is considered. Then, potential incomes for the municipalities are presented in Table 92.

Table 92. Potential incomes for the municipalities [€/year]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Economic activity tax	~12.750	~15.470	~46.410	~61.880	~36.570	~33.750	-
Construction tax	~5.390	~4.800	~7.000	~8.670	~5.420	~4.730	-
Municipalities' income	**~18.140**	**~20.270**	**~53.410**	**~70.550**	**~41.990**	**~38.480**	**-**

5.5.3. Distribution of incomes

Due to the fact that we are doing a social evaluation, the income distribution is calculated

42 It is well accepted that the cost of one installed Kilowatt is around 1.000 €. In these projects, the cost of one installed Kilowatt varies between 850 and 1000 €.

as the income of the local administration (i.e. public income) as a percentage of the companies' profit. However, it should be noted that the analysis must consider the income of the landlords and the number of landowners, but this is not possible due to the lack of information about the ownership of the land in which the windmills are planned.

First of all, there is a need to estimate the financial flow of each project. The time period considered is 20 years (the life of the windmills and the depreciation period). In Catalonia, the current price of the electricity produced from renewable sources is around 0,067 €/KWh, and it is estimated that it will grow at the rate of 2% a year.

The investment costs are presented in Table 94. They have been calculated based on the construction costs (see Table 91) and the price of the windmills (see Table 93):

Table 93. Windmills prices

Windmill	*Price*
850 KW	640.000 €
1,5 MW (Gerrsa)	1.129.500 €
1,5 MW (EHN)	1.150.000 €

Sources: EHN (2003); Entorn (2001); SATEL (2002).

Table 94. Investment costs [€]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Investment costs	13.590.000	15.324.500	42.300.000	57.624.500	35.800.000	30.550.000	0

The maintenance and operational (M&O) costs are 0,0052 €/ KW h for the two first years and 0,0078 €/ KW h for the remaining 18 years (EHN, 2003; Entorn, 2001; SATEL, 2002). And finally, it has been considered a discount rate of 5% (the interest rate of the European monetary policy during the second semester of 2007). With these figures we obtain the profit of the companies so as to compare them with the social incomes. Appendix B presents the calculations of the financial flows of each alternative.

Table 95 shows the distribution of incomes. This has been calculated considering the Net Present Value of the yearly incomes of companies and of the local authorities.

Table 95. Distribution of the income

		Project					
		CB Pre	*CB*	*ST*	*CBST*	*L*	*R*
Companies profit	M€/year	540	960	2.860	3.820	2.240	2.090
Local authorities income	M€/year	18,1	20,3	53,4	70,6	42,0	38,5
	Participation	3,4%	2,1%	1,9%	1,8%	1,9%	1,8%

As it can be seen in Table 95, the performances of the alternatives present no major differences between them. Only alternative CBPre is better in distribution terms, because windmills of lower capacity require higher investment by installed kilowatt.

It is worth noting that this criterion would be even more relevant if one of the former twelve alternatives (i.e. to set up a local cooperative to manage a windfarm) would not have been disregarded.

But there are some reasons to disregard this criterion from the multi-criteria evaluation, which does not mean to disregard it from the analysis. First, the definition of the preference and indifference thresholds would not be an easy task due to the difficulties in defining these values for this sort of rates. For instance, it is much more easy for the local administration to define the preference threshold for its revenues expressed in absolute terms.

Second, it is rather possible that we do double accounting by creating a criterion that includes another criterion already considered (i.e. the income of the local administration).

For these reasons, this criterion has not been considered in the further multi-criteria evaluation.

5.5.4. Number of permanent jobs

The calculation of this criterion score is made considering that in average, for 9 windmills one permanent job is created[43]. The criterion scores of each alternative are presented in Table 96.

Table 96. Number of permanent jobs

	CB Pre	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
Number of windmills	16	11	33	44	26	24	-
Number of jobs	2	1	4	5	3	3	-

5.5.5. Installed capacity

This criterion evaluates the will of maximizing the installed capacity of renewable energy sources, expressed by the Catalonian government and some ecologist groups in the region. By means of comparing the installed capacity instead of the projected electricity production, this criterion tries to consider the uncertainty related to possible changes in wind conditions. It is basically the amount of windmills multiplied by their nominal capacity. Table 97 shows the installed capacity of the different alternatives.

Table 97. Installed capacity

	CB Pre	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
Installed capacity [MW]	13,6	16,5	49,5	66	39	36	-

5.5.6. Visual Impact

One of the main arguments to oppose the construction of the windfarms is their visual impact.

There are several techniques aiming at evaluating the visual impact of a project. Most of them follow at least two steps:

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i. Assessment of the visual quality of the landscape where the project is planned, and

ii. Evaluation of the visual impact of the project.

There are expert/design approaches—such as Descriptive inventories[44]—and perception/experience approaches—such as Public preference models[45]—in order to carry out the former task. Most of these methodologies consider the biophysical features of the environment and the human perception as two "essential interacting components" of the landscape quality (Daniel, 2001).

There are theoretical and practical problems in evaluating landscape beauty. On the one hand, descriptive models assume that beauty is embedded in the landscape components, excluding the fact that landscape beauty also depends on the observer. On the other hand, in public preference models the evaluation is affected by socio-cultural factors, as well as the personality of the observer, its location, and many other factors. So, methodologies aimed at considering the interdependence of both sides of the landscape-observer interaction—such as Quantitative holistic methods—are needed. (For an overview of these methodologies see: Arthur et al., 1977; or The Macaulay Land Use Research Institute, 2005).

The evaluation of the visual impact of the projected infrastructure is the following task. The determination of zones of visual influence—using, for instance, viewshed mapping—and viewpoint analysis—using, for instance, photomontages—are the most common techniques to carry out this step. The former is aimed at both determining and characterizing the area within which the planned development can be seen, and the last is aimed at simulate the view of the planned development from some key viewpoints (More information about different techniques can be found in The Macaulay Land Use Research Institute (2005); for viewshed mapping see Möller, 2005; and for landscape simulation see Oh, 1994).

Additional factors to consider in the evaluation of the visual impact of any development are the combination of landscape characters, the landscape sensitivity and the landscape's capacity to absorb change (MOPT, 1992). It is worthy mentioning that the visual impact is not only how the windmills look like. Both light reflection from the rotating blades or shadows formation could be negative effects of windfarms. These factors are very difficult to incorporate in the evaluation, and yet the public is not aware of the problem. Anyway, shadow effect is not perceived from distances above 1 kilometre (Danish Wind Industry Association).

Although we are aware of the importance of assessing the scenic quality (task i), and the additional factors to be considered in the evaluation of the visual impact (task ii), these steps haven't been performed due to the scarcity of human and time resources. So, in this study the visual impact of the planned windfarms is evaluated by means of viewshed mapping[46], an accessible methodology for the research team.

Table 98 shows the cumulative viewshed of the windmills of each projected windfarm. It is important to note that the distance to assess the visual impact would influence the results of the evaluation. Unfortunately there are divergent recommendations in this respect and we have decided to use 10 kilometres as an intermediate distance.

44 Descriptive inventories consist in identifying the features of the components of the landscape (lines, colours and textures), and to classify the scenic quality relying upon the combination of the parts.

45 Public preference models rate the visual quality of the landscape based on the observers' individual preferences of the whole landscape. They use, for instance, questionnaires or verbal surveys to collect peoples' perceptions.

46 This is a map showing the area within which the wind-turbines are likely to be visible.
The software Miramon v.5.β.13 has been chosen to do this task. This GIS software has been developed by Xavier Pons at the Autonomous University of Barcelona.

Table 98. Regional visual impact

	CB Pre	CB	ST	CBST	L	R	NP
View-shed [Km^2]	76.570	71.465	276.550	348.015	220.400	163.290	-
Ordinal evaluation of visual impact	3rd	2nd	6th	7th	5th	4th	1st

There are also evaluations related to the amount of inhabitants surrounding the installations (in relative terms). In this case it is considered in absolute terms due to the variability of the frequentation expected in these territories (due to tourism development).

5.5.7. Forest lost

This criterion aims at reflecting two aspects coming from the social actor perceptions. First, the biodiversity lost and the territorial fragmentation produced by the construction of infrastructure. For instance, the installation of power lines, road construction, ground movement and the spread of the spare material generated by the construction itself. Second, deforestation produces both a CO_2 absorption capacity loosing and the probable release of the already stored carbon.

To tackle these issues, it has been decided to measure the deforested area which is produced by new and adapted roads. The effect of the high voltage power lines to the transport and distribution grid has been considered equal for all the alternatives because there is no information in this respect. To have an idea, a high voltage power line of 10 kilometres length to reach the grid will be needed.

The total deforested area due to new roads is the total length multiplied by their wide (6 meters). For the enlarged roads, the total area comes from the total length multiplied by the expanded area (2 meters). The forest lost produced by each alternative is presented in Table 99.

Table 99. Deforestation

	CB Pre	CB	ST	CBST	L	R	NP
New roads [Km]	14	13,5	9	22,5	6,5	4,3	-
Modified roads [Km]	-	-	6	6	-	-	-
Forests lost [ha]	8,4	8,1	6,6	14,7	3,9	2,6	-

Source: Own elaboration

5.5.8. Avoided CO_2 emissions

It is commonly accepted that wind energy helps to reduce the emission of greenhouse gases (GHG), like CO_2. However, there are some that challenge this arguments: the deforested areas to construct infrastructure and the operation of combined cycle power plant at lower efficiencies when windfarms are producing electricity are two arguments in this direction.

On one hand, deforestation produces both a CO_2 absorption capacity loss and the possible release of the stored carbon[47]. This effect is partially evaluated by the previous criterion (Forest lost). On the other hand, the production of electricity in Catalonia relies mainly upon

47 The emissions due to deforestation do not reach 1% of the avoided CO_2 emissions showed in Table 100 for each alternative. To calculate the CO_2 emissions it is considered that world temperate forests storage 56,7 t C/ha (IPCC, 2000). It is also assumed that every hectare of temperate forest absorbs about 6 t C/ha/year.

nuclear energy (with no GHG emissions at least in the generation phase), which covers the second worry (in the meantime).

It is also important to shed light on the fact that these installation will not replace electricity produced from current Catalonian sources, instead it will complement the current electricity generation. On the other hand, these windfarms are very small compared with the installed power capacity of Catalonia. Therefore, we can calculate the avoided CO_2 emissions as if the electricity produced from these windfarms replaces electricity produced from the Catalonian energy vector (see Table 116). For more information on the calculations, see Appendix B.

Table 100. Avoided CO2 emissions

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Projected electricity generation [MW h/year]	32.708	42.026	138.071	180.096	103.100	96.207	0
Avoided CO2 emissions [ton CO2/year]]	4.680	6.010	19.740	25.750	14.740	13.760	0
Ordinal evaluation of the avoided CO_2 emissions	6th	5th	2nd	1st	3rd	4th	7th

Source: Own elaboration

5.5.9. Noise annoyance

Noise can be described as unwanted sound. The audible frequency[48] range goes from 20 to 20.000 Hz. Our hearing system is not equally sensitive to all sound frequencies. Then, it is used the A-weighting system[49], which approximates the frequency response of our hearing system.

On the other hand, sound pressure is a basic measure of the vibrations of air that make up sound. These levels are measured in a logarithmic scale which uses decibels as units of measurement (dB(A) means decibels in the A-weighting system).

It can be said that, acoustic discomfort areas are those having sound pressure between 55 and 65 dB(A). Sound pressure levels below 45 dB(A) are not perceived as annoying. But 30 dB(A), for a continuous background noise, could be disturbing to sleep, and individual noise events exceeding 45 dB(A) should be avoided (Nardo, 2004).

Considering the social process in which these evaluations are done, the communication of these results should be done regarding the wide range of people involved. For example, the outcomes of the noise assessment were communicated by means of comparing the potential noise impact of the windfarms with the sound pressure level of common sounds (for instance, the rumour of the leaves of trees: 20 dB(A); residential zones: 40 dB(A); and so on).

Noise coming from the windmills operation can be classified according to its two mains sources: aerodynamic and mechanic. The former is produced when the rotor blades interact with the eddies caused by atmospheric turbulence. Mechanical noise comes from the rotor machinery operation (gearbox and generator).

In Catalonia, there are no official recommendations about the minimum distance between

48 Audible frequency is the number of vibrations per second of the air in which the sound is propagating, and it is measured in Hertz (Hz).

49 The A-weighting system weights lower frequencies as less important than mid- and higher-frequencies.

windmills and residential areas. Some authors suggest 300 meters and others, like EHN, proposes at least 1 kilometre[50]. In Catalonia, the noise emissions produced by the activities and the neighbourhoods are limited according to the levels indicated in Table 101:

Table 101. Noise sensitive zones and noise limits [dB]

	Noise limits	
Sensitivity zone	***Day***	***Night***
High (A)	60	50
Medium (B)	65	55
Low (C)	70	60

(A) Zone of High acoustic sensitivity: Zones of the territory needing high protection against noise.
(B) Zone of Medium acoustic sensitivity: Zones of the territory admitting medium perception of noise.
(C) Zone of Low acoustic sensitivity: Zones of the territory admitting high perception of noise.
Source: Catalonian government.

Table 102 shows the possible noise that could be perceived in the closest towns to the windfarms. This has been calculated based on Danish Ministry of the Environment (1991)

Table 102. Noise. Potential sound pressure level in the involved villages [dB(A)]

	CB Pre	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
Vallbona de les Monges	-	-	-	-	-	-	-
Montblanquet	39,9	39,6	26,6	39,6	30,1	13,3	-
Rocallaura	13,1	13,5	18,7	18,7	17,7	26,2	-
Els Omells de Na Gaia	22,0	22,1	6,2	22,1	9,7	0,0	-
Senan	38,6	38,9	21,7	38,9	22,6	0,0	-

Source: Own elaboration

In order to obtain a general evaluation of alternatives under this criterion, we do a multi-criteria evaluation in which the different criteria are the sound pressure level in each village.

The result (ranking) of this multi-criteria evaluation is presented in Table 103. This ranking is obtained by means of applying NAIADE model and considering the following preference thresholds:

- Much Better:15 dB(A)

- Better: 10 dB(A)

- Almost equal: 2 dB(A)

- Equal: 1 dB(A)

The ranking of alternatives is stable when changing the degree of compensation between criteria.

Table 103. Noise annoyance

50 Personal communication from EHN

	CB Pre	CB	ST	CBST	L	R	NP
Noise annoyance	5th	6th	3rd	6th	4th	2nd	1st

Source: Own elaboration

5.6. Application of a Mathematical Aggregation Convention

5.6.1. Ranking Alternatives

Table 104 presents the multi-criteria impact matrix of the problem we are dealing with. In order to obtain a final ranking of the available alternatives, the criterion scores must be aggregated by means of a mathematical algorithm. Many Multi-criteria models have been formulated since the Sixties, each one with advantages and disadvantages (see e.g., Arrow and Raynaud, 1986; Munda, 1995, Roy, 1996). Desirable properties for multi-criteria ranking procedure in the framework of public policy and sustainability issues are discussed in Janssen and Munda (1999) and Munda (2005a). In short, it is very important that such ranking methods are simple to guarantee consistency and transparency, non-compensatory to avoid that bad environmental or social consequences are systematically outperformed by good economic consequences or vice-versa, intensity of preference is not taken into account thus avoiding compensability and allowing for weights being importance coefficients and not trade-off. A simple ranking algorithm, respecting all these properties, is the Condorcet consistent rule presented in Munda (2005a) (see Young and Levenglick (1978) for its social choice characterization and Munda (2005b) for its implementation in a multi-criterion framework). For a brief explanation of the method, see Appendix B.

The algorithm uses this available information to rank in a complete pre-order (i.e. without any incomparability relation[51]) all the alternatives from the best to the worst one.

The mathematical aggregation convention can be divided into two main steps:

- Pair-wise comparison of alternatives according to the whole set of criteria used, and construction of the outranking matrix
- Ranking of alternatives in a complete pre-order.

The maximum likelihood ranking of alternatives is the ranking supported by the maximum number of criteria for each pair-wise comparison, summed over all pairs of alternatives considered.

Here, we obtain the most likelihood rankings by means of applying the model to the impact matrix (Table 104) and considering the preference thresholds presented in Table 105.

51 The relation between each pair of alternatives must be either of preference or indifference.

Table 104. Multi-criteria Impact Matrix

Criteria	*Units*	*Dir*	*CB Pre*	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Owners' income	€/year	▲	48.000	33.000	99.000	132.000	78.000	72.000	0
Municipalities' income	€/year	▲	~18.140	~20.270	~53.410	~70.550	~41.990	~38.480	-
Number of jobs	jobs	▲	2	1	4	5	3	3	0
Installed capacity	MW	▲	13,6	16,5	49,5	66	39	36	0
Visual Impact	Ordinal		3rd	2nd	6th	7th	5th	4th	1st
Forest lost	ha	▼	8,4	8,1	6,6	14,7	3,9	2,6	0
Avoided CO_2 emissions	Ordinal		6th	5th	2nd	1st	3rd	4th	7th
Noise	Ordinal		5th	6th	3rd	6th	4th	2nd	1st

Table 105. Preference thresholds

Criteria	*Units*	*Indifference threshold*
Owners' income	€/year	3.000
Municipalities' income	€/year	10.000
Number of jobs	jobs	1
Forest lost	ha	1
Installed capacity	MW	1

First, we obtain the outranking matrix presented in Table 106. This outranking considers equal weights to the socio-economic and socio-ecological dimensions indicated in Table 87, and splitting these values according to the number of criteria pertaining to each dimension. In this case, all criteria have a weight of 0,125.

Table 106. Outranking matrix

	CB pre	**CB**	**ST**	**CBST**	**L**	**R**	**NP**
CB Pre	0,00	0,50	0,13	0,38	0,13	0,13	0,63
CB	0,50	0,00	0,13	0,31	0,13	0,13	0,63
ST	0,88	0,88	0,00	0,38	0,75	0,63	0,63
CBST	0,63	0,69	0,63	0,00	0,63	0,63	0,63
L	0,88	0,88	0,25	0,38	0,00	0,50	0,63
R	0,88	0,88	0,38	0,38	0,50	0,00	0,63
NP	0,38	0,38	0,38	0,38	0,38	0,38	0,00

By applying the ranking procedure, among the 5040 possible rankings, the following four present the maximum score (see Table 107) (where the extreme left alternatives are the top ones and the extreme right alternatives are the bottom ones).

Table 107. Rankings

	Ranking position						
	First	***Second***	***Third***	***Fourth***	***Fifth***	***Sixth***	***Seventh***
Ranking 1	CBST	ST	L	R	CB	CB Pre	NP
Ranking 2	CBST	ST	L	R	CB Pre	CB	NP
Ranking 3	CBST	ST	R	L	CB	CB Pre	NP
Ranking 4	CBST	ST	R	L	CB Pre	CB	NP

It s worth-noting that the results (rankings) are stable when a sensitivity analysis on the weights of the criteria is carried out (See Appendix B).

5.7. Highlighting Distributional Conflicts

The first step is the construction of the *Social Impact Matrix*, that is, the evaluation every social actor gives to each option (see Table 108). The qualitative impact scores have been determined by the scientific group based on the information obtained in the whole process. The justification for each evaluation is derived from Table 85. Political representatives and GEPEC haven't been considered in this exercise due to their indirect involvement in the conflict.

Table 108. Social Impact Matrix

	Social groups	***CB Pre***	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
G1	Catalonia government	More or less good	More or less Bad	Very good	Perfect	Good	Good	Extremely bad
G2	Municipality of Vallbona de les Monges	More or less good	More or less bad	Very good	Perfect	Good	Good	Extremely bad
G3	Municipality of els Omells de na Gaia	Very good	Good	Bad	Good	Bad	Bad	Bad
G4	Municipality of Rocallaura	More or less good	More or less bad	Very good	Perfect	Good	Good	Extremely bad
G5	Municipality of Senan	Very bad	Very bad	Very bad	Extremely bad	More or less bad	Moderate	Perfect
G6	Coordinating committee to defend the land	Very bad	Very bad	Extremely bad	Very bad	Very bad	Bad	Perfect
G7	Platform for Senan	Very bad	Very bad	Extremely bad	Extremely bad	More or less bad	Moderate	Perfect
G8	Association of friends and neighbours of Montblanquet	Extremely bad	Extremely bad	Very bad	Extremely bad	Very bad	More or less bad	Perfect
G9	EHN	Extremely bad	Extremely bad	Perfect	Perfect	More or less good	Moderate	Extremely bad
G10	Gerrsa	Very Good	Perfect	Extremely bad	Perfect	Extremely bad	Extremely bad	Extremely bad

Note: The concepts used for the social evaluation is based on the nine categories managed by NAIADE (Munda, 1995): Perfect, Very Good, Good, More or Less Good, Moderate, More or Less Bad, Bad, Very Bad and Extremely Bad.

Starting from this social impact matrix, distributional issues can be taken into consideration by means of an eclectic approach using concepts coming from land use planning, fuzzy cluster analysis and social choice (Munda, 1995 and 2007). In synthesis, *A* is a finite set of *N* feasible policy options; *B* is the set of different social actors, $B=\{b_p\}$ $p=1, 2, \ldots, P$ considered relevant in a policy problem, $\Lambda=\{\lambda_p\}$, $p=1,2,\ldots,P$, with $\sum_{p=1}^{P} \lambda_p = 1$ is the vector of weights attached to the set of the P social actors, indicating their relative importance. By using a distance function d_{ij} as conflict indicator, a similarity matrix (achieved by means of the simple transformation) $S_{ij} = 1/(1 + d_{ij})$ for all possible pairs of groups can be obtained, so that a clustering procedure is meaningful. The hierarchical clustering approach, in particular, allows an evolutionary view of the aggregation process and can easily be dealt within fuzzy terms. By applying this procedure to the social impact matrix presented in Table 108 (by using the assumption of equal weighting for the various social actors), the dendrogram presented in Figure 19 is obtained.

The codes defined in the first column of Table 108 represent the social actors in the first line of Figure 19. On the left, the degree of credibility that one coalition to occur is indicated. For example, coalition C1=(G5, G6, G7 and G8) has a high degree of credibility that it would occur (≈0,72). Coalition C2=(G2 and G4) has also got a high possibility of occurrence (≈0,8).

In this way:

- The proximity of aims between the Municipality of Senan (G5) and the Platform per Senan (G7) are reflected in the dendrogram. Also the Municipalities of Vallbona de les Monges (G2) and Rocallaura (G4) are working together in looking for their benefits.
- The Ass. of friends and neighbours of Montblanquet (G8) joints to the first mentioned coalition (G5 + G7) with a medium-high degree of credibility. They meet with others actors in the Coordinating committee to defend the land (G6). Most of them working in independently.
- On other side, EHN (G9) has been negotiating with the municipalities and with the Catalonian government in order to push their project forward. This coalition (G2+G4+G1+G9) has a medium degree of credibility.
- A coalition between the municipality of Els Omells de Na Gaia (G3) and Gerrsa (G10) shares a medium degree of proximity with the previous coalition. Nowadays this coalition depends more or less in the amount of money that can be received from Gerrsa as benefit tax revenue.

In real-world applications, when the actors involved in a policy process look at dendrograms generally have a question like: *and so what?* Clearly further elaborations are then needed. In particular, information on rankings of policy options according to each coalition of social actors seems very desirable. This can easily been done by applying again the ranking procedure already used on the multi-criteria impact matrix. The coalitions obtained with the degree of credibility 0.7194 (thus a very high one) are considered.

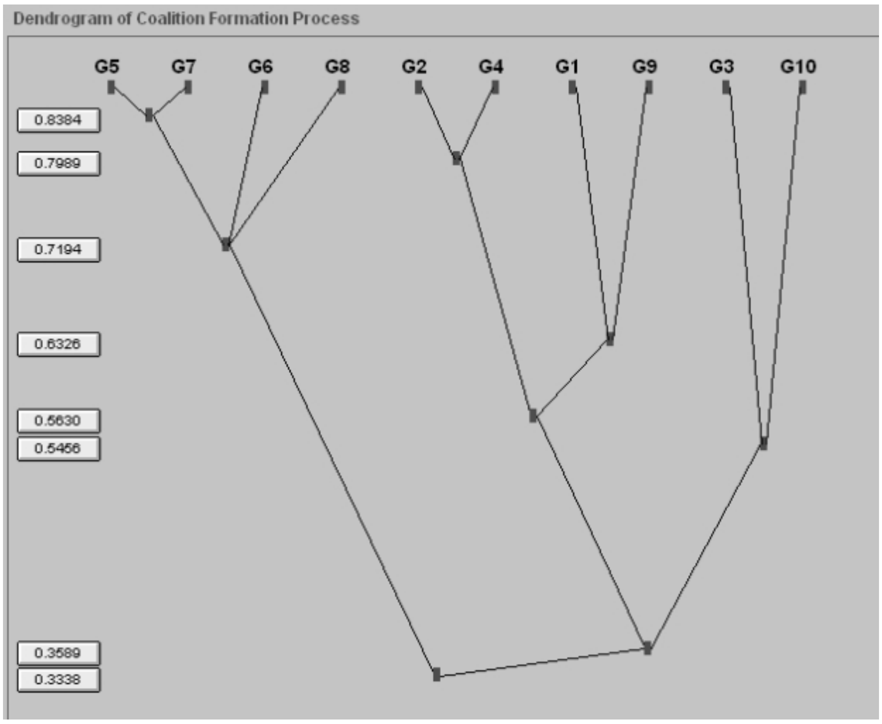

Figure 19. Coalition dendrogram.

The coalition C1, with Municipality of Senan (G5), Platform per Senan (G7), Ass. of friends and neighbours of Montblanquet (G8) and Coordinating committee to defend the land (G6) present the following rankings as the maximum likelihood ones (see Table 109):

Table 109: Most possible rankings for coalitions and social actors

	Ranking position						
Coalitions/actors	***1st***	***2nd***	***3rd***	***4th***	***5th***	***6th***	***7th***
C1 Municipality of Senan; Coordinating committee; Platform for Senan; Association of friends and neighbours.	NP	R	L	CB Pre	CB	ST	CBST
	NP	R	L	CB	CB Pre	ST	CBST
	NP	R	L	CB Pre	CB	CBST	ST
	NP	R	L	CB Pre	ST	CB	CBST
C2 Municipality of Vallbona de les Monges and Municipality of Rocallaura	CBST	ST	L	R	CB Pre	CB	NP
	CBST	ST	R	L	CB Pre	CB	NP
	ST	CBST	L	R	CB Pre	CB	NP
	ST	CBST	R	L	CB Pre	CB	NP
	CBST	ST	L	CB Pre	R	CB	NP
	CBST	ST	L	R	CB Pre	NP	CB
	CBST	ST	L	R	CB	CB Pre	NP
	CBST	ST	R	CB Pre	L	CB	NP
	CBST	ST	R	L	CB Pre	NP	CB
	CBST	ST	R	L	CB	CB Pre	NP
	CBST	L	ST	R	CB Pre	CB	NP
	CBST	R	ST	L	CB Pre	CB	NP
G1 Catalonian Government	CBST	ST	L R	CB Pre	CB	NP	
G3 Municipality of Els Omells de na Gaia	CB Pre	CB CBST	ST L R NP				
G9 EHN (promoter)	ST CBST	L	R	CB CB Pre NP			
G10 Gerrsa (promoter)	CB CBST	CB Pre	ST L R NP				

Note; Rankings of coalitions C1 and C2 are calculated based on the evaluation of their members. The rankings of the rest of the groups are based on the information contained in Table 108.

While for the coalition C2, with Municipalities of Vallbona (G2) and Rocallaura (G4) the following rankings receive the maximum score (see Table 109):

Moreover by looking at Table 108 (and therefore Table 109), it is clear that for the Catalonian Government, the alternative CBST is the best one. Anyway all the other alternatives are also more o less OK, except for NP that is considered as extremely bad. For the Municipality of Els Omells, the only acceptable alternatives are CB Pre, CB and CBST, all the others are considered bad. For EHN, alternatives ST and CBST are good options. L and R are more or less acceptable but NP is considered as extremely bad. For Gerrsa, alternatives

CB Pre, CB and CBST are at least very good options, all the other possibilities are considered as extremely bad.

Concluding, we can say that technically speaking, the most defensible alternatives are CBST, ST and L. From a social conflict analysis point of view, it seems that alternative CBST is the one which can generate the maximum conflict. Even if CBST is OK for the majority of the social actors involved, coalition C1 always ranks it in low positions. R has good evaluations, except by GERRSA which would be excluded in this case. L always ranked in medium positions by all social actors. It might also be a social compromise. NP is not acceptable for most of social actors. In synthesis, we may state that alternatives L and R seem the only ones defensible from both technical and social points of view. All the other options can maximize the social conflict or are not technically acceptable. It is interesting to note that business as usual is definitely not a desirable situation.

It is important to highlight that we are not maintaining that a policy-maker should not be free to take decisions different from the ones considered desirable in this study. What we want to emphasize here is that, if different decisions are made, this fact should be *transparent* and *responsibility* of doing so clearly assumed (e.g. to attach an enormous weight to a peculiar social actor…). Not necessarily a public policy-maker is always benevolent in nature; this is the reason why it is important to enlighten distributional issues and corresponding ethical (or unethical) positions. This call for transparency in modern public economics is widely shared by various contemporary authors (see e.g., Stiglitz, 2002).

5.8. Discussion

This sections analyse whether SMCE meets the requirements of a decision-making processes within the field of renewable energies: to be able either to integrate objectives expressed at local and global levels and to manage social conflict. Furthermore, SMCE should fulfil the expected advantages of public involvement in public policy processes (improvement of democracy, appraisal of complexity, legitimacy of decisions and social learning).

Regarding the results of the presented experience, SMCE fulfils the required features of a decision-making process in the field of wind energy implementation. First, it allows the consideration of objectives expressed by actors at different levels as well as including them into the evaluation process. The problem structuring is based upon several perspectives, including unrepresented or sub-represented minorities.

If the technical and social evaluations are the basis to make the decision, then it would imply a democratization of decision-making processes. The involved social actors can influence the process and its outcome since their concerns are taken into consideration in the problem structuring. In this way, decisions do not rely exclusively upon the criteria of the most powerful[52]. Power relations are balanced and democracy is improved.

Second, the combination of different (qualitative) social research methodologies are very useful in order to understand (complex) socio-political dynamics, which can also be sources of conflicts. In the case presented, conflict around the planned windfarms were in part rooted in previous political disputes, as well as issues related with the decision-making process regarding the planned windfarms and with the possibilities of the people to influence the development path of the region. Wind energy as such was not a main conflicting topic in this case; the effects of this technology were part of the conflict but not the central source of disagreement.

52 Recall the question raised by Martinez-Alier (2005): “Who has the power to reduce complexity by imposing a valuation language?” for instance, a monetary measurement rod.

Multi-criteria evaluation is a framework that allows the appraisal and assessment of the complex effects of wind energy installations, but also it can present this complexity in a more transparent fashion than methodologies reducing the impacts to a single unit of measurement.

Third, multi-criteria evaluation can also function as a communication tool to promote social learning. People can see the multi-dimensional character of a wind energy plan as well as the presence of several objectives in society reflected by the evaluation criteria. So, the impact on different social actors can be highlighted (who are the beneficiaries and who are the affected), as well as to raise concern about global problems among participants.

The discussion around potential noise annoyance produced by the wind turbines is a clear example of a social learning process. At the beginning, noise annoyance was one of the reasons used to oppose the planned installations. But all alternatives present good criterion scores under this attribute, thus this criterion can be consigned as irrelevant in the context of the evaluation. Therefore, counter-productive conflict around the issue can be avoided.

In this sense, it is important to shed light on the fact that within the SMCE framework research is guided by social needs and not exclusively guided by the research team criteria. In this way, research becomes socially relevant.

Fourth, SMCE would increase legitimacy of decisions. Social actors can be included in the different steps of the process. For instance, some people opposing the planned windfarms asked for a deeper involvement in the alternatives creation process. Since the final decision would be a consensus/compromise one, this would lead to a higher degree of acceptance of the outcomes of the process.

The combination of public involvement and multi-criteria evaluation under the framework of SMCE would foster transparency in environmental decision-making, therefore promoting the *accountability* of these processes and of the decision-makers.

On the side of wind energy planning, even if the promoters of wind energy argue that this technology could foster local development, there is some evidence contradicting this argument. So, policies aimed at boosting renewables should consider mechanisms targeting local agents, such as support to create cooperatives and/or the use of financial instruments oriented to medium and small investors in order to boost local ownership (see Meyer, 2003). Pre-investment economic instruments, such as subsidies, could be a good option in this regard.

Wind energy is characterized by its extensive land use, which is another source of conflict due to territorial inequalities. For instance, wind turbines could be seen from sites located in municipalities without any benefit from their installation. At regional and local scale, the vision goes beyond territorial administrative borders, and cooperation between neighbouring municipalities, social groups and/or local governments is needed in order to avoid the image of windfarms as *undesired gift from the neighbouring municipality*.

The analysis of alternatives is an essential part of any environmental impact assessment process (Gamboa, 2006). Therefore, the evaluation of both alternative locations and alternative projects is necessary. Then, some degree of flexibility within the investors' plans is needed, because the submitted project could be implemented in a different form than the original design (Upham and Shackley, 2005).

SMCE is presented as a way to avoid the pitfalls of technocratic and top-down procedures (Gamboa and Munda, 2007), which are frequently perceived by local actors as imposed and highly influenced by corporative elites. But SMCE could also avoid the monopoly of local administrations in territorial and energy planning, which may hinder the development of renewables (Khan, 2003).

In this context, participation could be the base for a bottom-up decision-making process. It would be practised in order to define the thresholds of local impacts and/or the acceptable trade-off between the objectives of the government, the investors and the local community. But at the same time, global problems can set the limits of the decision space (set of alternatives).

Then, we can avoid loosing the opportunities offered by wind energy technology and promoting the potentials of this sort of RES, such as the possibilities of local energy autonomy or clean energy deployment. We are facing problems that need urgent action, but we also live in an uncertain world with the presence of legitimate and contradictory values and objectives. So the improvement of decision-making processes is an essential requisite to reach a more sustainable evolution path.

5.9. Conclusion

This chapter has presented the evaluation of wind park locations that deals with a plurality of legitimate values and interests existing in society. The evaluation takes into account a wide range of assessment criteria (e.g. environmental impact, distributional equity, and so on) and not simply profit maximization, as a private economic agent would do.

In operational terms, the application of a social multi-criteria framework in this case study has involved the following main steps:

1. *Isolation of relevant social actors*, by means of institutional analysis, individual interviews with key agents, focus groups and open meetings. Ten social actors were identified: local and regional social movements, local and national authorities and private companies.
2. *Definition of social actors' values, desires and preferences*, mainly through in-depth interviews and focus groups.
3. *Generation of policy options and evaluation criteria*. Seven alternatives and eight criteria are the result of a dialogue between the scientists and the social actors. Criteria are indicators that assess to which extent the different social actors' objectives are achieved by each alternative.
4. *Construction of the multi-criteria impact matrix*. It synthesizes in a matrix form, the scores of all criteria for all alternatives. Each criterion score represents the performance of each alternative according to each criterion.
5. *Construction of the equity impact matrix*. This allows representing the distance between the positions of the social actors, by using a linguistic evaluation of the alternatives that expresses the point of view of each group. By means of a dendrogram, it shows the degree of conflict and the possible coalitions among the groups of social actors on each possible alternative.
6. *Application of a mathematical aggregation procedure*. Many Multi-criteria models have been formulated since the Sixties, each one with advantages and disadvantages. In each case the most appropriate must be chosen, weighting the pros and cons of each model. In this case, the Condorcet consistent rule presented in Munda (2005a) is used in order to obtain a maximum likelihood rankings of available alternatives. The algorithm is simple, uses ordinal information and weights have the meaning of

importance coefficients, hence no compensation is allowed.

7. *Sensitivity and robustness analysis*. This step is very important due to unavoidable degree of uncertainty that characterizes most real-world decision-making processes. In this case, the results (rankings) are very stable when the weights of the different dimensions change.

Of course, these steps are not rigid. On the contrary, flexibility and adaptability to real-world situations are among the main advantages of social multi-criteria evaluation.

Finally, the chapter has discussed the adequacy of SMCE as a decision-making process within the field of renewable energy planning and implementation.

Table 110. Summary of feedbacks between the research team and local social actors

Activity	***Place and Date***	***Participants***
Preliminary meeting	Municipality of Vallbona de les Monges 19/12/2003	2 Mayors
Open presentation of the project	Municipality of Vallbona de les Monges 09/01/2004	~30
Open presentation of the project	Municipality of Rocallaura 10/01/2004	~40
Focus group	Municipality of Vallbona de les Monges 16/01/2004	5
Preliminary meeting	Municipality of Els Omells de Na Gaia 16/01/2004	Mayor and 2 councillors
Open presentation of the project	Bar of the town of Els Omells de Na Gaia 17/01/2004	~30
Focus group	Municipality of Els Omells de Na Gaia 24/01/2004	5
Open presentation of the project	Municipality of Senan 14/02/2004	~25
Open presentation of the project	Central office of Montblanquet 27/03/2004	~15
Presentation of the preliminary results	Municipality of Vallbona de les Monges (and Rocallaura) 12/06/2004	2 Mayors and 4 councillors
Presentation of the preliminary results	Municipality of Els Omells de Na Gaia 25/06/2004	1 Mayors and 2 councillors
Open presentation of results	Bar of the town of Els Omells de Na Gaia 10/07/2004	~20
Open presentation of results	Vallbona de les Monges Municipality 01/08/2004	~25

Appendix B. Calculations of criterion scores and the multi-criteria model

This appendix presents additional information on the calculations of some of the criterion scores: Income distribution, Avoided CO_2 emissions,

B.1. Evaluation of criteria

a) Income distribution

The following tables present the financial flows of the different alternatives.

Amount of windmills	16	Year	Investment	Production	Price	Turnover	Costs	Depreciation	Profit b.t.	Cash flow b.t.	Tax	Profit a.t.	Cash flow a.t.	NPV	PMT
Power	0,85 MW			GW h	€/kW h	M€	M€	M€	M€	M€	M€	M€	M€	M€	M€/year
Hours of operation	2200 hrs	1	13.590.000 €	15	0,06	942	78	1.090	-226	-13.590.226	-79	-147	-13.590.147	6.803	546
Windmill price	640.000 €	2		30	0,064	1.923	156	1.090	677	677	237	440	440		
Investment	10.240.000 €	3		30	0,066	1.961	233	1.090	637	637	223	414	414		
M&O (2 first years)	0,0052 €/kW h	4		30	0,067	2.000	233	1.090	676	676	237	440	440		
M&O	0,0078 €/kW h	5		30	0,068	2.040	233	1.090	716	716	251	466	466		
Construction cost	3.350.000 €	6		30	0,070	2.081	233	1.090	757	757	265	492	492		
		7		30	0,071	2.123	233	1.090	799	799	280	519	519		
Total investment	13.590.000 €	8		30	0,072	2.165	233	1.090	841	841	294	547	547		
	999 € €/kW h	9		30	0,074	2.209	233	1.090	885	885	310	575	575		
		10		30	0,075	2.253	233	1.090	929	929	325	604	604		
		11		30	0,077	2.298	233	1.090	974	974	341	633	633		
		12		30	0,078	2.344	233	1.090	1.020	1.020	357	663	663		
		13		30	0,080	2.391	233	1.090	1.067	1.067	373	693	693		
		14		30	0,081	2.438	233	1.090	1.115	1.115	390	724	724		
		15		30	0,083	2.487	233	1.090	1.163	1.163	407	756	756		
		16		30	0,085	2.537	233	1.090	1.213	1.213	425	788	788		
		17		30	0,086	2.588	233	1.090	1.264	1.264	442	821	821		
		18		30	0,088	2.639	233	1.090	1.316	1.316	460	855	855		
		19		30	0,090	2.692	233	1.090	1.368	1.368	479	889	889		
		20		30	0,092	2.746	233	1.090	1.422	1.422	498	924	924		

Table 111: Financial flow of alternative CB Pre

Amount of windmills	11	Year	Investment	Production	Price	Turnover	Costs	Depreciation	Profit b.t.	Cash flow b.t.	Tax	Profit a.t.	Cash flow a.t.	NPV	PMT
Power	1,5 MW			GW h	€/kW h	M€	M€	M€	M€	M€	M€	M€	M€	M€	M€
Hours of operation	2547 hrs	1	15.324.500 €	21	0,06	1.324	109	1.230	-15	-15.324.515	-5	-10	-15.324.510	12.002	963
Windmill price	1.129.500 €	2		42	0,064	2.701	219	1.230	1.252	1.252	438	814	814		
Investment	12.424.500 €	3		42	0,066	2.755	328	1.230	1.197	1.197	419	778	778		
M&O (2 first years)	0,0052 €/kW h	4		42	0,067	2.810	328	1.230	1.252	1.252	438	814	814		
M&O	0,0078 €/kW h	5		42	0,068	2.866	328	1.230	1.308	1.308	458	850	850		
Construction cost	2.900.000 €	6		42	0,070	2.923	328	1.230	1.366	1.366	478	888	888		
		7		42	0,071	2.982	328	1.230	1.424	1.424	498	926	926		
Total investment	15.324.500 €	8		42	0,072	3.041	328	1.230	1.484	1.484	519	964	964		
	929 € €/kW h	9		42	0,074	3.102	328	1.230	1.545	1.545	541	1.004	1.004		
		10		42	0,075	3.164	328	1.230	1.607	1.607	562	1.044	1.044		
		11		42	0,077	3.227	328	1.230	1.670	1.670	584	1.085	1.085		
		12		42	0,078	3.292	328	1.230	1.734	1.734	607	1.127	1.127		
		13		42	0,080	3.358	328	1.230	1.800	1.800	630	1.170	1.170		
		14		42	0,081	3.425	328	1.230	1.867	1.867	654	1.214	1.214		
		15		42	0,083	3.493	328	1.230	1.936	1.936	678	1.258	1.258		
		16		42	0,085	3.563	328	1.230	2.006	2.006	702	1.304	1.304		
		17		42	0,086	3.635	328	1.230	2.077	2.077	727	1.350	1.350		
		18		42	0,088	3.707	328	1.230	2.150	2.150	752	1.397	1.397		
		19		42	0,090	3.781	328	1.230	2.224	2.224	778	1.446	1.446		
		20		42	0,092	3.857	328	1.230	2.300	2.300	805	1.495	1.495		

Table 112: Financial flow of alternative CB

Amount of windmills	33	Year	Investment	Production	Price	Turnover	Costs	Depreciation	Profit b.t.	Cash flow b.t.	Tax	Profit a.t.	Cash flow a.t.	NPV	PMT
Power	1,5 MW			GW h	€/kW h	M€	M€	M€	M€	M€	M€	M€	M€	M€	M€
Hours of operation	2440 hrs	1	42.300.000 €	60	0,06	3.805	314	3.394	96	-42.299.904	34	63	-42.299.937	35.627	2.859
Windmill price	1.150.000 €	2		121	0,064	7.761	628	3.394	3.739	3.739	1.309	2.430	2.430		
Investment	37.950.000 €	3		121	0,066	7.917	942	3.394	3.580	3.580	1.253	2.327	2.327		
M&O (2 first years)	0,0052 €/kW h	4		121	0,067	8.075	942	3.394	3.739	3.739	1.308	2.430	2.430		
M&O	0,0078 €/kW h	5		121	0,068	8.236	942	3.394	3.900	3.900	1.365	2.535	2.535		
Construction cost	4.350.000 €	6		121	0,070	8.401	942	3.394	4.065	4.065	1.423	2.642	2.642		
		7		121	0,071	8.569	942	3.394	4.233	4.233	1.481	2.751	2.751		
Total investment	42.300.000 €	8		121	0,072	8.741	942	3.394	4.404	4.404	1.541	2.863	2.863		
	855 € €/kW h	9		121	0,074	8.915	942	3.394	4.579	4.579	1.603	2.976	2.976		
		10		121	0,075	9.094	942	3.394	4.757	4.757	1.665	3.092	3.092		
		11		121	0,077	9.275	942	3.394	4.939	4.939	1.729	3.210	3.210		
		12		121	0,078	9.461	942	3.394	5.125	5.125	1.794	3.331	3.331		
		13		121	0,080	9.650	942	3.394	5.314	5.314	1.860	3.454	3.454		
		14		121	0,081	9.843	942	3.394	5.507	5.507	1.927	3.579	3.579		
		15		121	0,083	10.040	942	3.394	5.704	5.704	1.996	3.707	3.707		
		16		121	0,085	10.241	942	3.394	5.905	5.905	2.067	3.838	3.838		
		17		121	0,086	10.446	942	3.394	6.109	6.109	2.138	3.971	3.971		
		18		121	0,088	10.655	942	3.394	6.318	6.318	2.211	4.107	4.107		
		19		121	0,090	10.868	942	3.394	6.531	6.531	2.286	4.245	4.245		
		20		121	0,092	11.085	942	3.394	6.749	6.749	2.362	4.387	4.387		

Table 113: Financial flow of alternative ST

Amount of windmills	26	Year	Investment	Production	Price	Turnover	Costs	Depreciation	Profit b.t.	Cash flow b.t.	Tax	Profit a.t.	Cash flow a.t.	NPV	PMT
Power	1,5 MW			GW h	€/kW h	M€	M€	M€	M€	M€	M€	M€	M€	M€	M€
Hours of operation	2440 hrs	1	33.500.000 €	48	0,06	2.998	247	2.688	62	-33.499.938	22	40	-33.499.960	27.957	2.243
Windmill price	1.150.000 €	2		95	0,064	6.115	495	2.688	2.932	2.932	1.026	1.906	1.906		
Investment	29.900.000 €	3		95	0,066	6.237	742	2.688	2.807	2.807	982	1.824	1.824		
M&O (2 first years)	0,0052 €/kW h	4		95	0,067	6.362	742	2.688	2.932	2.932	1.026	1.906	1.906		
M&O	0,0078 €/kW h	5		95	0,068	6.489	742	2.688	3.059	3.059	1.071	1.988	1.988		
Construction cost	3.600.000 €	6		95	0,070	6.619	742	2.688	3.189	3.189	1.116	2.073	2.073		
		7		95	0,071	6.751	742	2.688	3.321	3.321	1.162	2.159	2.159		
Total investment	33.500.000 €	8		95	0,072	6.886	742	2.688	3.456	3.456	1.210	2.246	2.246		
	859 € €/kW h	9		95	0,074	7.024	742	2.688	3.594	3.594	1.258	2.336	2.336		
		10		95	0,075	7.165	742	2.688	3.734	3.734	1.307	2.427	2.427		
		11		95	0,077	7.308	742	2.688	3.878	3.878	1.357	2.520	2.520		
		12		95	0,078	7.454	742	2.688	4.024	4.024	1.408	2.615	2.615		
		13		95	0,080	7.603	742	2.688	4.173	4.173	1.460	2.712	2.712		
		14		95	0,081	7.755	742	2.688	4.325	4.325	1.514	2.811	2.811		
		15		95	0,083	7.910	742	2.688	4.480	4.480	1.568	2.912	2.912		
		16		95	0,085	8.069	742	2.688	4.638	4.638	1.623	3.015	3.015		
		17		95	0,086	8.230	742	2.688	4.800	4.800	1.680	3.120	3.120		
		18		95	0,088	8.395	742	2.688	4.964	4.964	1.737	3.227	3.227		
		19		95	0,090	8.562	742	2.688	5.132	5.132	1.796	3.336	3.336		
		20		95	0,092	8.734	742	2.688	5.303	5.303	1.856	3.447	3.447		

Table 114: Financial flow of alternative L

Amount of windmills	24	Year	Investment	Production	Price	Turnover	Costs	Depreciation	Profit b.t.	Cash flow b.t.	Tax	Profit a.t.	Cash flow a.t.	NPV	PMT
Power	1,5 MW			GW h	€/kW h	M€	M€	M€	M€	M€	M€	M€	M€	M€	M€
Hours of operation	2440 hrs	1	30.550.000 €	44	0,06	2.767	228	2.451	87	-30.549.913	31	57	-30.549.943	26.049	2.090
Windmill price	1.150.000 €	2		88	0,064	5.645	457	2.451	2.736	2.736	958	1.779	1.779		
Investment	27.600.000 €	3		88	0,066	5.757	685	2.451	2.621	2.621	917	1.704	1.704		
M&O (2 first years)	0,0052 €/kW h	4		88	0,067	5.873	685	2.451	2.736	2.736	958	1.778	1.778		
M&O	0,0078 €/kW h	5		88	0,068	5.990	685	2.451	2.854	2.854	999	1.855	1.855		
Construction cost	2.950.000 €	6		88	0,070	6.110	685	2.451	2.973	2.973	1.041	1.933	1.933		
		7		88	0,071	6.232	685	2.451	3.096	3.096	1.083	2.012	2.012		
Total investment	30.550.000 €	8		88	0,072	6.357	685	2.451	3.220	3.220	1.127	2.093	2.093		
	849 € €/kW h	9		88	0,074	6.484	685	2.451	3.347	3.347	1.172	2.176	2.176		
		10		88	0,075	6.614	685	2.451	3.477	3.477	1.217	2.260	2.260		
		11		88	0,077	6.746	685	2.451	3.609	3.609	1.263	2.346	2.346		
		12		88	0,078	6.881	685	2.451	3.744	3.744	1.310	2.434	2.434		
		13		88	0,080	7.018	685	2.451	3.882	3.882	1.359	2.523	2.523		
		14		88	0,081	7.159	685	2.451	4.022	4.022	1.408	2.614	2.614		
		15		88	0,083	7.302	685	2.451	4.165	4.165	1.458	2.707	2.707		
		16		88	0,085	7.448	685	2.451	4.311	4.311	1.509	2.802	2.802		
		17		88	0,086	7.597	685	2.451	4.460	4.460	1.561	2.899	2.899		
		18		88	0,088	7.749	685	2.451	4.612	4.612	1.614	2.998	2.998		
		19		88	0,090	7.904	685	2.451	4.767	4.767	1.669	3.099	3.099		
		20		88	0,092	8.062	685	2.451	4.925	4.925	1.724	3.201	3.201		

Table 115: Financial flow of alternative R

b) Avoided CO2 emissions

Table 116 presents the energy vector of Catalonia for the year 2001. It also shows the emission factors of different fuels used to produce electricity. Finally, using RETScreen software, one can obtain the GHG emission factor for the Catalonian electricity mix.

Table 116: Catalonian energy vector in the year 2003

Fuel type	Fuel mix (1)	CO2 emission factor	CH4 emission factor	N2O emission factor	Fuel conversion efficiency	GHG emission factor
	(%)	(kg/GJ)	(kg/GJ)	(kg/GJ)	(%)	(tCO2/MW h)
Coal	1,3%	94,6	0,0020	0,0030	35,0%	0,983
Fuel oil	2,6%	77,4	0,0030	0,0020	30,0%	0,937
Natural gas	25,4%	56,1	0,0030	0,0010	45,0%	0,452
Nuclear	55,8%	0,0	0,0000	0,0000	30,0%	0,000
Large hydro	13,9%	0,0	0,0000	0,0000	100,0%	0,000
Wind	0,4%	0,0	0,0000	0,0000	100,0%	0,000
						0,000
Electricity mix	99%	39,4	0,0017	0,0009		0,143

Source: Calculated by means of the software RETScreen, Version 2000, Release 2, © Minister of Natural Resources Canada 1997-2000.
(1) Gencat (2005).

The energy production is calculated regarding the equivalent functioning hours of the windmills[53] and the installed capacity. Then, the GHG emissions reduction is obtained by multiplying the expected generated energy and the GHG emissions factor (0.143 ton CO_2/MW h for the year 2003 and 0. ton CO_2/MW h for the year 2003).

Table 117. Avoided CO2 emissions

	CB Pre	CB	ST	CBST	L	R	NP
Projected electricity generation [MW h/year]	32.708	42.026	138.071	180.096	103.100	96.207	0
Avoided CO2 emissions [ton CO2/year]]	4.680	6.010	19.740	25.750	14.740	13.760	0
Ordinal evaluation of the avoided CO_2 emissions	6th	5th	2nd	1st	3rd	4th	7th

It is worth mentioning that the transport and distribution losses have been disregarded because there is no information about the evacuation power lines and their point of connection with the central grid.

c) Noise annoyance

At a point, for instance, at closest neighbouring property the sound power level of the mill can be measured at a height of 1.5 m:

$$L_{pA} = L_{AW,ref} - 10 \times \log (l_2 + h_2) - 8 \text{ dB} - \Delta L_a$$

8 dB is the overall correction for distance and hard ground: - 10 x log 4π + 3 = - 8

$$\Delta L_a = \alpha_a * \surd(l_2 + h_2)$$

53 This values has been got from the Environmental Impact Assessment presented by the companies.

Where

l:= distance from mill base to point of calculation

ΔL_a:= atmospheric absorption.

Attenuation coefficient α_a = 0.005 dB/m.

The indeterminateness relating to the calculation method for L_{pA} is ± 2 dB

i. Windmill GEWE 1.5/80 (General Electric)

According to the information given by EHN environmental impact assessment, the sound pressure level of the windmill LWA,ref is:

$L_{AW,ref}$ = 104,2 dB(A)

ii. Windmill G80-1500 kW (Gamesa)

Gerrsa has not given noise measurement information of their windmills. Then, for the calculation of the sound pressure level of these wind turbines it will be considered LWA,ref as:

$L_{AW,ref}$ = 106 dB(A)

For the windmills of 660 KW and 850 KW it was not possible to obtain LAW,ref. Then, the value considered for the calculations is 106 dB(A).

Table 118. Common levels of noise

Item	dB(A)
Birds singing	10
Car's horn	90
Rumour of the leaves of trees	20
Bus' horn	100
Residential zones	40
Inside of a club	110
Normal conversation	50
Motorbike without silencer	115
Office environment	70
Air plane over the city	130
Traffic	85
Pain threshold	140
Maximum level of noise allowed in buildings	
Hospitals	25
Library and museums	30
Cinemas, theatres and conference halls	40
Educational institutions and hotels	40
Offices	45
Big shops, restaurants and bars	55

Source: Waste Magazine (http://waste.ideal.es/acustica.htm)

With the distances separating windmills and towns, and the height of the windmills it is calculated the sound pressure produced by every windmill in every town.

iii. Windfarm's pressure sound level

At a windfarm the sound pressure level $L_{WA,ref}$ shall be determined on the basis of measurements of at least 3 mills chosen at random. If the park consists of less than 10 mills, LWA,ref shall be determined for all mills. The deviation shall be ± 2 - 3 dB when the mills are alike.

The noise level at a point is found by adding the noise loads calculated according to the formula for L_{pA} from individual mills:

L_{total} = 10 x log ($\Sigma 10L_{pi}/10$)

Table 119. Noise. Potential sound pressure level in the involved villages [dB(A)]

	CB Pre	*CB*	*ST*	*CBST*	*L*	*R*	*NP*
Vallbona de les Monges	-	-	-	-	-	-	-
Montblanquet	39,9	39,6	26,6	39,6	30,1	13,3	-
Rocallaura	13,1	13,5	18,7	18,7	17,7	26,2	-
Els Omells de Na Gaia	22,0	22,1	6,2	22,1	9,7	0,0	-
Senan	38,6	38,9	21,7	38,9	22,6	0,0	-

In order to obtain a general evaluation of alternatives under this criterion, we do a multi-criteria evaluation in which the different criteria are the sound pressure level in each village.

Figure 20 Shows the results (rankings) of this multi-criteria evaluation. This ranking is obtained by means of applying NAIADE model and considering the following preference thresholds:

- *Much Better:15 dB(A)*
- *Better: 10 dB(A)*
- *Almost equal: 2 dB(A)*
- *Equal: 1 dB(A)*

The ranking of alternatives is stable when changing the degree of compensation between criteria. Clearly, alternative NP (G in Figure 20) is the best, and alternatives CB (B in Figure 20) and CBST (D in Figure 20) are the worst due to their proximity to the inhabited areas.

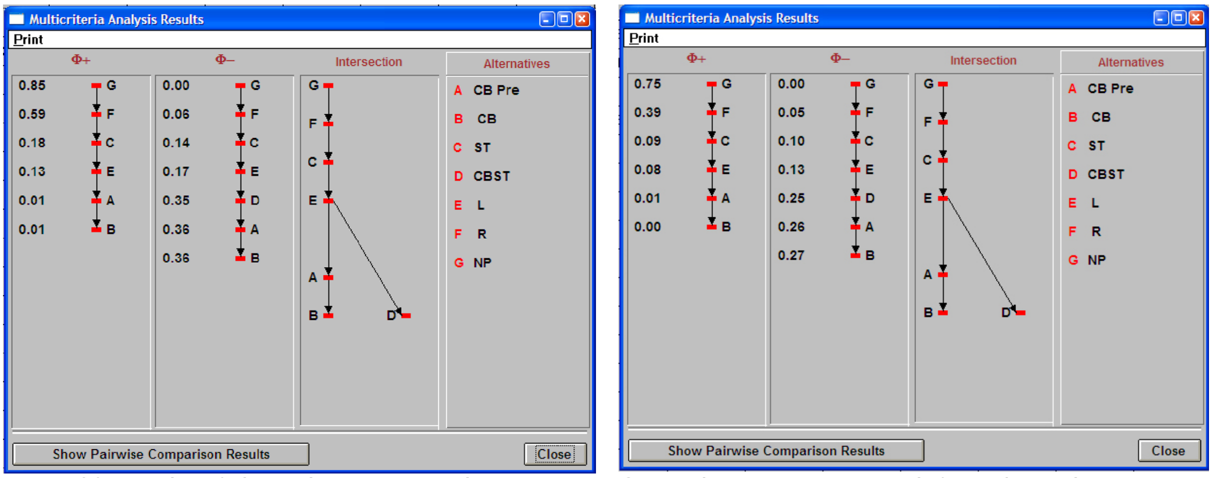

Figure 20: Results of the multi-criteria evaluation in NAIADE, with no compensation (left) and complete compensation (right)

B.2. The applied multi-criteria model (Munda, 2005)

Munda (2005) propose an ordinal multi-criteria model to be applied in the context of Social Multi-Criteria Evaluation. The model uses the ordinal information of the criterion scores so as to carry out the evaluation. Weights have the meaning of importance coefficients and no compensation is allowed among criteria.

It considers the existence of a set of weights ($W=\{w_1, w_2,\ldots, w_m\}$, with $m=1,2,\ldots,M$) assigned to each criterion, whose sum is equal to 1.

$$\sum_{m=1}^{M} w_m = 1$$

The problem is then how to use the available information, considering the relationship among alternatives as a complete pre-order (i.e. without incomparability relations[54]), so as to obtain a ranking of options from the best to the worst.

The mathematical aggregation procedure has two main steps:

- Pair-wise comparison of alternatives across criteria.
- Ordering of alternatives in a complete pre-order.

a) Pair-wise comparison of alternatives

The following axiomatic system is needed so as to carry out this step (adapted from Arrow and Raynaud, 1986, p. 81-82).

Axiom 1: Diversity. Each criterion is a total order on the finite set A of alternatives to be ranked, and there is no restriction on the criteria; they can be any total order on A. In other words, it must be possible to order all alternatives according to each criterion (no incomparability relations are admitted).

Axiom 2: Symmetry. Since criteria have incommensurable scales (that is, they are expressed using different units of measurement), the only preference information they provide is the ordinal pair-wise preferences they contain (they do not give information on the intensity of preference).

Axiom 3: Positive Responsiveness. *The degree of preference between two alternatives a and b is a strictly increasing function of the number and weights of criteria that rank a before b*[55]*.*

Thanks to these three axioms a N x N matrix, E, called outranking matrix (Arrow and Raynaud, 1986, Roy, 1996) can be built (See Table 120). Any generic element of *E: e*jk , is the result of the pair-wise comparison, according to all the M criteria, between alternatives *j* and *k*. Such a global pair-wise comparison is obtained by means of equation (4).

$$e_{jk} = \sum_{m=1}^{M} \left(w_m(P_{jk}) + \frac{1}{2} w_m(I_{jk}) \right) \qquad (4)$$

where $w_m(P_{jk})$ and $w_m(I_{jk})$ are the weights of criteria presenting a preference and an indifference relation respectively. It clearly holds

$$e_{jk} + e_{kj} = 1. \qquad (5)$$

In this case, we consider equal weights for the socio-economic and socio-ecological dimensions and we obtain the outranking matrix of Table 120. This means that the sum of the criteria in each dimension is equal to 50%. Therefore, the weight of each socio-economic criteria is 50/4, and of each socio-ecological criteria is 50/4.

Table 120. Outranking matrix

54 The relationship between alternatives must be of preference or indifference..

55 In social choice terms then the anonymity property (i.e. equal treatment of all criteria) is broken. Indeed, given that full decisiveness yields to dictatorship, Arrow's impossibility theorem forces us to make a trade-off between decisiveness (an alternative has to be chosen or a ranking has to be made) and anonymity. In our case the loss of anonymity in favour of decisiveness is even a positive property. In general, it is essential that no criterion weight is more than 50% of the total weight; otherwise the aggregation procedure would become lexicographic in nature, and the indicator would become a dictator in Arrow's terms.

	CB pre	CB	ST	CBST	L	R	NP
CB Pre	0,00	0,50	0,13	0,38	0,13	0,13	0,63
CB	0,50	0,00	0,13	0,31	0,13	0,13	0,63
ST	0,88	0,88	0,00	0,38	0,75	0,63	0,63
CBST	0,63	0,69	0,63	0,00	0,63	0,63	0,63
L	0,88	0,88	0,25	0,38	0,00	0,50	0,63
R	0,88	0,88	0,38	0,38	0,50	0,00	0,63
NP	0,38	0,38	0,38	0,38	0,38	0,38	0,00

For instance, when we compare alternatives CBPre with alternative CB, CB Pre is better under the following criteria:

- Owner's income (12,5%)
- Number of jobs (12,5%)
- Noise annoyance (12,5%)

indifferent under the following criteria

- Municipalities' income (6,25%)
- Forest lost (6,25%)

and the value of the element $e_{1,2}$ in the outranking matrix is 0,50.

Then, the model generates al the possible rankings of alternatives, that is the *N!* permutations of the *N* alternatives, where *N!=1·2·3·...·(N-1)·N*.

For each raking, compute the corresponding score Φ_S as the summation of the elements e_{jk} for each pair of alternatives *j* and *k*, where alternative *j* is over alternative *k* in the considered ranking.

$$\phi_s = \sum e_{jk} \qquad (6)$$

$$\textit{where} \quad j \neq k, \ s=1, 2, \ldots N! \quad \textit{and} \quad e_{jk} \in r_s$$

For example, the ranking CBST → ST → L → R → CB Pre → CB → NP, where alternative CBST is in the first position and NP in the last, its corresponding score Φ_S is calculated as the sum of the following values (coming from the outranking matrix):

CBST → ST	: 0,63	L → R	: 0,50
CBST → L	: 0,63	L → CB Pre	: 0,88
CBST → R	: 0,63	L → CB	: 0,88
CBST → CB Pre	: 0,63	L → NP	: 0,63
CBST → CB	: 0,69	R → CB Pre	: 0,88
CBST → NP	: 0,63	R → CB	: 0,88
ST → L	: 0,75	R → NP	: 0,63
ST → R	: 0,63	CB Pre → CB	: 0,50
ST → CB Pre	: 0,88	CB Pre → NP	: 0,63
ST → CB	: 0,88	CB → NP	: 0,63
ST → NP	: 0,63	Φ_S	**: 14,56**

The maximum likelihood ranking of alternatives is the ranking supported by the maximum number of criteria for each pair-wise comparison, summed over all pairs of alternatives considered. This/these rankings maximize equation (6).

One of the obstacles of this method is the difficulty of computing when the number of alternatives increases. In fact, the number of permutations could result easily unmanageable. For instance, there are 3,628,800 possible rankings with 10 alternatives.

In this case the maximum likelihood rankings, with different weights combinations, are the following:

Table 121. Maximum likelihood rankings with criteria equally weighted

	Ranking position							
	First	***Second***	***Third***	***Fourth***	***Fifth***	***Sixth***	***Seventh***	Φ_S
Ranking 1	CBST	ST	L	R	CB pre	CB	NP	**14,56**
Ranking 2	CBST	ST	L	R	CB	CB pre	NP	**14,56**
Ranking 3	CBST	ST	R	L	CB pre	CB	NP	**14,56**
Ranking 4	CBST	ST	R	L	CB	CB pre	NP	**14,56**

Table 122. Maximum likelihood rankings prioritizing socio-ecological criteria

	Ranking position							
	First	***Second***	***Third***	***Fourth***	***Fifth***	***Sixth***	***Seventh***	Φ_S
Ranking 1	CBST	ST	R	L	CB	CB pre	NP	**13,55**
Ranking 2	CBST	ST	R	L	CB pre	CB	NP	**13,5**
Ranking 3	ST	CBST	R	L	CB	CB pre	NP	**13,45**
Ranking 4	CBST	ST	L	R	CB	CB pre	NP	**13,45**
Ranking 5	CBST	ST	R	L	CB	NP	CB pre	**13,45**
Ranking 6	CBST	R	ST	L	CB	CB pre	NP	**13,45**

Table 123. Maximum likelihood rankings prioritizing socio-economic criteria

	Ranking position							
	First	***Second***	***Third***	***Fourth***	***Fifth***	***Sixth***	***Seventh***	Φ_S
Ranking 1	CBST	ST	L	R	CB pre	CB	NP	**15,73**
Ranking 2	CBST	ST	L	R	CB	CB pre	NP	**15,68**
Ranking 3	CBST	ST	R	L	CB pre	CB	NP	**15,63**
Ranking 4	CBST	ST	R	L	CB	CB pre	NP	**15,58**

Chapter 6
Some lessons learned from the case studies

The aim of this section is to draw some general conclusions regarding the application of Social Multi-Criteria Evaluation in the field of public policies and environmental management. Which is based upon the experience acquired in these two case studies.

I have already stressed the need for changing the current Environmental Impact Assessment process applied worldwide. I have also presented the findings of SMCE within the wind energy implementation context regarding the desired features of public decision-making processes. I start this chapter by complementing these last ideas in a wider frame.

Second, I analyse whether SMCE fulfils the desired features of a decision-making process in the public policy domain. In particular, I assess the role of public participation and multi-criteria analysis in: the improvement of democracy, the appraisal of socio-environmental complexity, the promotion of public acceptance of decisions and its usefulness for social learning.

Third, I make some comments on the way decision-making process are evaluated. Particularly, on the need of doing a multi-dimensional assessment of the process rather than a simplified judgement only based on the economic point of view.

Fourth, I outline some practicalities of carrying out public participation and multi-criteria evaluation in a SMCE context.

6.1. On the desired features of public decision-making processes

6.1.1. The improvement of democracy

a) The balance between aims expressed at different scales

Current multi-scale governance systems, such as the European Union, have found several difficulties in implementing environmental policy designed at higher levels of governance. Policy implementation processes are characterized by the presence of institutions and actors with contradicting objectives and unequal power distribution, and local actors can easily perceive their interest as disregarded compared to other actors (Adger et al., 2003). Therefore, we need environmental decision-making processes able at balancing local and global aims.

In the windfarm case study, local actors perceive certain degree of top-down imposition, and local benefits do not necessarily compensate negative effects at local level. Moreover, some groups opposing windfarms expressed their will of being involved in the design and evaluation of alternatives from the beginning of the process. But even though the wind energy companies carried out some public presentations of their plans, in practical terms, these groups have not been able to influence the process neither to decide about their future. They wanted to be part of the decision itself more than just being eared.

In the Aysén case study, a regional land use plan was set up before the arrival of Alumysa. Even though this plan was not binding, some social groups used it to stress the existence of other development alternatives for the region rather than its industrialization. Alumysa was considered as good for the national economy by some social actors (e.g. Government, Chilean construction chamber, Chilean industry chamber), but their aims collide with the objectives of some local actors concerned with the socio-environmental impacts of the project.

I think that the definition of local problems by local actors is a prerequisite for the implementation of (global/national) public policies. In this way, we can tackle global problems from the local. But decisions based exclusively upon local concerns are neither desirables. For instance, local monopoly in territorial planning could hamper the implementation of renewables (Khan, 2003). Therefore, national and global priorities should serve as guidelines for local policies, and local activities should be bounded by the limits imposed by global problems.

In the windfarms case study, the location and configuration of the windfarms was exclusively defined by the promoter companies. Some people expressed their concerns about the landscape affection, and the strategy followed by the entrepreneurs was to reduce the number of windmills and to raise their capacity (and hence the height of the turbines), so the installed capacity remain about same. In this way, the submitted projects were still exclusively based on the vision and interest of the private investors.

As a consequence, distrust among detractors and supporters of the windfarm projects increase due to the highly confronted positions toward the plans, and suspicion raised with time. On one hand, some municipalities give unquestionable support to the windfarms, and on the other hand, some groups evolve towards a radical opposition toward the projects (a strategic antagonistic behaviour in order to avoid the installation of all the projected wind turbines).

Some times, underlying political or personal problems undermine the communication among social actors and hence the search for consensus/compromise options. To carry out a conflict analysis is very important to identify the roots of disagreements and hence to guide the discussion and negotiation.

As noted in the beginning of this dissertation, the promotion of trust, cooperation and reciprocity is necessary in order to complement and strengthen local institutions that protect cultural diversity (Ostrom et al., 1999). Therefore, the manage of conflict becomes a fundamental aspect of public decision-making frameworks.

b) The multi-criteria structure and the manage of conflict

Once the different positions are identified and adequately represented, the multi-criteria structure can be seen as a social expression, which highlights both the diversity of involved viewpoints and the effects of alternatives on different dimensions. This framework is very useful in order to foster both discussion and the practice of (deliberative) democracy (see sub-section social learning below).

It is worth-noting that the problem structure determines the results of the technical and social evaluations. In technical terms, alternatives and criteria determine the outcome of the multi-criteria evaluation, and in political terms, the discussion is mainly based on this decision space.

In Gamboa and Munda (2007) we propose a mathematical solution base on Moulin (1981) to the problem of allocating veto power across the various groups of social actors. This solution has deep ethical implications, since it means to attach different weights to different groups.

The philosophy behind Moulin's theorem is that any group with *x* percent of social actors must be able to veto any subset containing less than *x* percent of policy options.

However, it is important to highlight that veto power is not a technical decision only. The number of alternatives and of social actors involved will certainly affect the percentage that every coalition could veto. Both the set of options and the social actors to be considered are defined in the problem structuring phase, which is mainly a technical, political and social process.

For instance, this way of proceeding could bias the process of alternative creation. Some actors could behave strategically so as to reduce (or increase) the number of alternatives, because it will determine the number of options each coalition can veto.

In order to overcome these problems, I just can imagine an open and transparent process that is regarded as fair by the involved social actors, who all have the possibility to influence the process, at least, raising and questioning issues. For instance, a consensus/compromise oriented process (See van den Hove, 2006), guided by the principles of discursive democracy (See Dryzek, 2000).

6.1.2. Representation and legitimacy in SMCE

a) In the problem structuring

Basically, something is legitimate when it conforms to the law or to rules[56]. The legitimacy of public decisions is highly related with people adopting decisions and with the process in which decisions are made. Adger et al. (2003) argue that contextual norms and beliefs guiding a decision-making process define whether the outcome of it is legitimate or not. In other words, legitimate is something considered fair, correct or appropriate in a given socio-cultural framework.

It is very important to keep in mind that powerful actors hold on their positions of privilege by legitimizing systems of rules, conventions and institutions (Beetham, 1991, quoted in Adger et al., 2003). In such cases, recognising the negotiation dimension of participatory approaches boosts the diversity of values and interests that inform a decision (van den Hove, 2006).

As previously mentioned, critics of qualitative participatory approaches usually highlights the lack of representativeness of these methodologies. In SMCE, participatory approaches are embedded within a process, which should be legitimate as a whole. So, one should emphasize the representativeness of the whole process rather than in specific participatory activities. Moreover, I really believe that, in order to meet legitimacy in the final decision, the involved social actors should take an important part in both defining the problem to be tackled and designing the decision-making process. In this way, one could balance the substantive feature of the approach—related to the quality of the decision (understood as fitting for purpose)—with the normative feature of the approach—related to the right to participate, to democratize the process and to empower social actors.

I think that having the possibility of influencing collective choices generates the feeling of shared responsibility on decisions, and therefore the commitment to comply them. In the case of compromise decisions, in which there are some gains and losses, I argue that a balance between voluntary compliance and social control is needed.

56 Oxford English Dictionary (http://www.askoxford.com/)

b) In the multi-criteria structure

The issue of representation of social actors also emerges in the multi-criteria structure. Preferences underlying criteria are present across social actors, but weighted differently by each one of them. In this way, the set of criteria is a social expression, and different priorities could be modelled by means of using different combinations of weights.

According to this, we can use a set of ethical principles so as to derive the weights of the different dimensions (economic, social, ecological, technical, political), and to split these values across the corresponding criteria (Munda, 2004). We can also get different rankings of criteria according to the priorities of the involved social actors, and then, run several evaluations using a model with weights as ordinal coefficients (e.g. REGIME).

This sort of sensitivity analysis show the robustness of the evaluation considering different priorities on the set of criteria. Also, one can shed light on the trade-off among criteria and produce relevant information for deliberation.

Multi-criteria evaluation is regarded here as a learning and decision support tool. There are many sources of uncertainty in the evaluation, and I think that the determination of precise weights for the criteria aggregation could be a waste of time if one considers that social weights are fuzzy in nature.

Finally, I want to shed light on the fact that, even though qualitative participatory approaches are more appropriate for deliberation than quantitative ones, the combination of both sorts of methodologies is always advisable. The last are aimed at knowing *what*, *when* and *how* things happen and behaviours occur, and the former are aimed at explaining and interpreting why people think and behave in certain ways as well as to generate discussion and negotiation among social actors.

6.1.3. Social learning

Multi-criteria framework is a powerful tool so as to structure information. But its content should be presented and communicated in a clear and transparent way in order to boost social learning.

SMCE, as a public decision-making framework, may present some practical limitations. One of them, is the complicatedness of many multi-criteria models, which can lead to a lack of transparency.

The impact matrix structures and systematizes the complexity of the problem at hand. But, visual tools are also needed in order to facilitate the understanding of the situation. Graphical computer simulations have shown to be useful in this respect, but less sophisticated representations, such as radar graphics or coloured impact matrix (see Table 124), would help in fostering discussion among social actors.

In the case of the windfarms case study, similar results can be derived from the coloured impact matrix presented below. But sometimes, the best (or second best) alternative can not be identified so easily, and the mathematical algorithms should ensure that the outcomes of the multi-criteria evaluation are consistent with the information of the performance of the alternatives.

Table 124. Representation of the impact matrix of the windfarms case study

Criteria	***CB Pre***	***CB***	***ST***	***CBST***	***L***	***R***	***NP***
Owners' income							
Municipalities' income							
Number of jobs							
Visual Impact							
Forest lost							
Avoided CO2 emissions							
Noise							
Installed capacity							

Position	**First**	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**	**Seventh**
Colour							

Source: Own elaboration

6.2. Some practicalities of doing SMCE

6.2.1. On participatory approaches

Within SMCE, one should match the objectives of each phase (*approaching*, *representing* and *evaluating*) with adequate qualitative participatory methodologies, so as to take as much advantage as possible in their application.

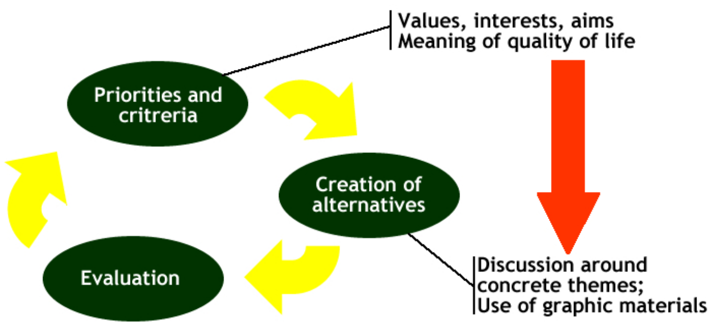

Figure 21: Participatory approaches within SMCE: from general issues to concrete themes.

In my opinion, the debate along the process should deal with general issues in the beginning to particular ones at the end (See Figure 21). The identification of general values, aims and priorities should be done at first. This information is the basis so as to identify *practical problems* to be solved, to define the evaluation criteria and to search possible options. For instance, deliberating about the meaning of improving or decreasing quality of life one can elicit the principles (criteria) that would guide social choices.

Then, the discussion about alternatives should be more concrete than previously. The use of graphic material, such as maps, photographs and so on, is advisable; these materials allow participants to concrete their ideas and to discuss the technical and social feasibility of different options. For instance, in a focus group within the wind energy case study, the discussion about the projected windfarms was based on maps of the projects, which allow participant to discuss, in a concrete way, the appropriateness of some locations for wind turbines construction. Possible consensus/compromise locations were also identified.

I think that when dealing with technical problems, general discussions about ideologies and values make more difficult to reach common points. On the contrary, it could be easier to reach consensus positions when talking about tangible issues.

The evaluation of the alternatives by the different social actors is the following step. The discussion could be based on the performances of the alternatives under each criterion, and the information gathered is the basis to carry out a conflict analysis.

Another important issue to have in mind is the need of balancing knowledge among social actors. For instance, to have a minimum knowledge about renewable energies before discussing about the location of windfarms is crucial. Equal distribution of knowledge is a fundamental pre-requisite for deliberation and learning.

6.2.2. Selecting social actors and participants

As mentioned above, historical and institutional analysis is one way to start the identification of the relevant social actors. Socio-economic diagnoses are useful to replicate social structure in qualitative experiences. Also, participatory approaches themselves are an important source of information to determine relevant actors.

But the identification of relevant social actors shouldn't be limited to external analysis. The process should be open for interested people and groups. In this sense, it is important to recover the trust of people in public participation; it is not difficult to find social movements who are unwilling to participate in this sort of processes due to a distrust in governmental authorities and some decision-making systems. Some reasons for this attitude can be found in the fact that their opinions and worries have been disregarded in the past, or because participatory processes have been used as a source of justification of decisions previously made.

Additionally, the identification of either places where local inhabitants meet and of local social practices are important issues to consider as well. This information helps in finding ways of communication between the research team and the local community. For instance, to carry out two public meetings of the windfarms case study in the social centres of the towns helps the team to generate a familiar environment in the gathering. Which, in turn, facilitates communication.

Since the degree of representativeness of qualitative participatory approaches can still be criticised, openness and transparency would be the most promising mean to reach legitimacy (Wittmer et al., 2006).

6.2.3. Criterion scoring

One question arising in the criteria valuation exercise is whether criteria should be valued in absolute or in relative terms. For instance, the use of relative variables to evaluate energy projects has been done elsewhere (See Siskos and Hubert, 1983; and MCDA-RES, 2004—specially the case studies in Utrecht and Troizina). These studies have assessed some impacts of energy projects by unit of energy produced: operational costs, birds affection and collective operational risks are evaluated per unit of energy (Kilowatt·hour) to be produced.

I think this practice is inappropriate as far as one benefit big projects with higher production capacities. Negative and positive impacts should be expressed in absolute terms in order to show the magnitude of the affection on society and the environment. The amount of (renewable) energy to be produced should be evaluated as a positive effect of the projects by means of a different criterion.

Multi-criteria evaluation framework allows us to include two *absolute* criteria instead of one *relative* criterion. This would describe in a better way the situation under study. For instance, in the windfarms case study the criterion *number of landlords renting land for wind turbines location* could be complementary to criterion *land owners' income*. This would improve the description of the situation, for instance, by showing the effects of the projects on the distribution of income.

Keeping this in mind, the definition of indexes to measure the performance of alternatives should be done considering the social framework, which implies valuing criteria in absolute terms.

Additionally, this practice is still more crucial when we consider intensity of preference in the multi-criteria aggregation procedure. The definition of preference and indifference thresholds requires the implicit determination of the substitution rate between, for instance, the amount of energy produced by unit of accidents, birds deaths, or whatever.

Other important issue is that of whether a criterion should be assessed in qualitative or quantitative terms. As we have seen in the Aysén case study, the use of qualitative valuation of criteria is useful so as to shed light: on the uncertainties around the potential consequences of the alternatives and on the available information regarding these impacts. According to this, the definition whether a criterion is valued in quantitatively or qualitatively could rely upon an uncertainty classification analysis (Gamboa, 2006).

6.2.4. The issue of quality control

As it has been stressed before, public involvement can play an important role in the quality check of decision-making processes. First, public participation is of utmost importance in the definition of the problem to be dealt with; it helps to look for *practical problems,* and to tackle the roots of the conflicts. In the environmental management for sustainability realm, it entails to answer the questions, sustainability of what? For whom? For how long?

In the windfarms case study, we dealt with the problem of windfarms location, but the underlying problem was about the definition of the development path of the region. This situation was also present in the Alumysa's case study: there was a vision of the region based on industrialization and economic progress, and another vision based upon a more conservationist perspective. Even though the discussion remained around the projects in both cases, to know the underlying reasons of the conflict is of fundamental importance so as to create alternatives and define criteria in an adequate manner.

Second, public involvement is basic for checking the quality of the problem structuring. That is, to decide the relevant dimensions and criteria to be considered in the evaluation, and the selection of potential alternatives.

In the windfarms case study, no one saw the creation of a cooperative aimed at constructing and managing a small windfarm as a viable alternative. Additional to the lack of interest in the public, some people express their concern about the lac of instruments aimed at supporting the creation of cooperatives in this field. Also in this case study, some criteria lost its relevance after the discussion among actors (e.g. Noise annoyance and distribution of income).

Third, we have to check the quality of the assumptions and information used in the criterion scoring step. But before doing that, we need to carry out a quality check of the viability and feasibility of the possible future developments.

Scenarios, for instance, should consider social, ecological and economic issues and interactions occurring at different temporal and spatial scales, and present internal consistency as well. In this regard, Multi-Scale Integrated Assessment of Societal Metabolism —MSIASM—(Giampietro, 2003) is a methodology that allows us to carry out this sort of quality check: to analyse the viability and desirability of scenarios[57].

Unfortunately, this dissertation lacks this quality check, which could be specially useful in the case study of the Chilean Patagonia. In social terms, for instance, one could check whether it is possible to run the economy with the local population plus the projected newcomers, or whether the region would need additional immigration so as to carry out the tasks required by the the socio-economic system.

For instance, scenarios E2 and E3 consider the massive migration of workers to the region. This would imply a change in the demographic structure of the region, and also an increase in the activity of some sectors (e.g. transport and commerce[58]). Then, the human activity in the production sector (agriculture, building and manufacture, and service and government) should be able to deliver the goods and services required by the consumption sector (rural and urban households). Recall that the human activity in the production and consumption sectors are determined by the new demographic structure of the region.

In general terms, an analysis based upon the MSIASM approach would entail to split the total human activity[59] in the production and consumption compartments, and split it again in the above-mentioned sub-sectors (i.e. agriculture, building and manufacture, service and government, rural and urban households). Then, based on the consumption patterns of the regional population one could assess the amount of goods and services required in the region, and also the human activity needed to deliver those required goods and services.

In this way, one can check whether the assumptions about the evolution of the different socio-economic sectors presented in Table 4 are right or not. Also, knowing the labour requirements of the promoted sectors in scenario E2 and E3, one can check whether the hiring crisis projected in the salmon-farming sector will be as acute as projected or not.

Participation is also important in order to assess the quality of the information used in the criterion scoring step. Recall the case in which the Alumysa's environmental impact study presents a map indicating the areas to be flooded in the Caro Lake zone, and the contradicting information given by the people living in those valleys. The inhabitants of that zone know, from their experience in rainy episodes, that the flooding dynamics in the area are quite different than the information contained in the Alumysa's environmental impact study.

57 This includes economic viability, biophysical feasibility regarding energy and material constrains, socio-economic viability in terms of human activity split across socio-economic sectors, and social desirability in terms of the willingness of people to be part of a certain socio-economic system.

58 It is worth noticing that most of the families of the workers of the construction and mining sectors remain in their original places.

59 Total Human Activity is defined by the amount of hours of available human activity during one year. For instance, a population of 100 people has a Total Human Activity of 100 people x 24 hours a day x 365 days = 876.000 hours

In cases in which the impacts of an option are not certain, uncertainty classification systems (such as Pedigree) can be useful so as to decide whether to use quantitative or qualitative criterion scoring depending on the quality of the available information.

Finally, public involvement is necessary to check the quality of the decision-making process itself. That is, to assure that the process is representative of relevant social actors, participants have the right to voice and their opinions are considered in the decision.

In this regard, it is worth noting that in the windfarms case study some groups opposing the installation of the wind turbines were asking to participate from the beginning of the process, including the definition of the location of the windmills. They considered the process as unfair due to their rather low capacity of both raising issues and influencing the final decision. Therefore, it remains the need of running structured and systematic evaluations of the role of public participation in decision-making processes. Different social actors should be involved in these evaluations, so we can assess the progress towards more fair and democratic public decision-making.

6.3. Evaluating decision-making processes

It is commonly argued that decision-making processes involving several social actors and multi/inter-disciplinary work would result in longer and more expensive procedures. But, there are other relevant aspects to be considered. For instance, Box 7 presents a set of criteria aimed at evaluate participatory instruments for conflict resolution (Wittmer et al., 2006). These criteria can be extrapolated so as to evaluate the decision-making process as well. According to these authors, the importance of each criterion should be defined according to the context and relevance of the decision itself. In other words, according to the degree of conflict, the uncertainty of the results, the urgency of the decision and the complexity of the phenomena.

Moreover, if we propose doing multi-criteria evaluation of public policies, the suggested decision-making processes should be evaluated in a multi-criteria way as well.

Also, if top-down policy implementation processes are prone to provoke social conflicts, then the application of those policies would be delayed, and the associated opportunity costs would increase.

For example, by 2002, the Catalonian government launched its energy plan until the year 2010 (ICAEN, 2002), which has been criticised by the lack of public involvement in its writing and implementation. In the renewable energy section, it fixed some territories for windfarms development without taking

Box 7: Criteria to evaluate methods for decision-making processes (Source: Wittmer et al., 2006)

Information	• Capacity of incorporating diverse aspects of the complexity f the situation • Integrate scientific and traditional knowledge • Integrate uncertainty and ignorance
Legitimacy	• Compatibility with the legal framework • Integrate knowledge produced during the process • Accountability • Inclusive/Representative • Transparency in rules and assumptions, for involved actors and also for external agents.
Social dynamics	• How it affects relations between involved actors • Foster social learning. • Oriented to action and/or empowerment • Facilitate convergence or highlight diversity
Costs	• Cost-effectiveness • Costs of the method • Opportunity costs

into account the opinion of the locals, and left the implementation of these infrastructures to the private initiative. Consequently, local opposition towards windfarms raised, and the Catalonian government had to declare a moratorium of windfarms construction (that remains until a new plan was launched). In this case, a top-down policy framework has been one of the roots of social conflict and of implementation delay, which in turn produced extra economic costs for the proponent companies.

An early and integrative public involvement in this process would produce consensus/compromise outcomes, give the opportunity of managing conflict and therefore to avoid extra delay in the implementation of environmental policies.

6.4. Some final words

As mentioned before, this dissertation presented the results and learned lessons from two of the various case studies I carried out during the last three years. During this time, I have acquired knowledge and experience that allow me to identify some areas of interest for further research.

First, even though some researcher have developed some frameworks aimed at managing uncertainty in environmental assessment (See for instance, the *RIVM/MNP Guidance on Uncertainty Assessment and Communication*[60] or the *NUSAP system*[61]), there is the need of developing a specific framework in the field of multi-criteria analysis. As I argue in Gamboa (2006), whether a criterion is evaluated in qualitative or quantitative terms should be defined in accordance with the degree of uncertainty in the available information.

Second, the issue of weights is another significant subject in multi-criteria methods that deserves attention. There are several studies combining MCA and public participation that run surveys in order to define the criterion weights for different social actors. I think that weights are fuzzy in nature, so to put excessive effort in obtaining an accurate number reflecting the priorities of social groups and individuals could be a waste of time. In addition, there are at least two general interpretations of weights: as importance coefficients and as trade-off, and one should do the right question for deriving weights so as to be coherent with the meaning of these parameters in the model (See for instance, Choo et al., 1999). My preliminary proposition is to work with ordinal weights, which I think are more appropriated for public decisions. In order to do so, we need to develop participatory methodologies aimed at defining rankings of weights for different social groups or coalitions instead of obtaining crisp numbers.

Third, it is the issue of the adequacy of multi-criteria methods for public decisions. As above mentioned, the desired characteristics of multi-criteria methods in the public policy domain are: simplicity (and hence transparency), non-compensatory, the use of weights as importance coefficients and the consideration of intensity of preference. But, due to the difficulties of fulfilling all these features at the same time, I think that the combination of different models is advisable: one using ordinal evaluations and weights as important coefficient, and the other one considering intensity of preference and managing compensation. In this way we can run sensitivity and trade-off analysis.

I think that the multi-criteria model used in the windfarms case study is a step forward in the search of an appropriate multi-criteria model in a SMCE. The use of ordinal weights instead of cardinal ones could be another improvement in this regard.

60 http://www.nusap.net/sections.php?op=viewarticle&artid=17
61 http://www.nusap.net/sections.php?op=viewarticle&artid=14

Fourth, even though participatory approaches should be defined according to the socio-cultural context in which they are applied, we have to explore and develop consensus/compromise oriented techniques for public involvement. As well, we could investigate in which step of the process (when and how) we should prioritize one of the approaches instead of the other.

The field of participation is plenty of opportunities to develop and carry out experiences with creativity and enthusiasm. But, I think that a basic pre-requisite for doing so is that participants should be wishful of taking part in public decisions, with compromise and responsibility. If people are eager to participate in defining their future, SMCE is also an adequate framework to develop and implement action-research, a practical way of democratizing science and politics.

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