SPATIAL DISAGGREGATION OF ECONOMIC RESULTS USING STAKEHOLDER INPUT AND GEO-COMPUTATION

Ву

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A la memoria de mi adorada madre, Marina Barajas

ABSTRACT

For a long time, cost-benefit analysis (CBA) has been used in many countries as an important tool for evaluating public policies. More recently, participation of stakeholders in CBA processes has become an important issue for governments. However, CBA by itself does not provide a good environment for public participation. A major reason for this is the lack of accessible methods for spatial disaggregation of consequences after economic analyses (such as CBA) have been conducted. In order to approach this lack, a participatory geographic information systems (PGIS) approach is proposed in this thesis. This approach is designed to generate spatial disaggregation and map representations of nontechnical factors, such as environmental, political and social impacts that affect public decision-making. A new conceptual framework is proposed for combining community knowledge and the technical data available for the specific situation. The conceptual framework model impacts in cases where uncertainty exists, using the soft computing theory of fuzzy logic to generate a raster map based on spatial inputs provided by the stakeholders. To implement the conceptual framework in real situations, an information technology (IT) system, called DISCUSS (Decision Information System for Community Understanding of Spatial Scenarios) has been also developed. The conceptual framework and DISCUSS are intended for situations where the government chooses to evaluate a policy using CBA, and desires to encourage public participation in disaggregating and evaluating the results identified by the economic method. DISCUSS was tested in a public participation case study with long-term impacts over a large area of south-eastern Australia. In this case study, the developed process proved to be a low-cost and efficient option for spatially disaggregating results from CBA and at the same time a valid approach to foster public participation. DISCUSS, applied using the conceptual framework, has a great potential in other public decisionmaking processes where restrictions on spatial information and economic resources are present, and aspects such as equity and environmental sustainability are important to evaluate.

STATEMENT OF ORIGINALITY

This thesis comprises only my original work. It does not contain any material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge, this thesis contains no material previously published or written by another person except where acknowledgment is made in the text.

The text of this thesis contains no more than 100,000 words.

Daniel Paez

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ACRONYMS

AHP Analytical Hierarchical Process

Al Artificial Intelligence

CBA Cost-Benefit Analysis (also called BCA)

CDSS Collaborative Decision Support System

DISCUSS Decision Information System for Community Understanding of

Spatial Scenarios

DSE Department of Sustainability and Environment – Victoria, Australia

DSS Decision Support Systems (DSS)

EU European Union

GAM Goals-Achievement Matrix

GI Geographic Information

GIS Geographic Information System

GIS-CK Geographic Information System for Community Knowledge

IRR Internal Rate of Return

IT Information Technologies

MCDM Multi criteria Decision-Making

NPV Net Present Value

PBSA Planning Balance Sheet Analysis

PGIS Participatory Geographic Information Systems (also known as

PPGIS)

SDI Spatial Data Infrastructure

SDM Sequential Decision-Making

SDSS Spatial Decision Support Systems

SEU Subjective Expected Utility

SI Spatial Information

1

INTRODUCTION

1.1 PROBLEM STATEMENT AND JUSTIFICATION

For more than three decades, governments have been using cost-benefit analysis (CBA) as an important tool to evaluate projects, programs and policies. This method has been tested in many situations and regions around the world. It is a current option for decision-makers and is encouraged for environmental policies in some countries such as the United States of America where Executive Orders support its use (OMB 1981, 1996). In most of the developed world and in many developing countries, CBA is the option most used by governments to make decisions when different investment alternatives are proposed (Farrow and Toman 1999).

CBA is popular around the world because of its ability to synthesise the benefits of the options proposed in a public policy evaluation into economic indicators for decision-making. Decision-makers can easily compare options when they are compressed into a single indicator and the differences between their benefits are quantified in monetary terms. These indicators—called the net present value (NPV) and the internal rate of return (IRR)—represent the net benefits that the community will receive if the policy is implemented. They are a picture of the amount (or monetary value) of the benefits of a policy alternative, or option, for society.

Although CBA is currently the most used methodology for evaluating alternatives in a decision-making process, this methodology on its own cannot produce all the

information that a decision-making process requires (Paez et al. 2004a). The CBA indicators do not show who is going to be affected or where the positive or negative impacts may occur. CBA results do not contain spatial references to the benefits (and costs) that they are forecasting. This identification of the beneficiaries and adversely affected entities, in conjunction with the figure representing the net economic benefits, are important for governments that wish to achieve a better balance between the technical and political aspects of a decision-making process. This individualisation of effects (or spatial disaggregation) is also needed to make explicit concepts such as environmental sustainability and equity when evaluating each of the alternatives proposed.

With the single figure produced by CBA, it is not evident (for example) whether a species affected negatively will be sustainable in the future. Similarly, the results from a CBA are not able to identify by themselves whether the best economic alternative will, at the same time generate a negative impact in the poorest areas of a city.

Governmental institutions and academia around the world recognise the importance of complementing the results from the CBA with an identification of the entities impacted if a particular option is implemented (Adler and Posner 1999; Farrow 1998; Toman 1998). Despite the demand for disaggregation of benefits and costs, in current practice, and after many years of developing alternatives, it is still a highly complex procedure which requires considerable effort (Morgenstern 1997) and which is affordable in only few decision-making processes. Current methodologies used to spatially disaggregate effects are complicated and, in most cases, highly demanding of resources (Bateman *et al.* 2003). Moreover, they are normally specialised to particular decision-making situations, are not applicable to the entire range of effects and might only consider the economic aspects of the decision and not the social and environmental impacts (Turner *et al.* 2000).

In addition, current methods for individualising effects in an economic evaluation use sophisticated technical procedures not comprehensible by the community involved in the decision-making process (Simon 1997, p. 91). This complexity in the analyses creates a poor environment for public participation, which today is fundamental for most of governments around the world after the multinational agreement Agenda 21 was signed (UN 2003).

Consequently, and considering the importance of integrating technical and political aspects of decision-making, the research problem explored in this thesis is:

Existing methods for spatially disaggregating consequences in public decision-making are complex, unsuitable for public participation and costly to implement. In addition, current methods do not provide information about such human aspects as political and social factors affecting the decision-making process.

This deficiency in current methods means that concepts such as equity and environmental sustainability are not adequately addressed, although today they are highly important for decision-makers in order to achieve sustainable development.

1.2 AIM AND OBJECTIVES OF THE RESEARCH

The aim of this research is to develop an alternative to spatially disaggregate impacts for those particular public decision-making processes that are based in CBA.

In order to achieve this aim, the following objectives have been identified:

- review current developments in decision-making, especially the application of CBA
- analyse existing methods used to disaggregate effects and appreciate how these procedures can be enhanced
- examine the importance of public participation in decision-making processes and how this can be extended through the use of geographic information (GI)
- develop a conceptual framework for simplifying the spatial disaggregation of effects in a CBA and allowing better public participation.
- develop the IT tools required to implement the conceptual framework in an existing decision-making situation

· test the conceptual framework and tools.

1.3 Scope of the research

This research has created a new conceptual framework for disaggregating effects in an economic analysis of public policies, using geographic information systems (GIS). Adopting this conceptual framework will allow governments, irrespective of their economic resources or social conditions, to identify more clearly the beneficiaries of the alternatives proposed and at the same time to have a clearer understanding of the environmental sustainability and equity of each of the options. This, combined with the use of community knowledge, generates better public participation, an aspect that guarantees the validity of the decision taken in the long term.

In addition, a participatory geographic information system (PGIS), as an IT tool for implementing the conceptual framework, has been created. This tool, called DISCUSS (Decision Information System for Community Understanding of Spatial Scenarios), permits government officials, community members and representatives of the private sector to apply the conceptual framework proposed in public decision-making processes.

During this PhD research a conceptual framework and related IT tools were designed, tested and refined, drawing on the literature reviewing experiences in many nations around the world and undertaking practical experiments in the State of Victoria, Australia. Since this research is generic in nature, the conceptual framework has been designed as broadly as possible so that it can be applied in other developed and developing countries. The IT tools, however, have been adapted to the current social conditions in the State of Victoria and the available spatial information (SI) of the region studied. The use of these tools in other states and territories of Australia, and in other nations, will require an analysis of those specific situations. In particular, special attention must be paid to aspects such as language, computer literacy and education of the stakeholders; available SI and geographic information systems (GIS); and legislation for decision-making and public participation.

Although the existence of several methodologies for evaluating public policies is acknowledged, because of time constraints this project had to be limited to

analysing those particular decision-making processes that use CBA. This economic methodology is currently the most used around the world for public evaluation of policies. In consequence, the conceptual framework and IT tools are developed for cases where CBA is used.

However, the conceptual framework is adaptable to those decision-making situations where tools similar to CBA (such as cost-benefit ratios and cost-effectiveness) are used or when other procedures for evaluating public policies require spatial disaggregation of benefits and costs.

The main purpose of this thesis is to provide a conceptual framework and associated tools for the disaggregation of effects in cases where CBA is used. Nevertheless, it is not intended to promote the use of CBA in government decision-making processes. Although the conceptual framework contributes to solving some current deficiencies of CBA, the main intention of this research is to improve the information available for public decision-making, regardless of the economic methodology used, the financial situation or social condition of the country.

1.4 METHODOLOGY

This research followed the five basic steps for scientific research proposed by Lang *et al.* (1991) and a similar approach used by Eagleson (2002):

- Define and study the problems associated with the lack of an accessible methodology for spatially disaggregation of consequences in public policy evaluations.
- Formulate a theory to describe the nature of the problem and its relevance in current public decision-making processes. Based on this finding, formulate a hypothesis to be tested.
- 3. Decide on the procedures to test the hypothesis and develop the necessary research instruments for this testing.
- 4. Test the hypothesis in a case study.
- Verify, reject or modify the hypothesis according to the findings in the case study.

These five steps constitute the basic structure of this thesis. The relation of these steps to the Chapters of this thesis is explained in the next section.

In order to identify the current problems with the methodologies for spatially disaggregating consequences, literature from economics and political science were used. For the development of the hypothesis, the conceptual frame proposed, the computer-based system and literature from engineering fields (mainly geomatics and computer science) were the primary sources of information.

The approach to evaluation of the conceptual framework and IT system was a case study from which general conclusions could be obtained. The case study was in the State of Victoria, Australia. The required spatial datasets for the case study were provided by the Land Information Group within the Department of Sustainability and Environment (DSE), which is currently the developer of the current spatial data infrastructure (SDI) for the State of Victoria and is also the custodian of most of the core datasets for the case study.

Technical, social and economical information about the particular situation studied was provided by the DSE Water Division, which was developing the public decision-making process called 'Lake Mokoan project'. With its support, and that of the Land Information Group, it was possible to access a significant number of stakeholders involved in the process. Qualitative research results from the stakeholders were obtained by applying the conceptual framework, IT system DISCUSS and surveys before and after the application of the conceptual framework in the case study.

1.5 THESIS STRUCTURE

This thesis has four main sections: background and overview (Chapters 2, 3 and 4), model and IT tools development (Chapters 5 and 6), model experimentation and formalisation (Chapters 7 and 8) and conclusions and recommendations (Chapter 9).

Figure 1.1 presents a flow of ideas and the different sections in this research project.

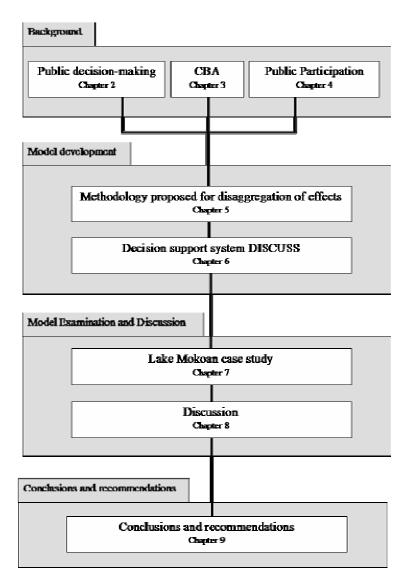


Figure 1-1: Sections and structure of this thesis

1.5.1 Background and overview

Chapters 2, 3 and 4 present a detailed description of the background theories used in this thesis and an overview of the current developments in decision-making, CBA, public participation and GIS. The main purpose is to observe in detail the different aspects of a governmental decision-making process in various situations where economic and social conditions are different and at the same time to appreciate how the multiple technologies, especially those related with spatial information, support a broad variety of decision-making processes.

Chapter 2 is focused on the technical and human aspects surrounding a decision-making process. The main purpose of this chapter is to present the

complexity of decision-making in public institutions. In addition, a discussion of the implication of rational analysis in decision-making is developed. Chapter 2 also analyses the state of the art in spatial decision support systems (SDSS), which are a sub-class of decision support systems (DSS). This Chapter finishes with the proposed trends for the future development of DSS and SDSS according to the new interests by governments in decision-making processes.

Chapter 3 studies CBA and the current methods used to disaggregate effects in an economic evaluation. Special attention is given to the relationships between spatial data and the methods currently used to spatially disaggregate effects in public decision-making. This chapter describes the research problem and a description of the different alternatives previously proposed to solve it.

Chapter 4 presents the social aspects surrounding a decision-making process by analysing the current justifications for including public participation in decision-making; the current problems regarding this participation; and the solutions proposed to better engage stakeholders in decision-making processes. In this chapter, the current relationship between public participation and technologies for obtaining and analysing spatial information is also observed. In particular PGIS, a division of SDSS, is the focus of analysis as the technological platform to enhance public involvement in decision-making.

The difficulties of including public participation when CBA is used in decision-making are also analysed in Chapter 4.

1.5.2 Model and IT tools development

This second section of the thesis presents the contribution of this research to knowledge. Chapter 5 introduces the hypothesis of this thesis and describes the conceptual framework according to the new trends for public decision-making, CBA and public participation identified in chapters 2, 3 and 4. This chapter presents a description of the conceptual framework, its procedures for application in real decision-making processes and how it could be used in the future to improve the analysis of concepts such as equity, environmental sustainability and the participation of the community in the decision-making process.

Based on the conceptual framework proposed in chapter 5, chapter 6 presents a description of the PGIS (called DISCUSS) developed to implement the conceptual framework. This chapter focuses on the use of GIS as the principal

technology underpinning DISCUSS. Chapter 6 also presents a review of other technologies and mathematical theories used to achieve the objectives for the computer based tool developed.

1.5.3 Model experimentation and discussion

The third section of this thesis comprises chapters 7 and 8. In these chapters the conceptual framework and IT tools are tested and then critically analysed.

Chapter 7 presents the case study 'Lake Mokoan', which is a real decision-making process in northern Victoria, Australia. In this decision-making process the conceptual framework and DISCUSS were used to promote public participation and at the same time foster analysis after CBA was applied.

Chapter 8 contains the critical analysis of the results of the 'Lake Mokoan' case study and proposes adjustments to the conceptual framework and DISCUSS. An effort is made also in this chapter to generalise the findings in such a way that the conceptual framework can be applied in other decision-making processes in developed and developing countries.

1.5.4 Conclusions and recommendations

The final section of this thesis is chapter 9, which includes the conclusions from this research project, the most significant findings and contributions of the research, as well as recommendations.

2

PUBLIC DECISION-MAKING

"The essence of ultimate decision remains impenetrable to the observer –often indeed, to the decider himself...There will always be the dark and tangled stretches in the decision-making process - mysterious even to those who may be most intimately involved."

John F. Kennedy, quoted in Allison (1971, p. 1).

2.1 Introduction

Probably the most important function of governments is to regulate and distribute the resources of a community. To accomplish this, it is normal practice to develop decision-making processes with the objective of maximising the net benefits for society. This commonly involves applying economic methodologies.

These processes of selecting the best course of action in government activities are the focus on this thesis. This chapter presents an overview of governmental or public decision-making, concentrating on the different factors affecting these processes. The main purpose of this analysis is to study the models used by governments to make decisions, the motivation of the leaders, the difficulties encountered and the implications of having computer systems supporting them. The analysis observes decision-making not only from the technical or scientific point of view; political, social, and psychological aspects are also considered.

The outcome expected from the analyses in chapter 2 is a better understanding of the current relation between IT and public decision-making as well as the future trends proposed in the literature for improving this relation.

2.2 THE DECISION-MAKING PROCESS

2.2.1 Definition, motivations and parts

Depending on the area of knowledge, the term 'decision-making process' will have different connotations.

According to Pomerol and Adam (2003), decisions are the consequence of dissatisfaction because decision-makers have a 'more desirable state', which they wish to accomplish. The difference between the desirable scenario and the actual world generates dissatisfaction, which, as a result, provokes actions (decisions) intended to reduce their dissatisfaction. (Pomerol and Adam 2003). Figure 2-1 represents this perception of the decision-making process in an optimistic world where each decision reduces the difference between the desirable world and the current state, generating, as a result, less dissatisfaction for the decision-maker.

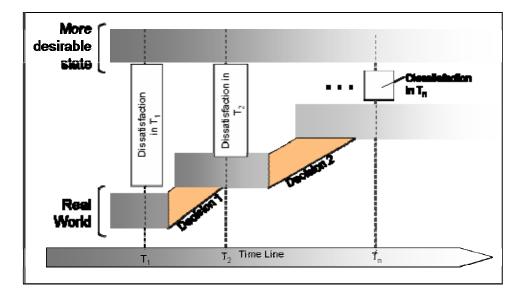


Figure 2-1: Decisions seen as a means to reduce dissatisfaction (adapted from Pomerol and Adam 2003)

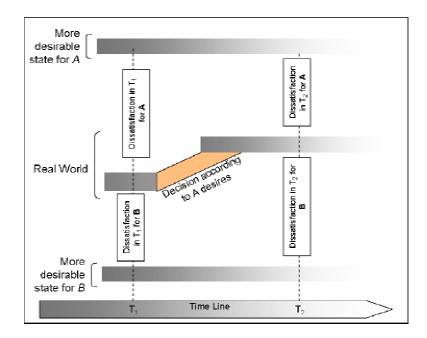


Figure 2-2: In some circumstances, the 'more desirable state' of one decisionmaker could be different from another, meaning that a certain decision, instead of reducing the level of dissatisfaction, increments it.

This dissatisfaction-based perception of the decision-making process shows how complex this process can be. The description of a 'more desirable state' will depend on the individual view of the decision-maker (Pomerol and Adam 2003). For instance, the desirable future state of decision-maker *A* might be different from the one that decision-maker *B* has. In this case, a decision that is taken according to the desires of *A* might increase the difference between the desirable world for *B* and the actual one, a situation that creates more dissatisfaction for *B*. (Figure 2-2).

Decision-making is a very important activity in our society and consumes much of the effort of managers in organisations. In a practical way, leaders dedicate most of their time to *solving problems* and *making decisions*, which are the two main tasks that compose a decision-making process (Simon *et al.* 1986).

Solving problems involves deciding the course of action, setting goals and finding possible alternatives or actions. It could also be classified as the planning or design activities of the organisation where architects, engineers, economists and other streams of knowledge within an organisation combine to produce possible courses of actions for a particular issue.

Making decisions, on the other hand, covers those activities where members of an organisation have to evaluate the different alternatives (proposed in most of the cases by the *solving problem* work) and choose the one believed to solve the issue. Managers, ministers, directors and executives are *making decisions* when they assess the different alternatives according to their goals or preferences and decide on a particular direction, preferring one alternative over the others.

This thesis focuses primarily on those events related to *making decisions* (to evaluate and to choose). It is not assumed, however, that these *making decision* duties are always preceded by a *solving problem* situation. *Making decisions* and *solving problems* are not always linear and rational activities. They are juxtaposed, and even though in most cases a *solving problem* activity is followed by a *making decision* work, there are also cases in public and private organisations in which a decision taken requires a *solving problem* effort afterwards (Simon 1997).

For this particular research, in which the main focus is on public or governmental activities, decision making is also defined as public policy analysis or public policy evaluation. These terms are commonly used in political science literature (Bobrow and Dryzek 1987; Nagel 1991) and do not refer only to evaluation of policies, but also projects and programs. Herbert A. Simon (1997) also proposed to use interchangeably the terms 'choice' and 'decision' for all processes in which a selection is developed, regardless of the ordinary connotation of self-conscious, deliberate, rational selection that they normally carry.

Thus, in this thesis decision making, choice making, public policy analysis and public policy evaluation are synonyms which express a selection, despite the degree of rationality involved.

Those who have an interest in or have been affected by public decision-making processes are defined in this thesis as stakeholders. Government officials of different levels (Commonwealth, state, municipal, local, etc.), community interest groups, private industry representatives and academics are examples of stakeholders commonly found in public decision making. In most cases the officials from the governmental institutions conducting the decision-making process are considered both decision makers and stakeholders, since they are assumed to represent the interests of their entire jurisdiction.

The implementation of the decision taken after a public policy evaluation always has an effect in the future. In this thesis these effects are called *consequences* or *impacts*. The term *entity* is used in this thesis to define those people, animals or things affected by the consequences or impacts of a decision. An entity could be a single farmer, the inhabitants of a town, the environment, an ecosystem, a river, the productivity of a region, etc.

An entity is receiving a benefit is called a *beneficiary*. On the other hand, if an entity is receiving a cost or a negative impact, it is called an *entity affected* or a *negatively impacted entity*.

In all decision-making processes, two or more possible courses of actions are available. These possible courses of actions are denoted as *policy options* or *policy alternatives* in this thesis. In some circumstances and depending on the context, the terms *options* or *alternatives* are used.

Decision-making analysis is an important activity, with an extensive literature not only in the political science area but also in economics, engineering, architecture, psychology and more. Simon *et al.* (1986) have shown how investigations in many sciences such as psychology, economics, mathematical statistics, operations research, political science, artificial intelligence and cognitive science have influenced the method of analysing decisions in public and private institutions, and at the same time have contributed to understanding this human process better.

This diversity of sciences involved in the same concept has generated several theories about the motivations, parts and characteristics of decision-making. Nevertheless, it is commonly agreed that decisions are taken in order to obtain a goal, which could be personal, institutional, political, economical, etc. Governments embark on decision-making processes to solve a particular issue, to fulfil a campaign promise, to distribute better specific budget allowances or, in some cases, just because of a feeling of a leader. In all these cases, an objective (which can be dynamic) directing the choice-making work can be discerned.

The differences about decision-making in the different areas of knowledge involve their interpretation of the justification for the decision goals. For Nagel (1991, p. 33), who represents the economic point of view, the main goal of decision making for governments is to achieve effectiveness and efficiency in the

use of the resources available. For Simon (1997, p. 55), a psychologist, the aim of a decision is not something completely objective or ethical: it is a combination of mixed aspects which produces a decision justification.

2.2.2 Dynamism of the decision-making process

Public decision making is not a straightforward procedure. Decision making is a highly complex process involving multiple dimensions (Marinetto 1998, p. 60), where each specific moment in the process can have a different goal. This changing of goals occurs because an initial goal might produce some discrepancies between leaders or participants in the decision-making process, which cause a revaluation of the goal. The next goal proposed might be closer to all the decision makers, but concurrent discrepancies might cause its revaluation again. This process continues until a final goal is reached (Simon 1997, p. 1).

For public institutions, Marinetto (1998, p. 3) has presented policy evaluation processes as a set of activities which, after numerous modifications, fuse to create the decision process. These modifications of the activities are what constitute a dynamic process.

Therefore, decision making is a process that could have one or several goals and where these goals are dynamic, creating a complex situation over time. These shifting definitions of issues are very important to better understand how the choice-making process is taking place (Ham *and Hill* 1984, p. 12), no matter the discipline under which it is analysed.

Within the dynamism caused by the modification of goals, fusion between the planning (also called design activities) and choice-making tasks occurs. Decision makers could, at some stage, be deciding about one option while at the same time they could be producing another alternative to be evaluated.

In addition to the shifting of goals in a decision-making process, it is also a reality that decision making is attached to the institution or organisation conducting the process. Each organisation has its own processes which define how decisions should be taken. This connection between the decision-making process and the organisation also generates a linkage between 'deciding' and 'doing' (Simon 1997, p. 1). Decision makers know that the process does not stop at the time the decision is taken; the implementation of decisions—or the 'doing' phase of a

policy, project or program—is also important. This is particularly so for public institutions were decisions require justification to electorates.

Consequently, the decision-making processes are modified over time in accordance with the 'doing' required by each of the possible decisions in such a way that when a possible alternative is evaluated, the implications required for the implementation might necessitate a modification in the proposed aim or in the evaluation method. Simon (1997, p. 3) has considered choice making not as linear processes. For him each problem causes another decision that sets another agenda and opens another decision process.

The complexity of the decision-making process and the dynamic involved means that public policy evaluation cannot be seen as a purely rational exercise. In the next section, this affirmation of being a partially irrational process is examined.

2.2.3 The reality of the decision-making process

Historically, natural sciences describe a complex phenomenon by developing a general theory or law for perfect conditions (for example the ideal gases theory). The purpose of a theory for perfect conditions is to simplify the phenomenon in such a way that the principal factors are identified, and at the same time the possible impacts in the real world can be analysed individually (Simon 1997).

During the first half of the 20th century, researchers in decision making took a similar theoretical approach and developed the theory of subjective expected utility (SEU). The SEU theory establishes the conditions of perfect utility, where all the probabilities of distribution of the variables are known (Simon *et al.* 1986). Put another way, a perfect decision-making environment occurs when the decision maker knows all the variables affecting the different options, so a function that maximises the utility according to goals established in advance can be created.

SEU does not deal with the set of goals or the evaluation method. It focuses on producing a perfect model in which nothing is left outside a rational justification, and where uncertainty of the future consequences does not exist. The SEU model is the perfect conditions apply to the situation. By comparing this perfect situation with the real world, researchers visualise how difficult it is to remove uncertainty from all the factors affecting a decision process.

Because of the complexity of the decisions in the public sector, many of the variables or factors affecting the process are unknown or cannot be estimated by rational methods. Thus, the public decision-making environment is not free of uncertainties and therefore the conditions of the SEU theory rarely exists (Simon *et al.* 1986).

Consideration of the psychological, historical and political views of decisionmaking clarifies why an SEU approach is rarely possible. These analyses are related to the human and social factors present in most of the decision-making processes developed by government institutions.

Herbert A. Simon could be considered as one of the major investigators of the psychological aspects affecting choice-making processes in organisations. In one of his principal books (Simon 1997) a complete explanation of the psychological aspects affecting the individual and the institution is presented. He points out that decision makers are individuals with the goal of satisfying their surrounding communities and not only maximising resources. This contrasts with the economic theories of decision making where the goal is to make the most of the resources available.

The aim of satisfying creates in decision makers an ability to make the decision work without considering all the possible alternatives (Simon 1997, p. 119). Consequently, decision makers have a bounded rationality that is substituted in decision processes by non-rational human social behaviour.

This non-rational human social behaviour also permits administrators and decision makers not only to fulfil their desires but also to substitute with their own views the lack of information caused by the limits of human knowledge and reasoning.

Marinetto (1998, p. 99) has also explained the reality of non-fully-rational decision-making processes in the decision makers satisfying needs through historical aspects present in the agency, institution or nation where the public policy analysis process is taking place. An example of decision-making process affected by history is when a nation decides not to develop a beneficial trade agreement because of a past armed confrontation.

Averch (1990, p. 142) has similarly concluded that political influences in decision making are caused by the *myopic* behaviour of politicians, stakeholders and

institutions. They (the institutions, stakeholders or the politicians) are only concerned with the direct impacts on their agenda and do not take into account how a decision will affect another sector, stakeholder or institution.

In conclusion, the SEU theory is infrequently present in actual choice-making processes. The reality is that a claimed 'rational decision-making process' is not completely rational even when desired by the decision maker. The world is a complex system that can rarely be simplified by rational models. Decision makers are also influenced by irrational factors (political, psychological, and historical) that take over where rational analysis stops.

In the next section, the relationship between rationality and public decision making is studied in detail.

2.3 RATIONALITY AND PUBLIC DECISION-MAKING

For the specific case of decision making in the public sector, the level of rationality that is intended and achieved depends on social, economical and political conditions surrounding the institution or individuals in charge of making the decision. A central focus of this thesis is those processes where rationality is intended at a high level, but where at the same time social and political factors are affecting the decision-making process, making it difficult to achieve a high level of rationality in all parts of the decision-making.

A search for rationalism is normally found in democratic nations where power is distributed between legislative, executive and legal branches. Different economic realities and the level of development could affect the availability of information for rational decision making (Paez et al. 2005), making it impossible for some countries to have full rational public decision making, even if highly desirable to decision makers.

Although the use of rationalism in decision making is widely promoted around the globe for sustainable development (Schmandt *et al.* 2000), some authors have pointed out the limitations that should be taken into consideration when seeking purely rational decision-making processes. These limitations are discussed in the next section.

2.3.1 Limitations of rationalism in public policy evaluations

Simon (1997) has argued that a wholly rational decision-making process requires complete knowledge and anticipation of the consequences that will follow each of the alternatives proposed. If all this information about alternatives and consequences is available, the SEU theory exists, creating a complete optimisation of resources in accordance with the goals proposed for the decision-making process.

However, the reality of most decision-making situations is that they confront our natural world, which is highly complex and very difficult to predict using exclusively rational methods. Lindblom (1968) has maintained that comprehensive rationality is unattainable because decision makers have to deal with issues of a very complex nature. He has also affirmed that searching for a decision-making process n which all the issues and alternatives are simplified to a rational perception is a detrimental aspiration in normal conditions.

Marinetto (1998) has perceived rationality as an element in decision making that is circumscribed by the mental capacities of humans because decision makers cannot have access to all the information required to analyse every possible course of action. Simon (1997, p. 95) has also subscribed to this perception of rationality and questioned the intention of some analysts in assuming that economic analysis tools are capable of dealing with the complexity of the environment. Economics in the theoretical world is very rational, but when the model is placed in the real world, the application confronts many difficulties. Experience has shown to decision makers that the perceived world in a decision-making process is a simplified representation of the confusion present in our real world (Simon 1997, p. 95).

Carley (1980, p. 34) has perceived the modelling of impacts or consequences under a rational process as partial, since political and bureaucratic elements are normally not included, although they exist in the reality of most choice making. This creates what is seen as a representation of the real world, but is in reality an incomplete picture because human aspects affecting the future consequences are not present.

Carley (1980, p. 34) in his criticism of rationalism in decision making has also considered that because of the lack of information for public evaluation of policies (which inevitably leads to assumptions in predicting consequences) a rational

analysis can produce—in a political arena—the result that every party or side desires, even when they are contradictory (Carley 1980, p34). Under this perception, rational decision making could be seen as a tool capable of justifying any decision, where the real moral and ethical values are hidden by a fictitious optimisation of resources.

Authors in the literature have not only been critical of the possibility of acquiring a fully rational estimation of the consequences of proposed alternatives. Herbert A. Simon also perceived the behaviour of decision makers when choosing an alternative as impulsive. 'The pattern of human choice is often more nearly a stimulus-response pattern than a choice among alternatives.' (Simon 1997, p. 117).

The sequential decision-making (SDM) model has also been proposed as an ideal form to have rational thinking in all decision-making processes. This model presents decision making as a three step sequential process: intelligence, design, and choice (Figure 2-3).

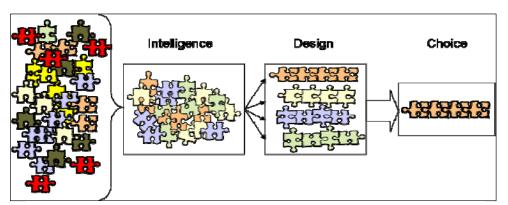


Figure 2-3 Sequential decision-making (Paez 2005, adapted from Langley et al. 1995)

The SDM model, as idealistic for all choice making processes, has been also questioned. The stability of SDM model depends highly on the rationality of the aim of the decision. In reality, organisations have ambiguous goals, diffuse actions and many participants in the decision-making process, with individual goals to be achieved (Langley *et al.* 1995, p. 262).

Furthermore, personal goals might interfere with the organisational goals and vice versa, meaning that the SDM model lacks an understanding of the selfishness and struggles for power of administrators in an organisation (Simon

1997, p. 87). Therefore, the SDM Model is not always a desirable decision-making pattern, as it cannot reproduce the human reality behind decisions.

Many authors (mainly from the humanities) question fully rational decision-making processes where space for other factors (such as emotional, historical and political) is not provided. Processes of making decisions are not only composed of rational thinking; room for including the human reality of the decisions must be included to fully understand the decision-making environment (Marinetto 1998, pp. 17 - 23).

However, rationalism retains supporters who observe the importance of focusing decision making around rational thinking. In the next section, their arguments in defence of rational choice-making are presented and some conclusions from the point of view of this research are also proposed.

2.3.2 Advantages of rational analysis

Rational decision making in government institutions has been seen not only as beneficial to morally justify spending of the public resources but also as an important characteristic in public policy evaluations capable of producing a better final decision for society.

Carley (1980, p. 32) has condensed these benefits of rationality in decision-making:

- Rational analysis promotes a systematic, orderly approach to the study of a policy problem, which at the same time generates in an institution the possibility of reviewing past decision-making experiences with the aim of improving those to be developed in the future.
- 2. When rational analysis is used, a clearer definition of the problem can be achieved. This allows the decision maker to deal simultaneously with all the aspects affecting the decision.
- 3. From the point of view of the political process, rationality normally facilitates transparency by assisting all the parties in the decision-making process with their needs for information. It is a normal practice in rational analyses to generate an environment where procedures and results are presented to all the stakeholders for their consideration.

- 4. Only through rational analysis can results be efficiently achieved in decision making.
- 5. Rational techniques, coupled with an aggressive public participation agenda in the public policy making process, can help and foster the involvement of all the stakeholders affected in the process. If rational techniques are not used as the basis for the discussion of the possible actions, a difficult environment is generated for negotiating the differences.
- 6. Rational analysis also promotes better forms of presenting the basic data of a problem and the transformations made to produce the estimation of consequences. This aspect, which is directly related to generating a better environment for public participation, allows expert and non-expert participants in decision making to understand better the proposals made by the technicians.

This summary of benefits that rationality brings to public decision making might be seen as contradicting the limitations of rationality presented in the section 2.3.1.

While some authors appreciate rationality as fostering public participation (Carley 1980, p. 23), others have seen rational analysis as a barrier for community inputs to the process. This particular aspect of the decision process will be analysed in chapter 4, where a more detailed analysis of public participation in choice making is developed.

From the political point of view, contradictions of the benefits of rationality for the decision-making process are also present. While some authors (such as Adler and Posner 1999) have argued that rational analysis is a tool to obtain whatever result is desirable, others (Carley 1980) observe in rationality an opportunity to advance the transparency of information in the evaluation of the public policy. In any case, most authors agree that it is a starting point and an engine that generates a more stable public debate within the decision-making process.

In conclusion, rational analyses in decision making are present in almost every situation and can be justified from many points of view. Economists, psychologists and politicians agree that in our current world, and because of the political conditions in democratic societies, rationality (or at least the search for it) is part of public decision-making.

However, rational analysis by itself cannot condense all the complexity of our world and cannot model all the other factors influencing the decision-making process. In consequence, rationality in decision making is a necessity, but with important limitations that should be acknowledged in order to balance the choice-making process with the human nature of the decision makers and stakeholders involved in the process.

The development of rational decision making has been followed by the inclusion of computers as tools for supporting decisions. Currently, computers are present in most of the models and estimations required in a public policy evaluation. The next section presents a summary of the influence of computers in decision-making.

2.4 DECISION SUPPORT SYSTEMS (DSS)

Information technologies have modified many activities in our societies and decision making has not been an exception. For more than 30 years, computers have been used to support choice making in the private and public sectors.

The use of computer tools during choice making constitutes the creation of decision support systems (DSS). Although computers have modified very modestly the patterns or models used by organisations to make decisions (Simon 1997, p. 21), they are currently present as supports to these choice-making activities. Our present world is full of information and computers have been designed to optimise this information. Similarly for decision making, 'the role of computers is not to change the behaviour of organizations when taking decisions, but to manage the information available' (Simon 1997, p. 22).

In this section, an analysis of DSS is developed. The main purpose is to understand its importance in a decision-making process and the current trends in public policy evaluation processes. A special interest is placed in spatial decision support systems (SDSS), which are those DSS that use geographic information systems (GIS).

2.4.1 Defining a Decision Support System

The term 'decision support systems' (DSS) emerged in the IT community at the Massachusetts Institute of Technology, where important documents in IT

research started focusing on the use of computers to support decision making (Gorry *et al.* 1971; Little 1970). By the early 1980s, many books and papers were punished in the DSS field, creating an important recognition of DSS in IT.

At that time, DSS were considered interactive computer-based systems which help decision-makers utilise data and models to solve problems (Sprague 1986). The main objective of DSS was to combine database, interface and model components towards a specific problem (Sprague 1980).

An important focus during these initial years of the DSS was to create systems where users had control over the models and representations used, rather than simply black boxes where an input from the user generated an output that was not easily explicable (Barbosa and Hirko 1980).

However, some of these concepts changed for the 1990s. The increased capabilities of the computers and the new graphical interfaces allowed these systems to become a more interactive tool, flexible and adaptable and with decision rules, models, databases and suitable formal representations of the decision makers' requests (Pereira and Quintana 2002). With the incorporation of artificial intelligence (AI) into the analysis, the transparent box became more obscure for non-expert users.

Paruccini (1991) described how 'DSS are not intended to replace the decision-maker in solving the problem; they are constructed to help the user to take responsible and documentable decisions, which use the information and scientific potential available as much as possible'.

Nowadays, the definition of DSS is very much in line with the principles followed during the last decade, yet many new IT areas participate in the development of these systems. A typical current definition describes DSS as 'an interactive, computer-based tool or collection of tools that uses information and models to improve both the process and the outcomes of decision-making' (Lessard and Gunther 1999).

The principle of supporting the decision makers has been established for many years, as well as the interactivity of the systems. However, current DSS tend to be more complex by containing a set of systems linked by networks of computers as well as incorporating new emerging technologies (e.g. wireless applications and web-based systems).

The increased potential of computers has made them important components of public decision making. DSS commonly incorporate rational procedures that allow better documentation of the process to be made, to select the better alternative. With this, the decision maker is shielded by the umbrella of objectivity, which is believed to separate decision makers from moral judgments.

However, this vision of DSS as a means to increment rationality is not agreed with by all fields. Currently, some authors encourage analytical methodologies while others promote qualitative approaches. There is, in some circumstances, focus on the technology and in others concentration on managerial and organisational issues (Forgionne *et al.* 2003). This is probably a consequence of the nature of decision making, as it is a complex process that can be analysed from many different points of view, with objectives that can be defined from many different angles.

Regardless of this, DSS continues to be successfully applied across a variety of public and private organisations and entities. These applications continue to involve the user more directly in the design, development and implementation process (Forgionne *et al.* 2003).

Because of the importance of decision making in many of the activities of our current society, DSS has been extensively studied. Therefore, it is possible to specify the definition of DSS according to its function or the type of information it is capable of processing (Mora *et al.* 2003, p. 51). Consequently, it would be inappropriate for this thesis to review the entire range of DSS reported in the literature.

Taking into consideration the main focus of the present thesis in spatial information and GIS as option to spatially disaggregate consequences, the next section is an analysis of spatial decision support systems (SDSS), which are a particular class of DSS that utilise spatial information as input and GIS as the main processing technology.

2.4.2 Spatial decision support systems (SDSS)

Just as DSS is a difficult concept to define, the literature about SDSS has also presented many different definitions of this particular class of DSS (Keenan, P. B. 2003). The development of SDSS occurred as a natural consequence of the new ability of computers to cope with heavy demands of spatial information. By the

1980s, the concept was becoming frequent in the literature and SDSS developed into an important focus of the GIS community (Armstrong *et al.* 1986). The controversy in the literature surrounding the definition of SDSS comes from the difficulty of differentiating whether a computer-based system is a GIS or a SDSS.

A GIS is a general-purpose technology for handling geographic data in digital form with the capability of pre-processing data from large stores into a form suitable for analysis (reformatting, change projection, re-sampling, generalisation, etc.); direct support for analysis; and modelling and post-processing of results (reformatting, tabulation, report generation and mapping) (Goodchild 1993). GIS is part of the spatial technologies, which are those capable of manipulating, storing and displaying spatial data using integrated and explicit functions (Batty and Densham 1996).

On the other hand, the concept of SDSS is related more to the development of computer-based solutions with the particular purpose of supporting part or all of a decision-making process. SDSS are commonly considered as application-specific software solutions, and GIS are described as generators for SDSS (Keenan, P. 1997).

In general terms, SDSS is a particular class of DSS in which computer-based systems are created to support decision making processes that have spatial information or analysis as one of the main sources of information. SDSS rely on GIS as the main instrument for analysis (Keenan, P. B. 2002).

SDSS differs in many ways from traditional DSS. SDSS are developed to cover interdisciplinary problems where data from many different sources are merged to support the decision-making process, rather than traditional DSS which have a focus on a particular resource and single decision-makers, and demand less expertise in the development of the solution (Feeney 2003, p. 198).

For many decades, the spatial information industry has encouraged the use of spatial information as an important part in decision making. This effort has obtained echoes at high levels in governments where political and economical supports have been provided for spatial information development as a means to obtaining better decisions (Williamson 2003).

From the technical point of view, spatial information and GIS have proven to be adaptable to many decision-making situations (especially those that involved environmental issues) since decision-making processes are usually characterised by spatial features (Pereira and Quintana 2002). Thus, SDSS, which are DSS that use spatial information and GIS appear today as the preferred computer technology to support choice making.

In some technical literature, SDSS and GIS tend to be placed at the same level. In this thesis, this is not the case, and a GIS is considered a support technology for SDSS.

Despite the increasing development of SDSS and the permanent growth of GIS in the IT community, in reality there has been a lack of practical usage of SDSS (Uran 2002). Currently, SDSS applications appear to lack full understanding of the main purpose of a DSS, creating a widespread view that in many cases SDSS often cannot support the decision that motivated its creation (Uran and Janssen 2003).

In addition, currently SDSS require important resources from the technological side (hardware and software) and from the information side, making difficult their development and application (Uran and Janssen 2003).

As Mora *et al.* (2003) have affirmed, DSS are here to stay and, therefore, SDSS are also to be present in the future of decision making. However, a review of the experiences (positive and negative) with computers in choice-making for more than 30 years has created new trends in the development of DSS and SDSS. Researchers have learnt from their mistakes and the new focuses on public policy evaluation have modified the focal point of DSS. The literature in this respect is not uniform, and many trends are proposed for the future. In the next section these possible trends for developing DSS and SDSS are presented as guidance to build a solution for the research problem presented here.

2.4.3 New trends in DSS

DSS and SDSS are important for governments and private organisations. However, the implementation of DSS demands resources such as computer hardware, software, data and analysts. Researchers are therefore looking for ways to make DSS less expensive, more attractive to decision makers and at the same time easier to apply.

There are two main trends in the literature for the development of future DSS. Some researchers encourage the development of more sophisticated IT systems which, by rational methods, reduce the uncertainty in the decision-making process. Other investigators believe in a future generation of DSS where more room for other factors affecting choice-making (such as politics, history and psychology) is provided.

Supporters of more advanced rational tools are Manuel Mora, Guisseppi Forgionne and Jatinder N.D. Gupta. In their book 'Decision making support systems: Achievements and Challenges for the new decade' they prognosticate that future DSS will evolve in such a way that 'many tasks that had been assigned to human experts can be delegated to virtual expertise within the decision-making support system' (Mora *et al.* 2003).

The future vision of choice making under more powerful rational analyses lies with IT systems powerful enough to cope with the complexity of our world. Under this scenario, future DSS reduce uncertainty to the point that doubts about the consequences of the alternative are nominal and, following the computer choice, will guarantee a better decision.

The opposite trend is to design DSS and SDSS in a more flexible way by incorporating diverse styles of analysis (not only rational) to allow more space for human factors affecting the choice-making. Under this scenario, researchers perceive future DSS as flexible computer-based tools where a better picture of the entire decision environment can be drawn by the decision-makers and stakeholders.

Examples of this trend are systems such as GOVERNe (Quintana *et al.* 2002), where the DSS was designed not as a deterministic tool, but as a supporter of the discussion between stakeholders in a water allocation problem. In this type of system the intention is to help the choice-making process 'by placing the system into a social process instead of embedding the social process into the system' (Pereira and Quintana 2002)

Uran and Janssen (2003) have also supported the need of future SDSS to be more open to the human reality of decision making rather than having more accurate rational analysis. After analysing five important SDSS in Holland, he has found that one important justification of the lack of use of SDSS is the desire of

technocrats to drive the development of the system in accordance with the available technology, rather than focusing on what users of the system need and can handle. For them, more sophistication will not improve the applicability of SDSS in government decision making but, on the contrary, it might adversely affect how systems are seen by decision-makers (Uran and Janssen 2003).

Stuart S. Nagel has criticised the trend of increasing rational analysis in choice making. For him, technocratic solutions limit the possibility of achieving agreement in public policy evaluation processes because these types of solutions based on rational analysis produce only one recommended alternative to be implemented, giving little or no room for negotiation. In contrast, flexible decision-making processes with multiple goals and alternatives promote agreement between parties in evaluations of public policies (Nagel 2002, p. 6). Therefore, DSS with more sophisticated rational analysis, capable of dealing with more complex issues than current systems, are not a guarantee that relations between stakeholders in a decision-making process are improved.

Nagel even promotes a different approach to public policy evaluations. The main objective in decision making should always be directed to find a super-optimum solution (or win-win solution) in which everyone exceeds their expected benefits (Nagel 2002, pp. 5, 6 and 24). A DSS based on this type of analysis cannot be based only in rational analysis, since finding a solution where everyone gains contradicts, in most of the cases, principals guiding optimisation of resources.

For the future, the main objective of a DSS appears to be supporting the human aspects of decision making, rather than been systems for documenting or justifying decision makers' desires. The development of DSS that is intended to better the decision-making process and rationality on its own is insufficient. Decision makers in the public sector desire new IT tools that allow them to cope better with the complexity of our world. However, they also want tools that deal with the reality of choice in the public sector, which involve complex negotiation of emotional, psychological and political factors between stakeholders.

If the development of future DSS focuses only on obtaining more advanced and powerful procedures to reproduce our real world, such future systems will definitely reduce uncertainty in decision making. However, they will be only able to support the decision-making process developed in accordance with SDM model, which is the only model for taking decision where a full rational process is

acceptable in all the different sub-processes. DSS restricted to rational analysis cannot support other models for decision making, since these all contain some degree of irrationality.

It is important to note also the new trend of relying more on group decision making than on individuals taking the final decision. For the past 15 years, organisational development in the public and private sectors has followed a trend towards a more horizontal structure (Jankowski and Nyerges 2001), resulting in responsibility in decision making being distributed at the different levels of the organisation.

The evolution of DSS tends to show a transition from a small number of experts to a system where entire communities participate in the development of the alternative chosen. 'Citizens and community groups are increasingly demanding a voice in these decisions, and developers are responding' (Feeney 2003, p. 198).

In conclusion, the development of more sophisticated rational procedures in DSS will occur, as it has been occurred for the past 30 years. Acceptance of these new advances, so they can get used in practice, will required also tools that support decision making as a human activity involving individual desires, rather than a machine alone selecting the best alternative.

2.5 REVIEW

Decision-making processes in government institutions are complex. The complexity is mainly a consequence of their being human processes where unpredictable human factors are juxtaposed. In addition, technical procedures used to predict consequences of proposed alternatives cannot fully model our complicated natural and societal world.

This means that decision-makers assume in complex situations the existence of significant uncertainties in the rational analyses, despite the best efforts of scientists, economists and planners to predict all the consequences. Cortner (2000) has argued that there is no truly objective science. While many may disagree with this, subjectivity is clearly a factor when complex environmental and social interactions are involved in a decision-making process and decision

makers are aware of this subjectivity when the results from the rational analysis are presented.

For the past 30 years computer-based systems have been added to decision making with the main purpose of reducing uncertainty and obtaining better outcomes. These computer systems in choice making, called decision-support systems (DSS), have continually sought more complete procedures that reproduce with more exactitude the reality surrounding the decision-making process.

In recent years spatial decision support systems (SDSS), which are DSS that use mainly spatial information and GIS, have grown in popularity to become an important tool, not only to model natural phenomena, but also as an advanced instrument to communicate technical results to a non-technical audience. SDSS are of increasing interest for governments, especially when outcomes contain spatial references.

DSS, and especially SDSS, have proven their ability to support decision-making with information, yet they have not modified the way decisions are conducted. DSS are expected to continue evolving and growing in the future.

The literature suggests two possible paths for future evolution. While some researchers projected a continuous evolution of the technical aspects of the DSS, others believe that the future of DSS is to support, with information and data processing, not only technical aspects of the decision-making process, but political, social, emotional and general human aspects, with the main objective to support a better environment for discussion and, therefore, consensus.

The proposed option for DSS, and in particular of SDSS, is to develop not only in the technical aspects, but also their support for human factors affecting the decision-making process. Future systems under this trend are conceived as flexible structures capable of being applied not only under the SDM model, but also under other decision models. The future for DSS should not be fully rational because 'rational analysis carried on in an ignorance of political reality, may well end up so divorced from social reality as to be of little use to anyone' (Rosenbaum 1998). Systems such as GOVERNe (Quintana *et al.* 2002) are a good example of the direction that SDSS are taking for the future.

Therefore, this thesis will consider the reality of the decision-making process, analysed in chapter 2, and the future trend for developing flexible DSS as the basis for a new conceptual framework and the IT system DISCUSS.

In chapter 3, one particular sub-process within decision-making—the evaluation of alternatives—will be studied in detail. In particular, cost-benefit analysis (CBA), which is currently the most popular economic methodology for evaluating alternatives in a choice-making process, will be analysed. CBA lacks an efficient method to spatially disaggregate effects. This lack is the justification and primary focus of the proposed framework and DISCUSS.

3

COST-BENEFIT ANALYSIS AND SPATIAL DISAGGREGATION OF CONSEQUENCES

3.1 Introduction

In chapter 2 an analysis of governmental decision making was made. The conclusion was that decision making is not a fully rational procedure, and other human factors, such as politics, emotions and history, also influence choice-making. New trends in the design and implementation of DSS were identified. Future DSS will focus more on supporting discussion in the choice-making process rather than systems capable of substituting the decision maker with rational analysis.

This chapter presents a detailed analysis of one of the most important parts of decision-making: the evaluation of alternatives. In particular, cost-benefit analysis (CBA) will be the central methodology studied. CBA is currently the most popular and relevant methodology to conduct evaluation of alternatives in a decision-making process and, therefore, is a central part of the research problem studied in this thesis.

The spatial disaggregation of effects has been identified in the literature as an important process but as something not handled efficiently in CBA. This deficiency is the primary justification for this research.

A link with the findings in chapter 2 will be made in this chapter to integrate the conceptual trends proposed for DSS with more practical aspects found in experiences with CBA and other methodologies for economic evaluation of public policies.

3.2 Cost-Benefit Analysis

3.2.1 Definition and history of Cost-Benefit Analysis

Cost-benefit analysis (CBA)—which is also called benefit-cost analysis (BCA) in some parts of the world—is an economic methodology to evaluate alternatives in decision making.

The main objective of CBA is to help public decision-making by facilitating, in theory, a more efficient allocation of societal resources (Boardman 1996, p. 3). The logic behind CBA is that decision makers act in the public interest and, with enough information, choose the alternative that will maximise the use of public resources (Averch 1990, p. 134). Although the application of CBA varies with the social and economic situation, there are two main characteristics of almost every CBA: the acceptance of the Kaldor-Hicks theory and the monetisation of all consequences (benefits and costs).

Nicholas Kaldor and J. R. Hicks simultaneously developed the current theory behind CBA (Hicks 1939; Kaldor 1939). According to this theory, it is desirable to make a change (or take a decision) if 'those who gained by the change would in principle compensate those who lost such that no one was made worse off '(Kelso 1984). This principle of CBA has been extensively studied (see, for example, Hausman and McPherson 1996) and is one of the most controversial aspects of CBA when employed in public policy making, because CBA accepts that most decisions benefit someone (or something) while at the same time negatively affecting others.

The other characteristic of CBA—the monetisation of all consequences—is due to the use of CBA in the public sector. Many decisions have consequences (costs and benefits) without clear market values (Averch 1990, p. 134). Such benefits or costs are not negotiable in a market from where a price can be obtained. Nevertheless, in CBA all the consequences (benefits and costs) of the proposed alternatives are converted into a monetary value, regardless of whether they have a market value or not. This monetisation of consequences is also very controversial, because analysts are required to assign dollar values to sensitive consequences such as population health, the value of clean air or the benefit of wetlands.

3.2.2 CBA procedure

CBA literature is very extensive. There are many academic texts—in the economic, engineering and political science areas—that describe all the components and steps developed in CBA in order to evaluate and rank proposed alternatives (for example Adler and Posner 1999; Boardman 2001; Buss and Yancer 1999; Farrow and Toman 1999; Fuguitt and Wilcox 1999; Hanley 2001; Heinzerling and Ackerman 2002; Lesourne 1975; Sassone and Schaffer 1978). From these texts and the step structure of CBA proposed by Farrow & Toman (1999), the different parts required to develop a cost-benefit analysis are described next.

CBA is used in public decision making after the planning phase has been finalised and some alternatives have been proposed. CBA can be present in any decision-making model as long as demand for economic monetary evaluations of policy options exists.

A hypothetical case of governmental decision making is now used to explain the different parts in a CBA. The main objective of the government, in this case, is to increase the mobility of the citizens of a municipality by reducing their travel times. The government has proposed two possible alternatives: the construction of a new bridge at a congested intersection; or the extension of the train network.

The first step of CBA is defining a baseline for the situation in which there is no change (a scenario where no action is taken). For the transportation example, the baseline (or third alternative) will be a scenario where no new project or action is implemented and therefore travel times and the other characteristics defining mobility in the city maintain their current tendencies.

The second step is to study in detail all the different alternatives (including the base scenario) in order to understand their consequences. This will require, in most of the cases, environmental, social and economic analysis where the impacts of all the alternatives are studied. Technical analyses such as ecological studies, financial forecasting and other estimations are made to determine how each of the options will impact on the study area.

These estimations are normally made using rational analysis. However, as concluded in chapter 2, rational analysis rarely includes all the complexities of our real world. In consequence, in this second step of CBA the normal practice is to

study and project only those consequences important from the economical point of view for decision makers or their technical advisors. Therefore, consequences with low economic impacts are normally ignored.

Returning to the transport example, during the second step of CBA the consequences of the alternatives (such as reduction in travel times, increments in atmospheric pollution and construction cost) are estimated.

With a complete picture of the policy alternatives, the third step is to identify the differences in benefits and costs between the policy or project alternatives and the baseline scenario. In the transport case, the benefits will be the differences between the basic scenario and the future scenarios with the new infrastructure built, for instance, the difference in travel times in the city between the current situation (projected into the future) and the future scenario with the new bridge. When the difference in one aspect between the baseline scenario and the proposed alternative is positive, the proposed alternative is said to produce a benefit for society in this aspect.

For example, if the bridge reduces the atmospheric contamination in the city (compared to the current trend of contamination), this is a benefit. On the other hand, if the construction of the bridge will generate more maintenance cost for the city (compared to the baseline situation where no bridge is built), the additional spending is a cost in the analysis.

The fourth and final step is to assign to these benefits and costs—identified in step two and quantified in step three—a monetary value. Some benefits and costs may have an evident monetary value (such as the additional cost for maintaining the infrastructure), while others might not (such as the reduction in atmospheric pollution). For those without an evident monetary value (a value cannot be determined using a market reference) a method to assign these monetary values is required and this method could be using direct or indirect valuation of the consequences (Prato 1998).

In the transport policy example, a reduction in travel times is considered a non-monetary benefit and will require estimation of a dollar value for each hour saved by users of the transport system.

Having all the effects of the policy in a dollar form (monetised), the fifth step is to calculate the overall net benefits for each of the alternatives and for each year.

This net benefit could be a positive or negative amount and is usually calculated on an annual basis, recognising that the cost and benefits to do necessarily accrue at the same time.

Table 3-1 shows a typical result for the fifth step of CBA and for one of the options (in this case the construction of the bridge). Table 3-1 is a simplified example of a CBA and only contain two benefits and two costs as an example. In normal CBA practice, many more benefits and costs will be identified.

Table 3-1: Flow developed during the fifth step of CBA for each of the options studied

Alternative 1 - Construction of a new bridge (Figures are in monetary units for the hypothetical case)					
	Year1	Year2	Year3	Year4	Year5
Benefits		•	•	•	1
Reduction in travel times	3	6.5	7.4	8	8
Reduction in atmospheric contamination	0	1	3	3	3
Costs					
Construction costs	12	8	0	0	0
Sound contamination for surrounding areas	0.4	1	2	2.2	2.3
	•	•	•	•	•
Net value for each year	-9.4	-1.5	8.4	8.8	8.7

Finally, with these results, an aggregation of the effects over time is done and a figure (or indicator) for each of the scenarios is calculated depending on the net benefits that they generate in each year. This figure is called the Net Present Value (NPV) and it is an indicator for each of the alternatives representing the net benefits that the community will receive if the alternative is implemented. The generation of the NPV and other economic indicators in CBA such as the internal rate of return (IRR) is a complex procedure applied in the last step of a CBA (a detailed description of how these indicators are obtained can be found in Lesourne 1975; Nas 1996; Sassone and Schaffer 1978). To produce these indicators, a discount rate is normally applied such that benefits or costs in later years are of less importance than benefits and costs in early years after policy implementation.

These indicators are the main outcome of CBA, and represent the monetary value of the benefits of a policy for society. This amount is calculated for a fixed period of time, which in most cases is 20 years. After this time the applied discount rate has reduced benefits and costs to negligible levels.

In some situations, and in order to improve the reliability of CBA, sensitivity analyses are developed to determine how robust the results in the model are as well as qualitative information on non-monetised benefits and costs (Farrow and Toman 1999).

3.3 THE REALITY OF CBA

CBA is a highly controversial methodology that has attracted strong detractors and eloquent supporters. Despite this debate, CBA is still a favourite tool of public decision-makers in most parts of the world, regardless of the nation's level of development.

3.3.1 Popularity of CBA

Never has opposition in the academic world to the use of CBA for public policies (especially in those cases where environmental and social factors are of importance) been greater, yet it retains popularity among decision-makers and government agencies (Adler and Posner 1999). Posner (2001) demonstrated, using a search in the Federal Resister database, a continuous increase since 1980 in the annual number of CBA in the United States of America. Moreover, the popularity of CBA has extended from central governments to states (Hahn 2000), indicating that the controversy surrounding its validity has not affected its use at different government levels.

According to Adler and Posner (1999), the opposition of academics in USA has not influenced important government agencies such as the Environmental Protection Agency (EPA) where the use of CBA in decision-making is increasing.

A possible reason for the increased popularity of CBA in the USA is explicit support and encouragement of two presidential executive orders (OMB 1981, 1996).

Elsewhere, the use of CBA is also widespread. Examples are the Scottish Environmental Protection Agency (SEPA) and the UK Environmental Agency (Hanley 2001).

In developing countries the situation is similar because of the influence of international organisations such as the World Bank, which have encouraged government bodies to use CBA in the evaluation of public policies (Farrow 1998). For instance, in Colombia the author, working as advisor to the Colombian government in the development of public policy evaluations during the period 1999 – 2001, observed that no other methodology has more credibility among local decision makers (Paez *et al.* 2003). In most cases, CBA is valued for its transparency and optimisation of resources. With scarcity as a fact in most societies (Frank 2000), any effort to optimise resources and improve the conditions of the citizens is welcome.

Even for renowned critics of CBA (Heinzerling and Ackerman 2002) it is evident that CBA has attracted a large and high profile group of individuals and organisations that support its use. It has clearly been applied in a large number (and diverse type) of choice-making processes such in most of the environmental policy evaluations of the Environmental Protection Agency (EPA) of the USA.

CBA is a methodology influencing most of the decision-making processes around the world. However, even the strongest supporters of CBA accept that is not a panacea. In the next section an analysis of the criticisms of CBA is presented.

3.3.2 Problems of CBA

One implication of applying a CBA in a decision-making process is that it begins and ends by adding equally the costs and benefits 'to whomsoever they accrue' (Farrow 1998). The decision-making indicators produced in a CBA (the NPV and the IRR) do not, by themselves, show who is going to be affected and where these positive or negative impacts may occur.

CBA fails to represent the distributional effects generated by policy. Therefore, questions relating to important aspects such as equity or environmental sustainability cannot be answered from its results (Richardson 2000). The unknown distributional effects (or lack of spatial disaggregation of results) have thus become the Achilles heel of this methodology (Farrow 1998).

Lack of spatial references is a problem when decision makers base their evaluation only on CBA. Experiences in developed and developing countries have shown that for decision makers it is important to know who is going to be negatively affected and benefited by each of the alternatives proposed (Bateman *et al.* 2003; Farrow and Toman 1999; Paez *et al.* 2004a). In many countries, policies of the central government (for example OMB 1981) emphasise the importance of known distributional effects when economic analyses are developed.

Another problem of CBA is the requirement of monetising effects. As explained above in section 3.2.2, CBA convert all the consequences (or impacts) of the alternatives proposed into a monetary value so they can be compared. Supporters of CBA admit that this comparison is very difficult when disparate categories of impacts are presented. For the critics, this comparison goes against essential decision-making principles (Frank 2000).

In CBA, for instance, a value is assigned to human life in order to be comparable with the cost of building and maintaining traffic lights. Similarly, in considering the construction of a new dam, a monetary value could be assigned to a specific ecosystem in order to observe whether its destruction is more expensive than the benefits from generating electricity.

As a result, some critics consider that CBA cannot be used in all decision situations, especially when the effects do not have a clear monetary value (Boardman 2001; Marshall and Brennan 2001).

CBA is a rational methodology where the optimisation of resources is developed in accordance with an economic procedure. However, as explored in chapter 2, taking decisions based only on technical models could cause problems. The best balance is possible when the information for decision making comes from different sources, rather than just technical ones (Nagel 1991, p. 26). However, CBA analysis is designed only to admit estimations of benefits and costs which have been deduced from quantitative and monetary technical procedures.

Farrow and Toman (1999) describe the difficulty in estimating benefits from improvements in environmental quality, since their values must be inferred from indirect evidence. This is crucial because among other factors, the credibility of

the CBA depends on the rigor of these estimations of future scenarios and the valuation of benefits and costs (Nigro 1984).

Although rationalism in CBA can be seen as a source of clarity regarding future consequences, in public decision making emotions may be high and stakeholders are liable to appreciate only the CBA results they want to see, despite of the level of sophistication or effort in the analysis (Simon 1997, p. 91).

Furthermore, Carley (1980, pp. 4-6) finds the main limitation of CBA to be the large reports used to justify the different calculations and models generated. These are rarely fully understood by decision makers, generating a sense of untrustworthiness in the analysis.

The inability of CBA to accommodate public participation has been evident in many choice-making processes. Posner (2001) found that CBA leads to a reduction in the understanding of interest groups in the decision making, creating a lack of stimulus for participation.

For Heinzerling and Ackerman (2002) CBA is, in practice, nothing like transparent because of the confusion that it can generate in the community and because in most cases the focus is placed more on the indicators produced rather than on the consequences and methods used to calculate them.

In addition, some researchers (Farrow and Toman 1999; Hanley 2001; Heinzerling and Ackerman 2002) have identified CBA as very expensive to apply if used properly (to its full potential) in decision making.

Many influential analysts therefore oppose the application of CBA in government institutions, especially for those cases where environmental issues are relevant. Heinzerling and Ackerman (2002) consider that the application of CBA often produces inferior results in terms of environmental protection and overall social welfare when compared with other methodologies.

In order to overcome some of the limitations of CBA, some authors propose to substitute it with other type of analyses, multi criteria decision-making (MCDM) being widely preferred. MCDM can use local people's perceptions in order to optimise resources by considering not only economic aspects, but also environmental sustainability (Tiwari *et al.* 1999). Multi criteria techniques

approach the analysis from multiple perspectives (Pereira and Quintana 2002), including aspects that cannot be clearly identified in CBA methodology.

In addition to multi criteria techniques, other rational and non-rational methods are also available to replace CBA in decision-making. Notable are cost-utility techniques; environmental and social impact studies; social forecasting and future studies; and evaluation research or the study of previous decisions.

In conclusion, the literature opposing CBA considers that its application in governmental decision making is not correct in principle, believing another methodology should be applied and leaving CBA only for those cases where the valuation of consequences can be easily done from market references. MCDM appears to be the preferred substitute to CBA.

Despite their strong arguments, opponents of CBA recognise that currently CBA has extensive popularity in governmental institutions. Some authors see this popularity as a consequence of the manipulative nature of CBA allowing decision-makers to produce whatever result is desired (Farrow and Toman 1999). Supporters of CBA see advantages that make it a powerful tool in governmental decision making. In the next section the arguments in defence of CBA are discussed.

3.3.3 Benefits of using CBA in public decision-making

Although some authors have characterised CBA as a complicated and expensive procedure in decision making, practical applications of the methodology in public agencies have shown that it is often the best option in terms of cost when it is compared with other alternatives (Adler and Posner 1999).

In addition, CBA is considered a powerful tool for optimising and distributing public resources, since it allows comparison of monetary and non-monetary costs and benefits for each of the alternatives by converting all the effects into monetary terms. This allows decision makers to clearly differentiate between alternatives in terms of their returns to society (Farrow and Toman 1999).

CBA can be seen as a test of economic efficiency when scarce resources require optimal distribution. Therefore, if a policy passed the CBA test, it would make 'the economic pie larger and a larger economic pie makes possible a larger slice for everyone' (Frank 2000).

Apart from its ability to optimise public resources, CBA can be seen as a generator of discussion when the isolation of costs and benefits contribute to better understanding of the proposed future actions (Becker 2000). CBA should not only be seen as a way to optimise resources; it is also a method for placing 'on screen' social, economic and environmental factors that might otherwise escape the attention of stakeholders (Sunstein 1999).

Hanley (2001) has appreciated CBA as a good framework for discussion, which allows the identification of the important aspects of the decision-making process and gives insight into whether a proposed action should be admitted on economic grounds.

CBA can be seen as a methodology facilitating the weighting of advantages and disadvantages and it can also constitute a reference to measure the rationality used to allocate public resources. These two characteristics are seen as a justification of the application of CBA, since they generate transparency and confidence in public agencies (Adler and Posner 1999).

In conclusion, supporters of CBA appreciate this methodology as the best decision-making process for promoting overall wellbeing and the optimisation of resources. The most common argument presented to defend CBA is that governments do not have unlimited resources to solve all the issues present in society. Therefore, scarcity requires a methodology that helps governments decide how to best invest the resources available. CBA is argued to be the best option to do this (Frank 2000) since its main purpose is to rank alternatives according to economic revenues for society.

Conceiving CBA as a tool for optimising public resources is what has made it so popular in public institutions. Decision makers have permanent pressure to use in the best possible way the resources from taxpayers to promote the wellbeing of the entire society. CBA allow them to justify, using economic terms and under a rational methodology, decisions that all might not agree with.

Despite the effort of a significant number of researchers in proposing alternative techniques to CBA (such as weighting and scoring schemes, environmental impact assessment, participatory methods, multi criteria analysis, and cost-effectiveness analysis), many economists continue to maintain an energetic defence of CBA (Hanley 2001). Abandonment of CBA could be seen as admitting

that economic efficiency is not important in decision making, something that is difficult for politicians and economic analysts to accept.

In the particular case of MCDM, it is difficult to conceive of it as a complete substitute of CBA, since its main objective is not to select the best alternative, but to identify relationships amongst impacts (Pereira and Quintana 2002).

Despite this, supporters of CBA admit the criticism about distribution of effects, acknowledging that CBA by itself cannot provide a good picture of where the benefits and costs are going. This limitation of CBA has generated several additional methodologies to disaggregate benefits and costs.

In the next section these methodologies are analysed. It is shown that these approaches are expensive and not accessible to decision makers, creating important limitations in the development and evaluation of public policies.

3.4 METHODOLOGIES TO DISAGGREGATE EFFECTS

After analysing the debate above, it is clear that CBA is a generally popular and often useful process, but it does not tell who is being positively or negatively affected to produce net social benefits.

In this section this limitation of CBA will be further explored, as it constitutes the basis for the development of this thesis.

3.4.1 Reasons for disaggregating consequences in a decision-making process

In CBA everyone and everything in the analysis is treated equally. Many authors (Buss and Yancer 1999; Farrow 1998; Farrow and Toman 1999) regard this as a disadvantage of CBA.

For many decades, researchers have proposed methods for disaggregating effects after the CBA results have been achieved. These methods can be classified in two categories. In the first category are those that use economics and statistical analysis to produce disaggregation for the entities of concern. In the second category are the methods that use GIS and spatial information for representing in a map form the spatial impact that the costs and benefits have. For this thesis, the former category is called non-spatial methodologies and the

later is denominated as methods for spatial disaggregation of effects. Analyses of current spatial and non-spatial methods are presented in section 3.4.2.

Farrow (1998) considered it fundamental for social equity and environmental sustainability to undertake an additional analysis in a CBA for vulnerable subgroups of the population. He proposed additional studies after CBA to know whether a particular option is compromising equity or environmental sustainability for a particular region.

Farrow's approach involves application of additional tests in the CBA by which to determine the equity and sustainability of the policy for identified groups either receiving net benefits or compensated for losses. However, the development of these tests, in a practical case, requires spatial disaggregation of effects, information that is not always available, and its generation presents an important challenge (Morgenstern 1997).

Equity often implies fairness, which is a concept that allows plenty of different interpretations. In general terms, equity could be defined as the search for equality of economic outcomes (such income) for all members of the community (Stilwell 2002). Therefore, knowing who is going to receive the benefits and the impacts is important in order to determine whether the alternative selected is contributing to achieving equity. If consequences are not disaggregated, decision makers implicitly agree that everyone should be weighted equally, regardless of their income or economic situation (Frank 2000). For Heinzerling and Ackerman (2002) CBA does not answer the question of who suffers as a result of the decision and, therefore, decisions based only in CBA tend to maintain the current economic and social inequalities. Therefore, testing for equality of outcomes in a logical and defensible way is important in most evaluations of public policies (Averch 1990).

As well as equity, environmental sustainability also requires disaggregation of effects and CBA cannot lead decision makers in this regard (Toman 1998). The concept of environmental sustainability has been widely studied and is of increasing interest for decision makers (Farrow 1998). Environmental sustainability is defined as the necessity for current decisions that affect the environment to consider the right of future generations of having the same, or better environmental conditions than those currently present (Liebenthal and WorldBank 2002).

Toman (1998) considered that CBA is not of itself the proper tool to provide information about environmental sustainability since it does not adequately address important distributional concerns, both within and across generations, making it necessary to produce information about distributional effects for the decision makers in another form.

The importance of knowing distributional effects has prompted central governments to increasingly encourage agencies at all levels to include such analysis as part of the decision-making process. An important example is the USA Executive Order 12866 (OMB 1996). This presidential document requires economists not only to present an evaluation of the value of benefits and costs, but also individual references to the effects estimated for each of the options.

3.4.2 Current methodologies for disaggregating consequences

Non-spatial methods

Dufournaud and Harrington (1990) describe how, for more than 30 years, analysts have developed methods to individualise effects in economic studies.

An available alternative, in all decision-making processes that use CBA, is to apply subsequent CBA to those special entities which are of interest to the decision maker (Paez et al. 2004a). For example, if the impacts caused by the construction of a new dam to a particular ecosystem are of interest for the government or the community, the government could develop a particular CBA for the ecosystem to determine individual costs and benefits for this ecosystem that were aggregated in the CBA for the dam. An individual disaggregation of effects to the ecosystem will permit the application of tests for equity of environmental sustainability. This procedure could be repeated for all the different entities which are of interest for the stakeholders or the decision-makers such a population centre or a water body.

However, CBA is not an easy methodology, and it normally demands significant resources from the agency involved in the choice-making process. Therefore, developing subsequent CBA to identify individual effects for each of the items in the analysis would not be cost effective, since it is normal for a decision-making analysis to have several entities being impacted on positively and/or negatively.

Another way to obtain individualisation of effects is to use traditional non-spatial methods such as planning balance sheet analysis (PBSA) and goals-achievement matrix analysis (GAM) (Carley 1980). These methods are normally applied after the CBA results are obtained and allow analysis of more than one entity at the same time. However, they also demand important amounts of data regarding the consequences analysed and the entities considered. In addition, if after applying the methodology an additional entity is deemed important, the methodology would have to be repeated, even if the new entity is a sub-division or fraction of an entity analysed previously.

Dufournaud and Harrington (1990) have proposed a methodology in which game theory is used for temporal allocation of resources. The methodology allows distributional effects in time and space. This proved to be useful in a river-basin allocation of resources. However, in this methodology an increase in the number of regions or areas considered implies important additional effort in the expansion of the procedure.

Spatial disaggregation of consequences

In the area of spatial disaggregation of consequences, GIS and spatial information can be used to generate a complete spatial disaggregation of the results of CBA. GIS and spatial information have permitted technicians to produce parallel to the traditional CBA indicators (NPV and the IRR) a map of how these indicators are distributed in the study area.

A distinguished work developed using GIS to completely disaggregate the CBA results is the case study by Bateman *et al.*(2003). In this resource allocation situation, they were able to disaggregate the NPV to the farm level. This allowed decision makers and stakeholders to observe not only how the most important consequences were affecting the individual land parcels, but also how each of the alternatives proposed were impacting each individual farm production and income. Figure 3-1 and Figure 3-2 show examples of the results founds with this methodology.

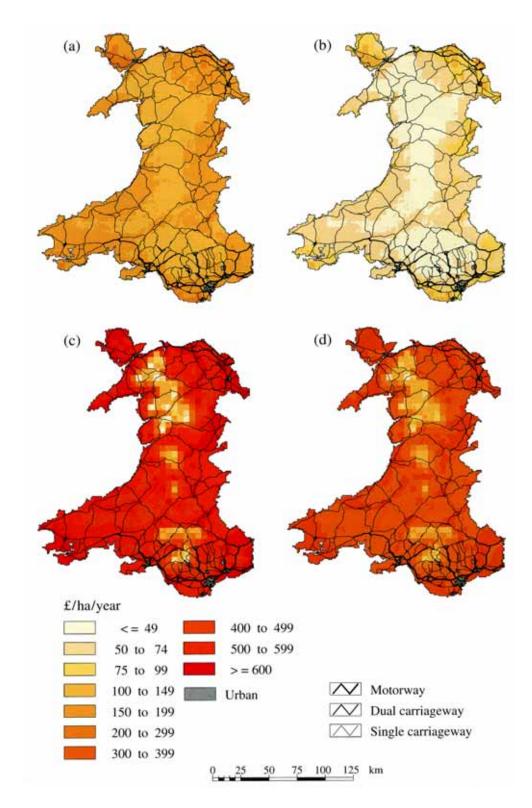


Figure 3-1: (a) Predicted farm-gate income for sheep farms; (b) Predicted shadow value for sheep farms; (c) Predicted farm-gate income for milk farms; (d) Predicted shadow value for milk farms (Bateman *et al.* 2003).

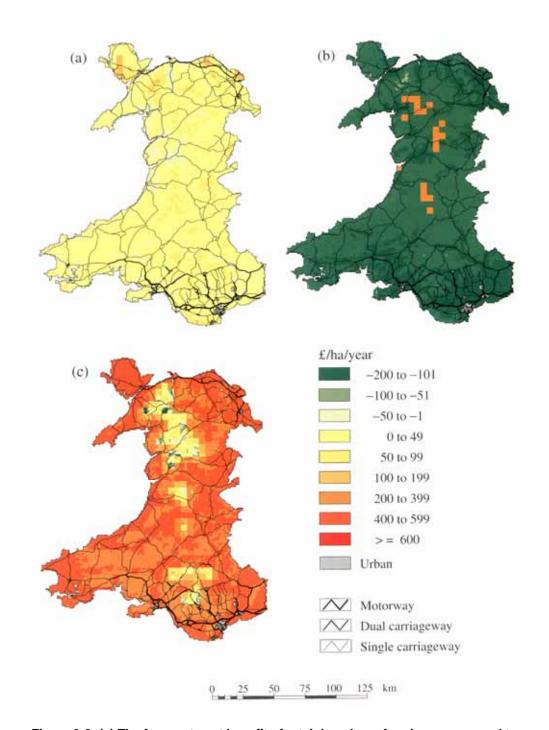


Figure 3-2: (a) The farm-gate net benefit of retaining sheep farming as opposed to conversion to conifer woodland; (b) The social net benefit of retaining sheep farming as opposed to conversion to conifer woodland; (c) The farm-gate net benefit of retaining milk farming as opposed to conversion to conifer wood (Bateman et al. 2003).

Bateman et al.(2003) have argued that the principal achievement of the methodology is improvement of the relationships between economic analysis and spatial and environmental variables by using GIS. With this approach, it is possible to incorporate into the traditional economic analysis the complex spatial models developed to identify, measure and disaggregate consequences of the alternatives proposed (Bateman et al. 2003).

However, the proposed methodology demands significant computational and data resources. In addition, the authors found that use of a multi-model system carries forward all the uncertainties present in the individual rational models used for each of the effects considered (Bateman *et al.* 2003, p. 288). Figure 3-3 shows the general scheme for the CBA and models needed in this approach and Figure 3-4 and Figure 3-5 show the methods and processes to modelling and evaluate and spatially disaggregate the impact 'recreation', which is only one of the several consequences needed to be analysed in this case.

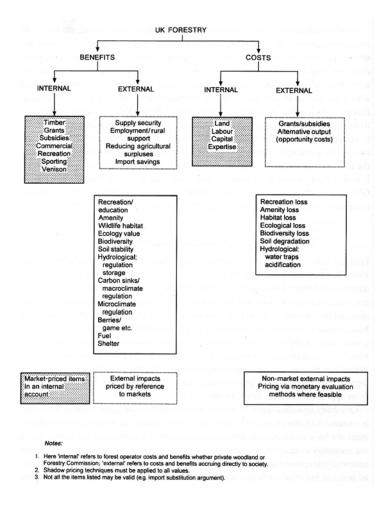


Figure 3-3: Cost and benefits of woodland (Bateman et al. 2003).

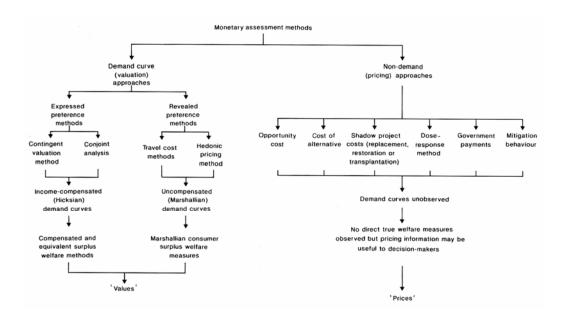


Figure 3-4: Methods for the monetary assessment of non-market and environmental goods (Bateman *et al.* 2003).

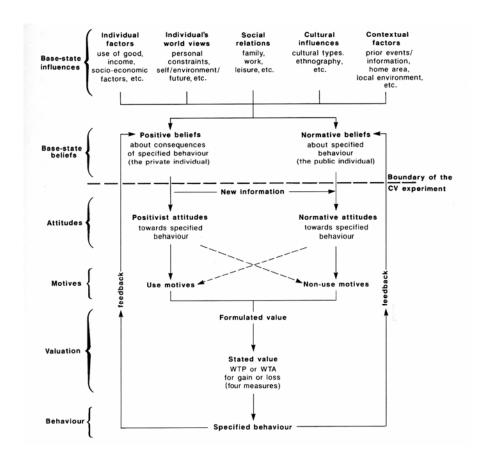


Figure 3-5: The value formation process for recreation (Bateman et al. 2003).

Another difficulty of spatially disaggregating effects using rational methods is that technical information is difficult to keep current. In the case of Bateman *et al.*, the authors found that their analysis 'becomes dated even while it was under construction' (Bateman *et al.* 2003, p. 288).

Furthermore, if the results are observed under the reality of decision-making processes, they could be considered of limited use for helping to select the best alternative, since they come exclusively from rational analyses and are not designed to support other factors (political, emotional and historical) beyond the technical and economical perspective, which are proven to influence decision-makers.

Moreover, the extent to which spatial models can be developed depends on the available spatial data (Williamson 2003);, the methodology by Bateman *et al.* (2003) is limited to being applied to those cases where the availability of spatial data for the particular study area are robust enough to cope with the extensive demands of datasets by the models that predict each of the individual consequences analysed in the CBA.

Turner et al. (2000) have also developed a framework for disaggregating consequences using GIS and MCDM that is capable of presenting the results of CBA in a spatial form. This framework was used in a decision-making process affecting surface water and wetland vegetation. Figure 3-6 shows the connections among wetland functions, uses and values considered in this case.

The main characteristic of the Turner *et al.* (2000) framework was the combination of economic valuation, system modelling, multi criteria analysis and stakeholder analysis to produce a better understanding of spatial implications and factors present. This proposed framework obtained important benefits for the choice-making process, since it allowed a better public participation process and promoted a better understanding of some of the sophisticated models used to calculate future scenarios.

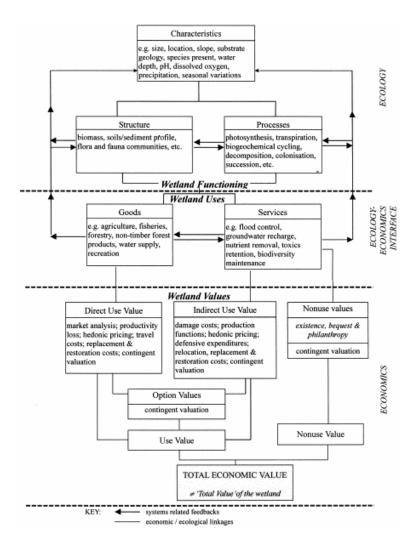


Figure 3-6: Connections used in the methodology developed by Turner *et al. (2000)* to obtain a valuation of wetland vegetation

However, the methodology was complex to apply, given that several types of analysis were needed. Therefore, to improve the methodology the ability of GIS to present results should be exploited, especially for the improvement of the relationships between the stakeholders' perceptions and the results obtained by technical analyses (Turner *et al.* 2000).

In addition to complete disaggregation of the economic results from a CBA, extensive examples of disaggregation of one or more effects—using GIS—are present in the literature. The work by Guo *et al.* (2001), Knox *et al.* (2000), Loague *et al.* (1996) and Qiu *et al.* (1998) are good examples of using GIS and spatial information to spatially disaggregate single effects. In all these examples GIS was used either in the modelling of consequences or to obtain a spatial (or mapped) result that complements the economic analyses. In each case the

analysis conducted was very demanding in terms of rational analysis, as well as spatial data. When GIS is used in the spatial disaggregation of effects, the main objective is usually to complement the rational economic results.

3.4.3 Analysis

Although CBA is popular and provides many benefits to public policy evaluation, the lack of disaggregation of the results constitutes one of the basic arguments against its application.

Economists and other supporters of CBA have been aware of this weakness and have been developing methodologies to disaggregate the costs and benefits of the alternatives proposed.

Despite these efforts and interests from decision makers, current methodologies for disaggregating effects are complex, expensive and very technical, limiting their application in public decision making. Even more, when extensive resources are used in current methodologies, some omissions are always present since they try to reproduce our real world in a technical form (Bateman *et al.* 2003).

For the spatial methods, the extensive costs in their application are in part the result of their demand for extensive geographic data. If a particular jurisdiction has insufficient spatial data to support the demands of the spatial disaggregation methodologies, its ability to make decisions is limited.

In addition, current disaggregation methods mainly focus on supporting the choice-making process by rational analysis. There are limited proposals in the literature for methods to disaggregate consequences that include additional information to support political or emotional factors affecting public decision making.

Some authors have proposed other approaches to improve disaggregation methods. In the next section new trends for disaggregation methods and for CBA supportive analyses are explored.

3.5 THE FUTURE FOR EVALUATING ALTERNATIVES AND SPATIALLY DISAGGREGATING EFFECTS

The current debates surrounding CBA and the results of the existing methods for disaggregating consequences have generated future trends towards solving the many controversial aspects of CBA by improving spatial disaggregation of effects. In this section new trends in spatial disaggregation are analysed. These new trends are the basis for the design of the conceptual framework and DISCUSS in Chapters 5 and 6.

3.5.1 Proposed trends for evaluating alternatives in decision-making processes

Economists, who are the strongest supporters of CBA, recognise the need for CBA to be modified in order to include new parameters for decision making, such as equity and environmental sustainability (Farrow 1998). Currently decision makers are pressured by society to act sustainably, and practitioners of CBA have realised that their findings need to be embedded in a broader set of information (Toman 1998).

When a proposed policy involves negative or positive consequences to people from a particular area or social group or to vulnerable environmental entities, and at the same time the spatial consequences are not clear, agencies directing the process should modify or depart from CBA (Adler and Posner 1999).

In addition to equity and sustainable development, public participation is desirable during and after the development of CBA. The technocratic nature of CBA means the analysis is seen by the general public as a black box, from which results emanate without a clear justification (Hanley 2001; Heinzerling and Ackerman 2002). This lack of transparency in the analysis limits public participation.

Therefore, one option for future systems and analysis is for them to be opened to include the views of the public, especially in the valuation of environmental assets (Hanley 2001). Although some might argue that the current methodologies of 'willingness to pay' could capture people's valuation of the environment, practical experiences have shown that 'willingness to pay' does not entirely capture what people feel about the environment (Sagoff 1988).

For Adler and Posner (1999), government institutions could capture the real perception of the community by firstly informing them of the calculations made or even by generating a public participation process where imaginative reconstruction of their valuation is created.

In order to include environmental analysis and equity, and permit better public participation, two future alternatives are proposed. On one hand, detractors of CBA consider that it is not able to cope with social and environmental aspects and should be substituted by other methodologies for evaluating alternatives. On the other hand, some researchers (such as Farrow 1998; Toman 1998) recommend the extension of CBA with additional analysis in such a way that its results can be complemented with additional information for the decision makers.

MCDM could be considered a good substitute of CBA for those cases in which several social and environmental factors are affecting the different alternatives (Heinzerling and Ackerman 2002). However, experiences with MCDM, where it has been used as the methodology for evaluating alternatives, have shown its limitations in terms of arbitrary weighting, ignorance of costs, and neglect of consumer preferences. These limitations make it difficult to convince economists and decision makers of the ability of MCDM to fully substitute for CBA (Hanley 2001).

Supporters of extending CBA—rather than substituting it—based their arguments on the fact that decision-makers are dealing with processes that affect limited resources; creating the necessity of a methodology capable of ranking alternatives in such a way that economic optimisation is possible. This demand for optimising resources is currently present in our world and is not expected to change. Few researchers accept that CBA can deal with all the concepts and factors important in a decision-making process, yet they perceive that CBA has proven to be a methodology that both in theory and practice moves towards enhancing the use of scarce public resources (Hanley 2001).

The academic discussion about substituting or extending CBA is endless. Nevertheless, governments around the globe have been increasingly using CBA methodology not only in situations where economic aspects are important, but also in cases where environmental and social aspects are too. This popularity has meant that in practical terms, decision makers prefer to keep CBA as the chosen methodology for selecting alternatives. Many authors have dedicated

extensive efforts in proposing new analyses to overcome the deficiencies of CBA. These are discussed in the next section.

3.5.2 Proposed trends for complementary analysis to CBA.

Toman (1998), after an extensive analysis of CBA from the economic point of view, concluded that CBA is, in most cases, the preferable rather than the best methodology. He proposed that additional analyses complementing CBA should not seek to be purely rational.

Environmental sustainability, for example, contains complex aspects in relation to ecological integrity and social legitimacy. It appears obvious that these additional analyses should not be based purely on scientific procedures (Toman 1998).

For Hanley (2001) an ideal vision for CBA and its complementing analyses is one where all relevant consequences of the alternatives can be captured and where the information needed to assess the desirability of the options is present. These two conditions can only be obtained if a spatial disaggregation of the effects complements the economic indicators in such a way that tests about sustainability and equity (for example) can be developed.

GIS and spatial methods have proven ability to deal with spatial relationships and the capacity to analyse economic results with other spatial information such as demographics or infrastructure. GIS is flexible in defining geographic entities and allowing cross-analysis with other spatial data available for the study area. These advantages offereed by GIS in spatial disaggregation cannot be found in the non-spatial methods used to disaggregate effects. However, the quality of GIS-based results depends on the accuracy of the input information and the quality of the models used to replicate real-world phenomena (Bateman *et al.* 2003).

After developing and applying a framework for improving decision making affecting environmental assets, Turner *et al.* (2000) have proposed systems complementing the economic analysis not only to be based on GIS, but allow an interaction from the stakeholders with geographic data in such a way that a visualisation of impacts is obtained as well as representation of economic results in map form.

In summary, current methods for disaggregating effects are expensive, information-intensive and mainly based on rational analysis. These shortcomings

make extensive application in public decision making difficult. Therefore, it is desirable for disaggregation methods to be less resource-intensive and easier to apply in different situations where the availability of spatial information is limited (Paez et al. 2004b).

3.6 REVIEW

Although CBA has been a very controversial methodology used to evaluate alternatives in decision making for the past 20 years, and despite its limitations, CBA has been the preferred methodology for public sector decision makers to rank alternatives in a decision-making process. This popularity of CBA is not expected to change in the future.

Consequently, all research dedicated to enhanced public decision making has to be aware of this reality. 'It seems certain that cost-benefit analysis will continue to play an important role in decision-making. Under the circumstances, both friends and foes of cost-benefit analysis have a shared interest in trying to eliminate the biases that distort its prescriptions' (Frank 2000).

This thesis, with its focus on enhanced public decision making, must recognise the present and future reality of CBA. Therefore, any conceptual framework or IT system chosen to support decision-making has to accommodate the demands and characteristics of CBA and, if possible, complement it in such a way that controversy surrounding economic results from the CBA is reduced. If a proposed DSS is not in concordance with the current demands of decision makers, they will have real doubts about its applicability in governmental decision making and so limit its use in those countries where optimisation of resources is vital.

Nevertheless, CBA may not survive in its current form. As was explored in section 3.5.2, many authors consider that CBA will be the base from which other evaluation methods are built. Our real world is complex and relying purely on CBA will demand that every consequence is placed in monetary terms, which is difficult to admit for decision makers, since choice-making processes are normally influenced not only by economic criteria, but by multiple-competing criteria including environmental and political factors (Tiwari *et al.* 1999).

Any analyses to complement CBA must provide disaggregation of effects. Many non-spatial and spatial methods have been proposed to support this

disaggregation of benefits and costs. However, spatial methods (using GIS) have demonstrated many advantages such as better integration of information with the models for forecasting consequences; improved representations of results; and improved integration with other spatial information for supplementary analyses (Bateman *et al.* 2003; Turner *et al.* 2000).

Current methodologies used for spatially disaggregating effects in CBA are difficult to apply and are demanding of important resources. This is mainly because they rely on scientific procedures and data, which in most of the cases is expensive to obtain and hard to keep up-to-date. These limitations restrict their application to a wide range of public decision-making processes, since not all governmental institutions are capable of supporting purely technical spatial disaggregation of consequences. When a spatial disaggregation of effects cannot be delivered, public decision making is restricted and decision makers have to make choices without proper analysis of aspects such as environmental sustainability and equity.

An alternative approach to disaggregating consequences may be to include more non-technical sources of information, such as information from experts and community members. This type of information is available at a low cost and could allow methods for spatially disaggregating effects to be more efficient, easier to apply in different social conditions and at the same time adaptable to the different decision-making models.

An important advance in decision-making will be to generate an environment where the discussion is not mainly concentrated in the technical procedures used to obtain results, but in the alternatives proposed (Carley 1980, p. 33).

However, the inclusion of community and expert knowledge in a decision-making process is itself a complex activity and the approach taken depends on government objectives. To further develop this concept, chapter 4 will study the theory and state-of-the-art IT technologies for public participation in governmental decision -making.

4

PUBLIC PARTICIPATION

4.1 Introduction

Chapters 2 and 3 established the importance for governments of tools to support the technical and political aspects of public policy evaluations. In this regard, public participation was identified as capable of bringing together the political, social and economical aspects surrounding decisions.

Today, numerous methods exist to encourage public participation in decision making. Some of these have been given names such as rapid rural appraisal, citizen panels, and citizen juries (Armour 1995; Coote and Lenaghan 1997). These methods normally 'share the feature that they are based principally on inputs from and decisions by ordinary people, rather than experts.' (Hanley 2001).

This chapter will explore public participation as a component in the decision-making process. The main focus will be on the existing conceptual models and their limitations, as well as on the relationships between public participation and CBA.

In a similar way to chapters 2 and 3, the analysis will include consideration of the role of spatial information and GIS. The objective is to appreciate the extent of support provided to public participation by spatial information through an important subset of spatial decision support systems (SDSS) called participatory geographic information systems (PGIS).

Ultimately, this chapter will provide a description of the concepts that have motivated public participation in decision making and the new trends proposed in the literature for the involvement of the community in public choice making. These trends are used in chapter 5 to design the conceptual framework developed in this research.

4.2 PUBLIC PARTICIPATION IN GOVERNMENTAL DECISION MAKING

4.2.1 Basic concepts

Public or community participation is the involvement of citizens in decision making. This involvement occurs in multiple ways and with many different objectives. Weidemann and Femers (1993) have proposed a ladder to describe the different levels of this involvement. The Weidemann and Femers ladder can be complemented with a similar scale describing the objectives of the government for public involvement. Figure 4-1 contains two parallel ladders for public participation, where the left one is the level of involvement of the public proposed by Weidemann and Femers (1993) and the one on the right, which is proposed here, shows the possible objectives of government for public involvement.

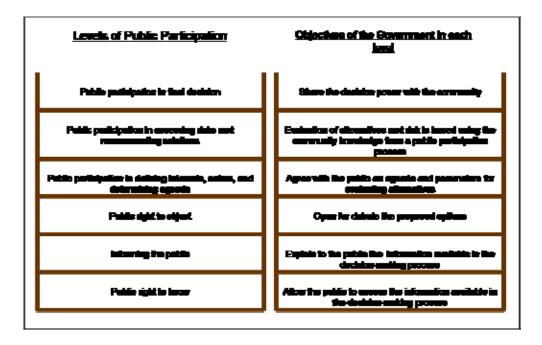


Figure 4-1: Ladder of levels of involvement of the public and corresponding objectives of the government in a decision-making process (Adapted from Weidemann and Femers 1993)

Tyler (2003) argued that public participation only occurs when the public is approached by the government with the intention of making it part of the process and allowing it to have a direct involvement. Public consultation, on the other hand, occurs in those situations where the public is approached in order to have its opinions and comments on a proposal, but with limited intervention in the final result (Tyler 2003).

The ladder of objectives in Figure 4-1 could be used as a reference to decide whether the involvement of the public in a decision-making process is public participation or public consultation. The top three levels in the ladders are public participation processes, since the government is transferring powers in the decision-making process to the public. In public participation, the community not only acts as a passive listener, but as an active decision maker. Processes where the government cannot conceive of transferring powers should not be seen as public participation, but as public consultation.

The conditions of public participation should not be restricted only to the delegation of powers. Public participation also requires the involvement of the community at a stage of the decision making when the options or alternatives are open and the decision has not been taken (Tyler 2003). In addition, effective public participation is present only when stakeholders have the resources, such as adequate analytical tools, and a correct legislative environment to intervene in the process (Walker *et al.* 2002).

Decision-making processes where public participation exists have more than one decision maker (outside government officials) since the community becomes an active participant. The existence of more than one decision maker transforms the situation to a group decision-making process.

The concept of group decision making under a public participation scheme demands a change in the operation of the decision-making procedures, especially in the information systems area (Walker *et al.* 2002). The design and implementation of DSS for group decision making should be re-evaluated when the public is invited to participate.

In summary, public participation occurs in a decision-making process when the government has the objective of delegating some of the rights and responsibilities to the community; allows this intervention at a stage where the influence of the

public will affect the process; and provides the tools and a legislative framework to validate and make relevant the community contribution. It is important to distinguish between public participation and public consultation, since this research is focused on the application of public participation in governmental decision making. Therefore, the term 'public participation' will be used for those processes that are in the top three levels of the ladders in Figure 4-1.

The product of public participation is community knowledge, which is at the same time *soft information*. The term 'community knowledge' (in the context of public decision making) refers to what community members know about a particular area and their interpretation of future consequences if new policies are implemented. The degree to which community members 'know' the spatial implications of a policy option can vary. Their knowledge may be based on careful study, direct observation, press reports or discussions with neighbours. In some cases this knowledge might be truly believed but not truly accurate. It is more properly regarded as an individual opinion.

In this thesis, the term *soft information* refers to information that comes from subjective sources (e.g. community knowledge, individual opinions, expert knowledge) and is used to differentiate this information from that attained using rational or scientific methods, which is called *hard information* (Malczewski 1999, p. 11). Considering that an important objective of this thesis is to incorporate the social and political factors in a public evaluation of policies, soft information is highly significant for this purpose since this type of information has been extensively used in decision-making processes to incorporate social values into the judgment of alternatives (Malczewski 1999, p. 12).

A combination of soft and hard information always exists in public decision making. For Malczewski (1999, p. 12) the use of soft information depends on the relationship between the amount of technical information required and what is available. For those cases where the SDI available for the study area lacks vital information to predict consequences using rational methods, soft information (from the experts and community knowledge) will play a complementary role in filling those gaps (Paez et al. 2004b).

As decision-making is often a step-wise process, decisions based on human judgments can also be considered as a form of soft information.

A significant number of current governments rely on public participation to obtain better decisions. In the next section the benefits and justifications of public participation are discussed.

4.2.2 Benefits and problems of public participation

Commonly, people who have not been publicly consulted oppose decisions. Stakeholders tend to react with their emotions to imposed decisions, even though these decisions might benefit them in the future (Paez *et al.* 2003). One of the most important benefits of including public participation is enhancement of negotiation ability for both the community and the government.

Parker and Pascual (2002) have demonstrated in an urban decision-making case the advantage of public participation of converting emotional reactions from the community into analytical inputs.

Ball (2002) has described public participation as the only tool capable of generating consensus in public decision making. For him, scientific veracity can hardly be guaranteed in choice-making, since people are affected by the technical results in different ways. Therefore, consensus might only be obtained by public participation processes capable of linking the communities with the environment or infrastructure changes in question. Public participation is a means to reduce the disagreement caused by the uncertainty of rational analysis, as it can place different perceptions in a debatable form.

These benefits of promoting a better environment for discussion and at the same time encouraging consensus have greater acceptance for the sustainability of decisions (Ball 2002). The community tends to adopt those decisions in which it has been consulted, easing the implementation of new policy. This sense of ownership not only helps in the alignment of the community to the policy objectives but also becomes a fundamental tool to create sustainable development (Porritt 1998).

Crewe (2001) and Ball (2002) have argued that in many situations the knowledge of the community, although it cannot be justified using rational methods, can expand views of what is conceived of as good practice by creating new ideas for the technical consultant of the decision process. For them, community knowledge (produced after a public participation process) is an important complement to scientific knowledge, helping generate better decisions.

Public institutions, and in general our modern society, have moved to a more decentralised approached where a bottom-up approach is more conventional (Longley and Batty 2003, p. 248). Public participation, as a mode to place group decision making in the public sector, helps accommodate choice-making into the new move of society, where authoritarian decisions are rarely seen and more participative processes are encouraged in order to obtain sustainable development.

Tyler (2003) has concluded that public participation, when used in policy evaluations, serves not only as a good generator of consensus, but also as a cost-saving tool, as it reduces the number and complexity of late objections to proposals.

The benefits of public participations in the areas of sustainable development, negotiation, cost reduction and decentralisation have been diffused in many multinational and governmental policy documents, with the objective of promoting public participation in all nations around the world.

In 1992, when representatives from 178 nations met in Rio de Janeiro to participate in the World Conference on Environment and Development (UNCED), the necessity of public participation in all government processes was clearly identified. During this meeting the multinational plan of action, Agenda 21, was signed, giving special consideration to community involvement in governance (UN 2003). Agenda 21 became the main document in a series of documents and multinational meetings to support public participation as a key component in sustainable development.

At a regional scale, the Aarhus convention became an initial point for the European Union (EU) to regulate and guarantee the right of access to information and public participation in public decision making (Aarhus-Convention 1998). This convention involved all countries in the European Union and sought improvement in all decision-making processes involving the community. The main objective was to find ways of minimising the social and environmental impacts of future decisions and at the same time promote in the EU a culture of openness to public participation as an element of good governance.

In Australia, and more particularly in the State of Victoria, the 2001 Environmental Protection Act establishes some important principles, not only for environmental

protection, but also in terms of accountability. This Act asserts that public participation procedures should be created to allow real opportunities for the public to participate in the formulation of environmental policies, creating an important framework in which public institutions can conduct decision making (Cook 2003).

Despite encouragement from multinational organisations and central governments, some academics and researchers, especially in the economics area, have expressed reservations about the benefits of public participation.

Walters *et al.* (2000) have condensed the major criticisms to public participation to four points:

- 1. Technical experts consider the exercise of bringing subjective knowledge from the community as irrational.
- Public participation can become a procedure where the public acts only as selfserving and ignores the importance of optimising resources.
- 3. The main objective of governments is to optimise resources. Public participation generates a conflict with this objective since the democratic pursuit of participation contradicts the rational pursuit of efficiency that public choice-making should have.
- 4. Public participation can be viewed as a time consuming, costly, complex and emotionally draining alternative.

Hanley (2001) has emphasised the third point by considering it difficult for economists to accept a better result from public participation than from purely rational analyses since community members are unlikely to identify efficient uses of scarce resources. He also criticises public participation because of the lack of statistical validity of its results, as in most cases public participation congregates small numbers of individuals compared to the entire society affected by a decision.

Few (2001) and Bickerstaff et al. (2002) have expressed doubts about the benefits of public participation by warning about the possible undemocratic consequences that public involvement could have. For them, the normal

approach for selecting the participants in community participation corresponds to a top-down approach, rather than a self-governing selection of representatives.

Arguments against public participation are frequently related to economic efficiency (Hanley 2001; Walters et al. 2000). For many economists, public participation cannot contribute to a better distribution of resources as efficiently as economic methodologies, such as CBA.

However, governments have a dilemma. On one hand they know the benefits of CBA in justifying their decisions, and on the other they understand the importance of public participation for sustainable development.

In the next section the incompatibilities between CBA and public participation are analysed.

4.2.3 CBA and Public Participation

Economists have always argued for decision-making procedures where the main objective for evaluating alternatives is the optimisation of resources. The subjectivity of public participation is seen as a barrier to obtaining a better distribution of economic resources while community knowledge (which is the main product of public participation) is not considered to be as valid as technical knowledge derived from rational procedures.

When public participation is applied in governmental decision making, frameworks need to be modified because some responsibilities (as well as rights) are assumed by the community. The determination of governments to adopt public participation demands modification of CBA procedures: something that supporters and practitioners of CBA have difficulty accepting (see section 3.5.2).

The proposed alternative is to leave CBA as it was conceived under the Kaldor-Hicks theory and add further analyses. These further analyses are expected to cover the social, political and environmental issues not treated in CBA.

Therefore, an acceptable approach to merging public participation with CBA appears to be the inclusion of public participation within the additional analyses that are developed in order to complement CBA.

Public participation is commonly found in decision making when other methodologies apart from CBA are used to evaluate alternatives. Multi criteria

procedures are a good example. Tiwari *et al.* (1999) have used multi criteria decision -making (MCDM) and the analytical hierarchical process (AHP) to weight alternatives, while Pereira and Quintana (2002) have found in public participation an alternative way to validate technical information. The main source of information for decision making in all these practical experiences with public participation was community knowledge, supporting the ability of this information to be part of public policy evaluations.

However, examples in literature, of public participation being used during CBA, are very rare. Public consultation, on the other hand, commonly occurs in governmental evaluations of policies as a tool to promote transparency.

Posner (2001) has observed that CBA reduces the influence of interest groups, as CBA procedures to obtain economic indicators for decision making are not easy to understand. Completely separating public participation from CBA dismisses the value of community knowledge. This is particularly short-sighted in situations where hard information is expensive and soft information from the community is a cheap and accurate option (Posner 2001).

If community knowledge is accepted as a complement to technical information, not only can better decisions be achieved, but the public can also obtain a space to express its opinions, something which is desired in most decision-making processes.

GIS has been an important tool to support public participation processes and the acquisition and validation of community knowledge. The next section includes an analysis of the literature about the support that GIS provides to public participation.

4.3 Public Participation and GIS

'Current trends in modern organisations towards flatter structures and the involvement of many stakeholder groups in solving decision problems have created a need for information technologies capable of supporting participatory decision making' (Jankowski and Nyerges 2001, p. 2). This also applies to government decision making. One of the current technologies used to facilitate public participation is the SDSS, built primarily from GIS.

It is recognised that GIS and all the technologies related to it are increasingly employed in research and projects intended to enhance community participation in decision making (Craig *et al.* 2002b, p. 3).

When GIS is used for the particular purpose of supporting public participation in decision making, the term 'participatory geographic information system' (PGIS) is used (Jankowski and Nyerges 2001, p. 1). PGIS (which is also named as PPGIS in some texts) has a research history of more than two decades and many practical applications (for complete description of its history see Craig *et al.* 2002b, p. 6).

Members of the public involved in a decision-making process can typically better understand graphics than simply words or tables for a variety of situations. 'An image, a drawing, a map conveys information more succinctly, if not better, than tables of numbers, a textual description, or a mathematical equation' (Jankowski and Nyerges 2001, p. 37). Dangermond (2002) has demonstrated that our ease of world recognition by the human eye-brain combination allows people to obtain great amounts of information. This ability of acquire important information from a single image (for example when someone enters a room) could also be applied to spatial images and, therefore they are capable of transmitting an important amount of information in a short time.

These advantages of maps over other methods validate the current trend towards PGIS. PGIS interact with technical models and deliver and acquire knowledge from members of the community regardless of their intellectual or technical level.

Throughout the last decade, PGIS have been developed at many different levels. The public has had input through Internet-based systems, field-based portable devices and options in between. In each case, developers have sought to facilitate the integration of community knowledge with knowledge from the experts. This blending of knowledge is a key objective of PGIS (Craig *et al.* 2002c, p. 367).

PGIS has been a specific area of GIS development using a wide range of approaches to promote the involvement of the community in decision making. For William J. Craig, Trevor M. Harris and Daniel Weiner (Craig *et al.* 2002a) the design and development of PGIS is dependent on the context of the application

(Craig *et al.* 2002c). Broadly, any use of GIS as a tool to enhance public participation could be considered as an application of PGIS.

PGIS have different levels of sophistication. A PGIS could use commercial GIS software to integrate narratives and local knowledge; involve multimedia GIS with interactive features for public use; provide a collaborative decision support system (CDSS); or use non-hierarchical systems of information flow (Leitner *et al.* 2002, p. 37).

CDSS support not only the decision-making processes, but the involvement of the public during deliberations. CDSS can be classified by the level of support that they can provide to decision-makers and stakeholders. Jankowski and Nyerges (2001, p. 104) has proposed three levels:

- Level 1 (Basic Information Handling Support): In this level are those PGIS dedicated to managing information, visual aids and simple group collaboration.
- Level 2 (Decision Analysis Support): PGIS capable of generating options are in this level. Examples are techniques such as GIS-based suitability modelling and models for generating future alternatives
- Level 3 (Group Reasoning Support): In the highest level of support are those PGIS with judgment-refinement techniques (such as sensitivity analysis) and analytical reasoning techniques including fuzzy logic, rough sets, data mining, etc.

In this thesis, PGIS that comply with the definition of public participation presented in section 4.2.1 will be called geographic information systems for community knowledge (GIS-CK). GIS-CK have the objective of giving the community administrative rights and responsibilities in a public decision making process, which means in reality full decision-making powers for the community. GIS-CK are a subclass of PGIS where the systems not only communicate, but also acquire and process information from the stakeholders (which at the end is community knowledge).

PGIS, and in particular GIS-CK, have demonstrated important benefits for several decision-making processes where public participation has been a priority. In the next section some of these benefits are presented.

4.3.1 Benefits of PGIS

Several experiences around the globe have proven the benefits of PGIS, especially for situations where environmentalist groups are involved. Sieber (2002) ha developed a PGIS application for north-eastern California, USA, capable of producing cartographic representations of spheres of influence of non-profit organisations engaged in a public process involving changes in land use and urban planning issues (see Figure 4-2).

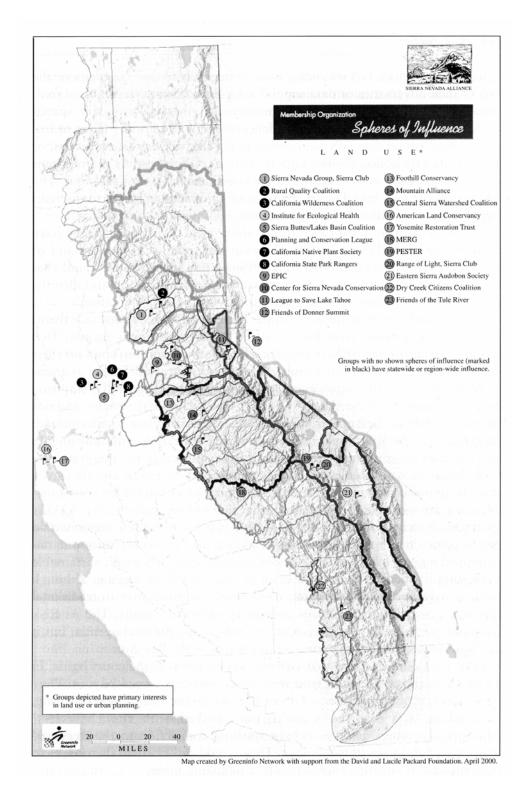


Figure 4-2: Map showing spheres of influence of a non-profit organisation engaged in land-use or urban planning issues in north-eastern California, USA (Sieber 2002).

This map with spheres of influence allows analysis of the political and social atmosphere surrounding the decision-making process, improving the negotiation tools for public decision-making.

PGIS are capable of facilitating the prioritisation of issues, improving understanding of the situation, generating new alternatives, and attaining a viable conclusion. PGIS can become a common spatial language for discussion, which acts as a means to integrate people in a decision-making process. (Dangermond 2002, p. 308). In addition, PGIS are capable of facilitating the integration of qualitative and quantitative information, which is vital to accomplish consensus between technical and non-technical stakeholders (Craig *et al.* 2002c).

PGIS are also capable of helping communities and governments to move from a consultative approach with the community to a participative reality. Craig *et al.* (2002b, p. 5) have demonstrated the ability of PGIS to help the community to climb the public involvement ladder (Figure 4-1) by providing pertinent information and developing appropriate responses and technologies to support the creation of community knowledge.

Moreover, PGIS have also proven to be a source of motivation to the stakeholders since a local capacity to produce information for decision making is built (Meredith *et al.* 2002, p 206), creating the possibility for communities to justify better their positions. In addition, PGIS can provide a better understanding of the complex social, cultural and political landscapes in the choice-making process (Craig *et al.* 2002c, p. 368).

The benefits of PGIS can be seen not only from the advanced results that can be obtained. PGIS, applied in such a way that community members are simply being asked their opinions, has proven to be very beneficial to public choice making as access to community members is created (Harris and Weiner 2002, p. 256). This access generates enthusiastic responses, which is something desirable in all PGIS applications.

Despite these testimonies of PGIS success, some researchers have found limitations to PGIS (and particularly to GIS-CK). In the next section these limitations are presented.

4.3.2 Current limitations of PGIS and GIS-CK systems

Some experiences with PGIS have shown difficulties in using spatial representations to support stakeholders. For Shiffer (2002, p. 317) the use of complementary technologies (such as GIS) to provide the public with better information could make it very difficult for groups to reach a consensus. Furthermore, the use of PGIS could be a source of confusion and also be misleading if the spatial information available is not the best option to foster the decision-making process (Meredith *et al.* 2002, p. 216).

Kyem (2002, p. 229) describes a case study where spatial technologies did not find support from the community. The community did not fully trust the public officials and foreign experts implementing the PGIS; this reduced community engagement. Dedicated work in justifying a PGIS and its application is always needed. PGIS have to confront a lack of skilled support personnel and scarce infrastructure, aspects that constitute an obstacle to PGIS application (K. Kyem 2002).

One of the principal objectives of public participation is to obtain and use community knowledge to achieve better decisions and at the same time guarantee the long-term acceptability of the decisions. However, capturing community knowledge has proven to be challenging, even when spatial technologies are used. This is normally due to the social differences in a group of stakeholders, which generate a wide range of possible interpretations of the consequences. In turn, this generates doubts about how the final product of a public participation will be used and for whom this outcome is valid (Harris and Weiner 2002, p. 256).

Jankowski (2001, p. 105) has proposed the use of facilitators in PGIS applications in order to compensate the for lack of experience in the community with spatial information and with the collaborative process. On the other hand, a facilitator could be used as a tool to mislead and confuse the community, becoming a risk to the independence of the community knowledge.

All these limitations of PGIS have prompted GIS researchers to propose improvements. In the next section the proposed developments for PGIS (and in particular GIS-KC and CDSS applications) are discussed.

4.4 FUTURE DIRECTIONS FOR PUBLIC PARTICIPATION

More than three decades of PGIS has left a wide range of positive and negative experiences. From these experiences, and with the availability of new communication technologies and with new societal interests, researchers around the world have proposed future developments of PGIS. In this section the conceptual changes proposed for PGIS are analysed first and then the practical issues are studied. These conceptual trends and practical issues have been used as a basis in the design of the conceptual framework and IT system DISCUSS, which are described in chapters 5 and 6 respectively.

4.4.1 New concepts for PGIS

One of the principal objectives of public participation is to contribute to consensus on future actions. Governments recognise that having more support for their decisions generates more confidence in the validity of the decision. Today PGIS developers seek not only good resources (such as hardware and software) but also simple methodologies and procedures that transform participative exercises, in an open discussion, in which all the stakeholders can interact (K. Kyem 2002, p. 230).

Opening the discussion to all stakeholders can reduce the possibility of having a 'toxic decision processes' where strong emotional reactions are mixed with technical issues. Toxic decision processes, which were extensively studied by Maitlis and Ozcelik (2004), are situations in which the balance between rational and non-rational aspects of the decision-making environment is lost.

Emotional or political factors are of immense relevance in current decision making. Therefore, future PGIS should incorporate strategies for integrating technical aspects with political, emotional or social factors.

However, consensus can only occur if the government trusts the public and the public participation process enough to relinquish some of its power to the community. Conclusions from several practical exercises (such as Chabot and Duhaime 1998; McCann 2001) have demonstrated that few governments are willing to give up their rights and responsibilities to the community, demonstrating that the trust (either in the process or in the community) is not strong enough for public decision making. Therefore, PGIS should focus on being not only a good ideological and political experience, but a teamwork activity where an optimal

political result is obtained from a mutually beneficial exercise between the public and the government (McCann 2001).

For Hanna (2000), consensus is built between participants when full access to information is permitted to all stakeholders. This suggests that future PGIS will have to focus on balancing the privileged position that governments normally have in terms of information in public policy evaluation.

Craig *et al.* (2002c, p. 368) argued that PGIS should be more than simply a tool to bring the opinions of people and communities to the discussion table. The challenge is to translate the graphical results of PGIS into real power and political influence. Successful public participation can only occur if the public options appear at a stage where they really can affect the final outcome (Tyler 2003). Community participation developed at a later stage (when informing, rather than involving the community, is the main objective) deceives the public and contributes to the lack of trust in public decisions. Furthermore, future systems supporting public participation should ensure that community knowledge has an equal place in the discussion alongside the technical results (Tyler 2003) so the community knows that participation is possible.

Finally, and in order to accord public participation with the findings in chapter 2, one of the principal challenges is to adapt PGIS to the economical focus of the government and become real a CDSS (Craig *et al.* 2002c, p. 370). Otherwise, PGIS would remain in a supportive stage to the public process with limited influence on the final decision.

4.4.2 Proposed practical changes for PGIS

The reality is that GIS technology is rapidly evolving, often making it more exclusive rather than more democratic. If PGIS is to use the best technologies, efforts should continue to be made for technical personnel to liaise with stakeholders (Meredith *et al.* 2002).

One option for generating a better linkage with the experts is to focus the development of PGIS on systems capable of producing understandable and tangible results (K. Kyem 2002, p. 229). This could create a community sense that the decision is not taken only through the application of mathematical rigour. 'Information being delivered to the public should be free of jargon and understandable' (Tyler 2003).

Jankowski and Nyerges (2001, p. 105) stress the importance of facilitators in PGIS. At the same time, Tyler (2003) has proven the availability of responsible moderators in public participation processes. However, from a practical perspective, research into the role and strategies of the moderator is lacking. The ideal situation would be to have a completely impartial, independent moderator who cannot be associated with any of the factions participating in the decision-making process. The moderator should not be a participant in the process, but a component of the system used to foster the involvement of the public.

In reality, idealistic moderators are difficult to find, and practical experiences with stakeholders (such as Stock and Bishop 2003) have proven that a government official could act as a moderator or system operator without generating doubts about the credibility of the public participation process.

4.5 REVIEW

Public participation is fundamental for governments as a pathway to sustainable development. From the Aarhus Convention (Aarhus-Convention 1998) and the recent developments of the European Commission for the Environment, it seems that public participation is here to stay (Tyler 2003) and public institutions must learn how to use it to their benefit.

However, public participation is more than public consultation. Public participation occurs when the government is willing to concede some power in the choice-making process by allowing public contributions at a stage of decision making where the community input will really influence the outcome.

PGIS is an emerging technology to foster public participation in decision making. Many experiences have shown its advantages in bringing together technical knowledge and the community. Some technical and conceptual limitations exist to PGIS, but the future promises an improvement in its involvement with the community.

In the future it will be desirable to have PGIS that support the creation of consensus by opening the information, generating clearer results, supporting the discussion and promoting a linkage between the technical personnel and the stakeholders in such way that none of the participants is diminished.

Governments understand the need for public participation as support for the long-term perceived validity of the decision. They wish to know the popularity of the decision, and at the same time how it might affect the political situation. However, they also acknowledge and promote the use of CBA, despite the barriers that this economic methodology places on public participation.

The developments in PGIS have been isolated from CBA, although it is the most popular methodology for ranking policy options in public decision making. Few proposals have been made to integrate the use of CBA and public participation in a single conceptual framework that allows governments to continue using CBA as the leading methodology to evaluate alternatives and at the same time permits greater public participation.

Considering the need for new systems and methodologies to support public participation, which are at the same time capable of providing information about the human factors (political, social, environmental, emotional, historical, etc) affecting public decision-making, the next chapter presents a new conceptual framework that encompasses all these factors in accordance with the demands of current governmental desires and community interests.

Chapter 4 concludes the background section of this thesis. The next two Chapters describe the *model development* in this research.

5

CONCEPTUAL FRAMEWORK

5.1 Introduction

In the previous three chapters, an analysis of the background literature led to significant conclusions about decision making. Chapter 2 concluded that governments currently demand from DSS more information about human factors (emotional, historical and political) affecting public decision-making. Chapter 3 found that DSS to support decision-making should be developed after CBA results have been obtained; be efficient in terms of data demands; and support human factors.

From the analysis presented in chapter 4, it was evident that public participation and not simply public consultation is necessary to truly engage the community in decision making. Public participation processes that make the community a decision maker permit the use of community knowledge in such a way that better decisions can be obtained and popular support for the chosen alternative exists in the long term.

Chapter 5 is the beginning of the second section of this thesis: *model development*. In this chapter, the conclusions and analyses from the background chapters are used to propose a hypothesis and develop research instruments to test it. In this chapter the conceptual framework, one of the principal research instruments developed in this thesis, is presented. The other research instruments are explicated in the following two chapters.

5.2 RESEARCH HYPOTHESIS AND METHOD

The hypothesis and research method in this thesis are based on the research aim, which is to propose and alternative to remedy the current lack of an accessible methodology for spatial disaggregation of impacts in public decision-making that are based on CBA.

5.2.1 Hypothesis

Community knowledge when combined with rational information using participatory geographic information systems (PGIS), generates an effective, accessible, practical and low-cost means to spatially disaggregate economic, environmental and social consequences in public decision-making processes.

5.2.2 Aspects to be tested and proposed method

The central proposition to be tested in this research is that community knowledge is a legitimate source of information to spatially disaggregate consequences and therefore enhance public decision-making.

It is also important for this thesis to test whether:

- the disaggregation of consequences using community knowledge facilitates a better understanding of the proposed policy options
- GIS, as a component in DSS, are capable of acquiring community knowledge to be used in the spatial disaggregation of consequences
- the combination of hard information (from rational analyses) and soft information (from the community) constitutes a real cost-effective, applicable and accessible source of information for spatially disaggregating effects
- the inclusion of community knowledge facilitates the dialogue between the community and the government in such a way that human factors affecting decision-making can be detected, understood and negotiated (if required)
- the outcomes from the IT tool DISCUSS, which implements the conceptual framework proposed in this thesis, complement the results from CBA in political, social and environmental aspects

- the conceptual framework helps governments and communities determine the actions to be taken in order to implement the alternative chosen
- the conceptual framework and DISCUSS facilitates the attainment of consensus in public decision-making.

Investigating the validity of community knowledge as a phenomenon in its own right would be an enormous task and outside the scope of this PhD research. Therefore, a *case study* method was chosen to conduct action research. Case studies are particularly usable in situations where a phenomenon or statements are investigated in such a way that the results obtained from 'can later be condensed to draw generalisations' (Evans 1995, p. 78).

In order to test the hypothesis using the case study, three research instruments were designed and developed: a new conceptual framework, a DSS called DISCUSS, and individual surveys for stakeholders participating in the case study.

The conceptual framework is the guideline to develop an integration of soft and hard information to produce spatial disaggregation of effects. The objectives of the conceptual framework, its design and components will be explained in the next section.

DISCUSS (Decision Information System for Community Understanding of Spatial Scenarios) is an information technology system developed over a GIS commercial package capable of implementing the spatial analyses required in the conceptual framework. DISCUSS is explained in Chapter 6.

The third research instrument used in this thesis was surveys completed by the Lake Mokoan's stakeholders (community and government officials). Chapter 7 explains the objectives of these surveys and their results.

The conceptual framework and the computer-based system DISCUSS are not only instruments to test the hypothesis, but they also prove to be a solution to the research problem encountered by this research. This statement is discussed further in the conclusions of this thesis (chapter 9).

5.3 CONCEPTUAL FRAMEWORK

The conceptual framework is a research instrument created to test the combination of community knowledge and technical information in public decision-making.

The conceptual framework should be seen as the guiding principles for the additional analyses proposed to spatially disaggregate the results of CBA and better understand the human factors affecting the process.

Feeney (2003, p. 199) has described a decision environment as it relates to spatial data infrastructures (SDI) as the result of the interrelationship of the technological, data and people components. Figure 5-1.a shows a graphical representation of the *decision environment* and Figure 5-1.b represents one of the main objectives of the conceptual framework, which is to expand the available *decision environment* by enlarging the data and people environments. Expansion in decision environments normally improves the end results of decision-making (Feeney 2003).

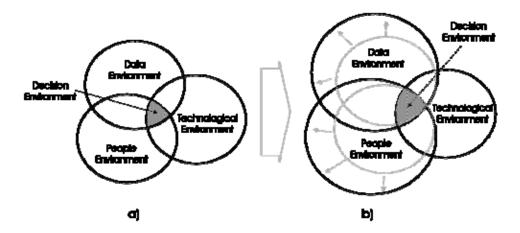


Figure 5-1: Decision Environment (a) before and(b) after the conceptual framework is applied (adapted from Feeney 2003, p. 199)

The conceptual framework expands the *data environment* by including community knowledge (or soft information) from a public participation process. The *people environment* expansion is also a consequence of the public participation as public involvement generates a better understanding of the situation from the political and social points of view.

5.3.1 Conditions for the public policies to be considered with the conceptual framework

A broad variety of definitions exist for the term 'policy'. This is mainly because policy refers to what should be done to deal with economic, technological, social, political, international and legal problems at the societal level (Nagel 2002).

The conceptual framework has been designed to be applicable in a broad variety of public policy evaluations. However, some limitations exist on the type of policy that can be analysed.

For the purpose of this thesis, and considering the extensive range of activities in which governments develop public policy evaluations, the term policy has been narrowed to cover only those decisions involving policy options that have spatial effects (positive and negative). For example, a future policy of a government, included in this definition, could be the desire to reduce atmospheric contamination in a city. This policy has effects with a clear spatial component since suburbs in the city are affected differently. The conceptual framework is also limited to those situations where the political institutions allow for the possibility of greater power sharing. This restricts its application to broadly democratic societies.

5.3.2 General scheme of the conceptual framework

The conceptual framework has three main modules:

- Module 1: CBA result-processing and decision-making process analysis.
- Module 2: Spatial disaggregation of consequences.
- Module 3: Generation of additional results for decision making.

Figure 5-2 shows a general diagram of the three main modules and the flow of information in the conceptual framework.

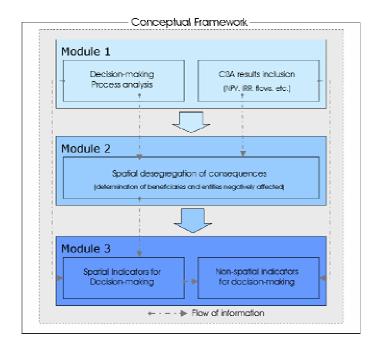


Figure 5-2: Diagram of the three main modules in the Conceptual Framework

Figure 5-3 shows the proposed location of the conceptual framework in public decision-making processes and the flow of information between the conceptual framework and the 'deciding' and 'doing' steps of the decision-making process.

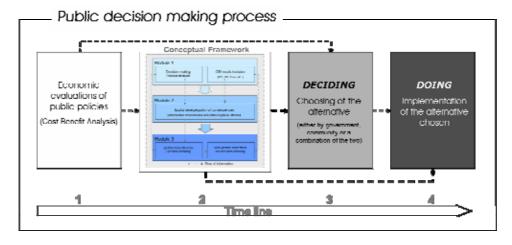


Figure 5-3: Location of the Conceptual Framework in public decision-making processes

In general terms, module 1 has been designed to obtain characteristics of the decision-making process and results from the CBA. Final results from the CBA are required before module 1 can be initiated. In module 1, information such as

the number of alternatives to be studied, the number of participating stakeholders and usage of soft and hard information are defined.

Module 2 takes all these characteristics of the decision-making process from module 1 and generates spatial disaggregation of effects using community knowledge (from a public participation process) and the available technical data.

After generating spatial disaggregation of effects in module 2, module 3 produces the additional spatial/map results and indicators to be used as supporters of the decision-making process.

Map results and indicators are the main contribution of the conceptual framework to enhance public decision making by providing information about political, environmental and social factors surrounding the process.

Embedded in the conceptual framework is a public participation process which acquires and processes community knowledge. Figure 5-4 shows the location of this public participation process in the conceptual framework.

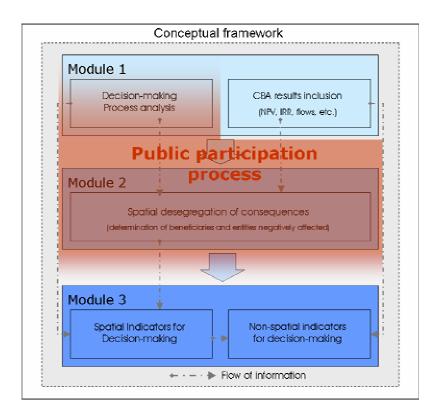


Figure 5-4: Location of the public participation process in the conceptual framework

The public participation process occurs mainly during module 2, when the spatial disaggregation of consequences is developed and during the analyses made for decision-making characteristics (module 1). To a lesser degree, the public participation process can also be part of module 3 in the generation of results.

5.3.3 Principles for the conceptual framework

The conceptual framework was developed from the findings in the background section of this thesis (chapters 2, 3 and 4).

The conceptual framework's principles have been organised into three main groups: principles for the reality of public decision making; principles for the economic evaluations and rational analyses in public decision making; and principles for public participation and community knowledge.

Principles for the reality of public decision-making

Principle 1: The conceptual framework should support procedures which are applicable in situations where access to technical and economical resources is limited.

Currently there are sophisticated and well-developed methods to spatially disaggregate effects, which use technical datasets and rational models (hard information) to predict the beneficiaries of a future policy. Examples of methodologies can be found in Turner *et al.*(2000) and Toman (1998).

However, as it was explored in section 3.4 (page 57), current methodologies are costly and very demanding of technical expertise. These limitations are very significant for developing countries where such resources are limited.

Following principle 1, the conceptual framework was designed in such a way that community knowledge can be easily acquired through public participation. Community knowledge can substitute where technical information is not available because of financial restrictions, or when the use of community knowledge facilitates the negotiation process.

Additionally, the use of community knowledge guarantees that the conceptual framework is applicable to more decision making situations, regardless of the jurisdiction's fiscal situation, as it requires less professional expertise compared to purely technical methodologies.

The application of CBA for more than three decades in government institutions around the globe has generated a culture within public institutions. If the conceptual framework was to modify CBA in some way, re-training of significant numbers of personnel, within government institutions would be required. Therefore, the conceptual framework promotes cost efficiency by using the results from CBA analysis as they are currently produced.

Principle 2: The conceptual framework should support development using a technological platform that facilitates access to information to all participants in the decision-making process and also supports effective procedures for capturing stakeholders' individual opinions.

The conceptual framework was designed to develop better channels of communication with the stakeholders.

To build these channels, the conceptual framework provides for a PGIS (as described in section 4.3). PGIS has proven to be an advanced tool to facilitate the understanding of technical information by people using spatial representations. PGIS facilitates the prioritisation of issues for citizens, improves understanding of the situation and the attainment of a viable conclusion. Therefore, GIS (in the form of a PGIS and used to process spatial information) is conceived as the primary technological platform to inform the community and acquire community knowledge.

Turner *et al.*(2000) have proposed that future DSS should be capable of complementing common economic analyses such as CBA with results in a spatial or map form. Uran and Janssen (2003) demonstrated that PGIS are not practical tools if they do not consider users' needs. Developing a methodology where only spatial data is used to support decision making denies the reality of public decision making, where economic information is the main focus.

Therefore, the conceptual framework has been extended to promote also non-spatial information in the form of social, environmental, political and economic indicators for decision making to analyse concepts such as environmental sustainability and equity. This non-spatial information is produced from the maps results proposed by the conceptual framework.

Principle 3: The conceptual framework should be applicable in a variety of decision-making situations and institutions.

One of the difficulties of current methodologies for disaggregating effects in decision-making processes is their lack of adaptability to the institution running the process. This adaptability is fundamental, as each organisation embarks on decision-making in a different way (Simon 1997).

To improve this, the conceptual framework is flexible and can be applied in different situations (such as urban or rural cases) and by different types of governmental institutions (such as technical departments or political bodies).

To accomplish this flexibility, a variable proportion of soft and hard information can be used. For example, a particular jurisdiction may only use community knowledge to assess particular social impacts and develop the rest of the analysis using technical (or hard) information.

Principle 4: Procedure developed under the conceptual framework should not only be supportive of the 'deciding' phase of decision-making. They should also provide information concerning the 'doing' or implementation phase.

Sections 2.2.2 and 2.2.3 demonstrated the tight relationship between the selection of the most desirable alternative (choosing phase) and the implementation of this decision in the real world (the doing phase). CBA and most of the economic methodologies for evaluating alternatives give information to the decision makers about the benefits of each of the alternatives during the deciding phase. However, no significant guidance, especially in social and political factors, is provided to the 'doing' phase of the process. As a consequence, principle 4 establishes that the conceptual framework should also be supportive of the 'doing' phase in public decision-making processes.

To achieve this, the conceptual framework promotes the generation of an indicator called option level of agreement (OLA) (explanations of this indicator is presented in section 5.3.5 of this chapter). With this indicator, the community and the government have a better picture not only of those social sectors that might be supportive or against each option, but also the discontent that each option produces within the stakeholders.

Principles for the current reality of economic evaluations and rational analyses

Principle 5: The conceptual framework should be conceived of as a complementary analysis to CBA, capable of expanding the information for decision-making in environmental, social and political issues. It should not interfere with basic theories and methodologies in CBA.

Chapter 3 concluded that the analyses complementing CBA should not contradict its basic theories and methodologies. However, it was also concluded that CBA cannot provide information to quantify aspects such as environmental sustainability and equity. Therefore, principle 5 of the conceptual framework establishes a congruous relationship between CBA and the additional analyses for spatially disaggregating consequences.

Results under this conceptual framework complement any information available to quantify social, environmental and political aspects, but do not contradict the results from CBA as they do not deal with economic efficiency. Moreover, analyses in the conceptual framework are of a different nature when compared with those from CBA as they are not based only on rational techniques.

Principle 6: The conceptual framework should enable transfer of the central debate from the uncertainty of the technical analyses to the real issues disturbing government officials and the community.

Although uncertainty is something not desirable in public decision-making processes, the reality is that it always exists. 'The more one looks at the details of the world, the more uncertainty one is bound to discover' (Zadeh 1965).

Critics of CBA, which is a rational-analysis method, argue that it opens a gap to deviate the discussion from the real issues. Considering that rational analysis can be manipulated to produce the result that each party desires (Carley 1980), stakeholders in a decision-making process can always debate against a policy option by attacking the technical procedures made to calculate benefits and costs.

Although in some situations stakeholders might have a fair argument to contradict the technical analysis, doubts about technical procedures can always be used to hide the real issues concerning the stakeholders. To avoid this diversion from the real issues, the conceptual framework allows stakeholders to express their positions openly without the necessity of justifying it under technical procedures. In the conceptual framework, an opinion from a stakeholder is presented in the discussion table regardless of the level of justification that it contains.

Principles for public participation and community knowledge

Principle 7: The conceptual framework should encourage the use of public participation as a means to achieve sustainable development.

Section 4.2.2 illustrated cases in the literature in which public participation proved to be a means to sustainable development, as it created in the public a sense of ownership. This sense of tenure encourages support from the community for the policy objectives (Porritt 1998).

However, public participation is more than public consultation and therefore principle 7 determines that the conceptual framework should support public participation under the definition presented in page 74. This definition established that public participation occurs when the government transfers some of its decision powers; provides the necessary tools for the public to participate; and allows the public to be involved at a time in the decision-making process where their opinions will affect the final outcome.

In consequence, and in order to have a real public participation process, the conceptual framework should be applied before the final decision is made.

Principle 8: The conceptual framework should be a channel for the government to communicate better with the public and at the same time an arena to better understand the community concerns

As Government institutions coordinate public decision making, they must have the initiative and desire to implement the conceptual framework. Therefore, the benefits of the conceptual framework are not only directed to the community. The conceptual framework is also a tool for the government to efficiently communicate technical information. This is achieved by congregating the public under a public participation umbrella and presenting its perceptions of the situation in a graphical (or map) form, which is often more easily interpreted by stakeholders than purely numerical results.

The main objective of principle 8 is to generate channels of communication between stakeholders (including the government, academia, the public sector, local communities, etc.) so the different perceptions in the decision making can be expressed and debated on common ground. The conceptual framework does not produce a recommendation or action to be adopted; it establishes a platform for the decision makers to choose an alternative using economic data (from the CBA) in concert with political, social and environmental information from the spatial disaggregation of effects.

Principle 9: The results of the conceptual framework should be understandable to all stakeholders, regardless of their backgrounds or computer literacy.

Following the recommendations for PGIS from the evaluations conducted by Uran (2003), the conceptual framework and its implementation, DISCUSS, were conceived not only considering the current technological possibilities, but also the real needs of the users and their limitations.

As it will be seen in section 5.3.5, all the indicators and map results of DISCUSS come from transparent analyses where all the stakeholders can observe how the indicators and graphical results were generated. In the same way, the acquisition of community knowledge using DISCUSS can be developed in several different forms, depending on the computer literacy of each stakeholder.

5.3.4 Tasks required to achieve results in the conceptual framework

Tasks in module 1

The main objective of module 1 is to obtain the information for the particular choice-making case. Module 1 has two tasks: including the results and information from CBA (1.a); and analysing the characteristics of the decision-making process (1.b). Figure 5-5 shows the different tasks and sub-tasks in module 1.

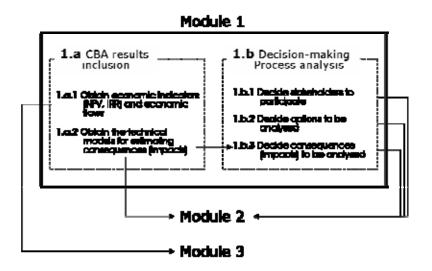


Figure 5-5: Tasks and sub-tasks in module 1

The first sub-task in the conceptual framework corresponds to task **1.a.1** where the economic indicators from CBA and other information about the economic evaluations conducted are included. These indicators are the net present value (NPV) and the internal rate of return (IRR). Along with these indicators, it is important to have information about the economic flows calculated to obtain these indicators. These flows, which are commonly developed for each option for a period between 20 and 50 years, indicate the most important impacts (benefits and costs) of the options, as well as their occurrences over time.

Sub-task **1.a.2** is an application of the models used to determine the benefits and costs of each option. Examples of the models to be included in sub-task **1.a.2** are travel demand estimations in a transport study and statistical analysis of a population growth in a resource management project.

Information in sub-task **1.a.2** should also be processed by technical personnel and is used in sub-task **1.b.3** to determine which impacts are of importance.

The tasks under the **1.b** decision-making processes analysis (Figure 5-5) are to be conducted using a collaborative process between community and government as the results from this task constitute the basis of the analyses to be developed in module 2.

Sub-task **1.b.1** determines which stakeholders are included in the process. Although in most of the cases the government is in charge of selecting the stakeholders affected in a public policy evaluation, it may be preferable to

develop a democratic process to select a group of stakeholders that represents all factions.

Radical opponents and supporters of particular options should especially be included, as they might play a vital role during the 'doing' phase of the decision-making process.

After determining the stakeholders to participate, sub-task **1.b.2** consists of the selection of the policy options to be analysed. In this aspect the conceptual framework is flexible, as any number of policy options can be analysed. However, considering that the analysis of each option represents significant increases in the required processes in modules 2 and 3, the selection of only those options that appear after the CBA as the most viable is recommended. In any case, the selection of options should be agreed with the stakeholders. The omission of an option important for a particular faction could render the whole process invalid.

The next sub-task, **1.b.3**, is the selection of the most important consequences (costs and benefits) of the options selected in **1.b.2**. This sub-task should also be agreed between stakeholders and the government.

Similar to sub-task **1.b.2**, in task **1.b.3** the number of consequences selected for analysis should be reduced to the lowest number possible as the addition of new consequences involves important increments in the tasks in module 2.

The results of the sub-tasks under **1.b** are all used in module 2. Table 5-1 condenses the most important aspects of the tasks in module 1.

Table 5-1: Characteristics of tasks in module 1

Task#	<u>Task name</u>	Developed by	Input from	Output to
1.a.1	Estimation of economic indicators (NPV, IRR) and economic flows	Technical personnel	СВА	module 3
1.a.2	Collection of technical models for estimating consequences (impacts)	Technical personnel	СВА	1.b.3 and module 2
1.b.1	Selection of stakeholders to participate	Government	Public and government	1.b.2 and module 2
1.b.2	Selection of options to be analysed	Stakeholders selected	Stakeholders and 1.b.1	1.b.3 and module 2
1.b.3	Selection of consequences (impacts) to be analysed	Stakeholders selected	Stakeholders and 1.b.2	module 2

Tasks in module 2

Module 2 consists predominantly of two tasks.

In task **2.a** stakeholders have to determine those entities (people, ecosystems, towns, areas) that will obtain a net benefit (or a net cost) if a particular option is implemented. This decision is based on the stakeholders' personal opinions and technical studies (if they exist).

Task **2.b** is similar to **2.a**. However, in this case the determination of the entities receiving the benefits and the cost is made independently for each of the consequences under analysis.

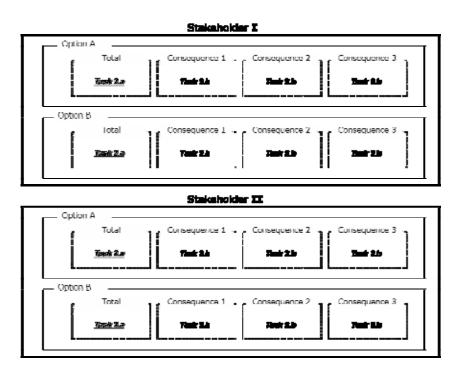
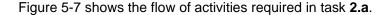


Figure 5-6: Example of the tasks required in module 2 (this particular situation has two stakeholders, two options and three consequences)

Figure 5-6 shows a hypothetical example of the required analysis for a case where there are two stakeholders (I, and II), two options (option A and option B) and three consequences under analysis in the conceptual framework (consequence 1, consequence 2 and consequence 3).

As can be seen in Figure 5-6, the number of times that task **2.a** and **2.b** need to be repeated in module 2 depends on the number of stakeholders in the analysis

(from task **1.b.1**), the number of options to be analysed (from task **1.b.2**) and the number of consequences to be considered (from task **1.b.3**).



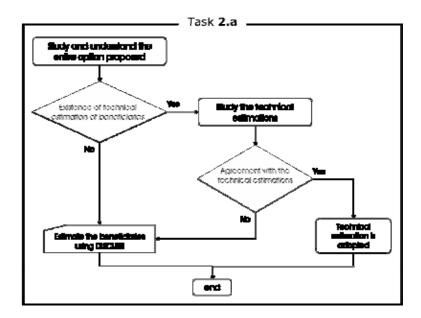


Figure 5-7: Flow-chart of activities in task 2.a

The first activity in tasks **2.a** is to study and understand the option under consideration. During this activity the government should provide all the required information as well as answer questions from the stakeholders. This activity in task **2.a** presents a great opportunity for the government to explain to the stakeholders the options in a detailed form. This first activity follows principle 8, which establishes that the conceptual framework should be a channel for the government to communicate better with the public.

After studying the option, the stakeholder is presented with the technical disaggregation for the particular option. If the stakeholder agrees with the technical disaggregation, it is adopted as the result from the task. If there is not a technical disaggregation or the stakeholder does not agree with this technical estimation, DISCUSS is used to capture the opinion of the stakeholders (see Chapter 6, section 6.5).

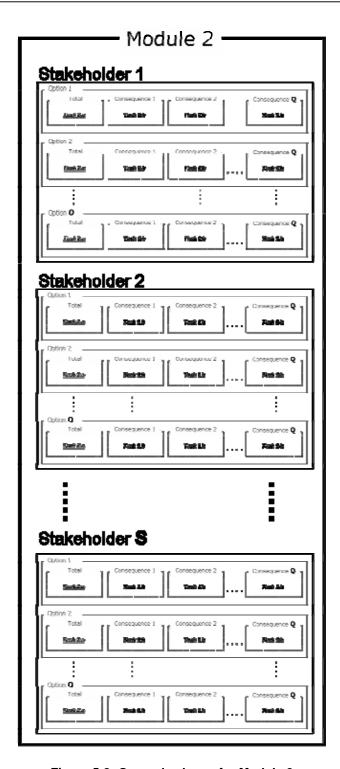


Figure 5-8: General scheme for Module 2

It is important to clarify that the output of task 2.a could be a map result (where geographic areas are identified as receiving different levels of benefits and impacts), or it could be a non-spatial result, where entities (such as the

environment, an ecosystem or a state outside the study area) are identified as receiving benefits or costs.

The flow of activities in tasks **2.b** is very similar to that in task **2.a**. The only difference is that in task **2.b** the stakeholder analyses each of the particular effects in each of the options, while the analysis in **2.a** is made for each entire option.

The main purpose of tasks in module 2 is to collect soft information from the community and the rest of the stakeholders. Figure 5-8 represents a general scheme for module 2 where **S** is the total number of stakeholder, **O** is the total number of options and **Q** is the total number of consequences analysed. The total number of task **2.a** to develop in module 2 is:

$$T2a = S \times O$$

And the total number of tasks 2.b is:

$$T2b = S \times O \times Q$$

If the framework is applied in a situation where 10 stakeholders have been selected to participate, three options are to be considered with five consequences to analyse the total applications of task **2.a** will be 30 and the total applications of task **2.b** will be 150. Taking into consideration that for each task **2.a** and task **2.b** DISCUSS creates six spatial layers (which for this example will give a total of 960 layers), the amount of processing time is incremented rapidly depending on **S**, **O** and **Q**. This reaffirms the importance of considering carefully the number of stakeholders, options and consequences chosen in applying the conceptual framework.

The main output of tasks in module 2 is the estimation of beneficiaries and entities affected in each of the options and for each of the consequences. This estimation constitutes a spatial disaggregation of consequences developed using primarily the opinion of stakeholders and with the support of the available technical information.

Table 5-2 shows a summary of the primary characteristics of the task in module 2.

Table 5-2: Characteristics of tasks in module 2

<u>Task</u> <u>#</u>	<u>Task name</u>	Developed by	Input from	Output to
2.a	Estimation of beneficiaries and entities affected in each of the options	stakeholders	Task 1.a , 1.b and personal experiences	module 3
2.b	Estimation of beneficiaries and entities affected for each of the consequences (impacts) study	stakeholders	Task 1.a , 1.b and personal experiences	module 3

Tasks in module 3

The main objective of module 3 is to produce indicators for decision-making to complement the economic results from the CBA in social, political and environmental factors.

To do this, module 3 has two main tasks: **3.a** generation of the spatial results (maps) and **3.b** generation of numerical (non-spatial) indicators.

In task **3.a**, developed by DISCUSS, results from the individual disaggregation of consequences (developed in tasks **2.a** and **2.b**) are processed to generate aggregated results as well as maps showing the differences between stakeholders.

Task **3.b** uses the map results from **3.a** and aggregates them to produce single figures. Those are then combined with economic indicators from the CBA obtained in task **1.a.1**. Figure 5-9 shows the flow of information related to module 3.

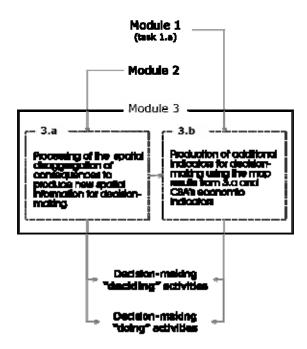


Figure 5-9: Tasks and flow of information in module 3

The next section of Chapter 5 is dedicated to explain the output from module 3.

5.3.5 Map results and new indicators produced by application of the conceptual framework

The results produced under the conceptual framework are divided in two main groups: map results (or results presented with spatial references) and numerical indicators. For both types of results the outcome is for each option and their main purpose is to support stakeholders (especially those who are acting as decision makers) in obtaining a better picture of how each of the consequences (positives and negatives) are distributed in the space. Numerical results are derived from spatial results and other demographic and economic information available.

Map results

The map results produced with the conceptual framework can be classified in two groups: *core map results* and *derived map results*.

Core map results are obtained from processing the information in task **2.a** and **2.b**. derived map results are produced from the combination of core map results with prior spatial information for the study area. Therefore, derived map results in social, environmental and political areas depend on the degree of spatial information available.

Core map results

The basic core result, called individual consequence disaggregation (ICD), is the individual spatial disaggregation for each consequence, under each option and for each stakeholder. Figure 5-10 shows an example of an individual consequence disaggregation where a stakeholder has represented in a map the areas that he or she considered will be advantaged or negatively affected.

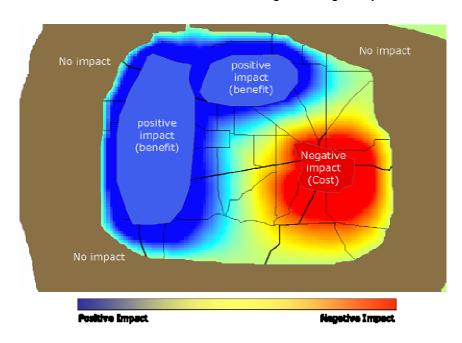


Figure 5-10: Example of an individual consequence disaggregation (ICD)

Considering the hypothetical case where the result in Figure 5-10 has analysed the consequence *change in land value*, areas in blue are where the stakeholder considered that the option analysed provides an increase in the land values for those zones. In the same way, red areas are where the stakeholder considered that the land values will be decreased as a consequence of implementing the option analysed. This result presented in Figure 5-10 has been processed by DISCUSS using a fuzzy logic methodology to reduce uncertainty in the input. Section 6.5.4 explains the spatial and mathematical analyses developed to obtain ICD map results.

Individual option disaggregation (IOD) is another core map result, and it is similar to individual consequence disaggregation (ICD) with the only difference that IOD considers the option in its entirety, rather than individual consequences.

Using these two core map types the area of agreement and disagreement (AAD) map is obtained. This represents the areas where stakeholders agree and disagree in terms of the beneficiaries and entities affected. ADD result is calculated by DISCUSS (see section 6.6) and Figure 5-11 is an example of area of agreement and disagreement map.

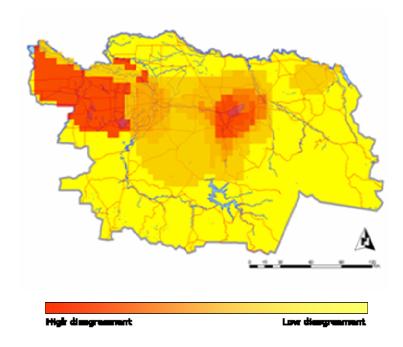


Figure 5-11: Example of a map of the areas of agreement and disagreement (AGD)

Areas in intense red in Figure 5-11 are zones where there is a high level of disagreement between stakeholders. Zones in orange represent varying levels of disagreement and those in yellow are where stakeholders agree about the impact (negative, positive or no impact). Maps of agreement and disagreement may also be used to qualify policy options with the advantage that privacy of stakeholders' opinions is protected.

The conceptual framework also allows for production of an average spatial disaggregation (ASD) map, which is a normalised arithmetical mean between individual option disaggregation maps (for explanation of the technical procedure in DISCUSS see section 6.6 in the next Chapter).

Figure 5-12 is an example of an average spatial disaggregation result. In the blue areas stakeholders, on average, considered that a benefit will be obtained if option A is implemented, and brown is where, on average, a negative impact is expected.

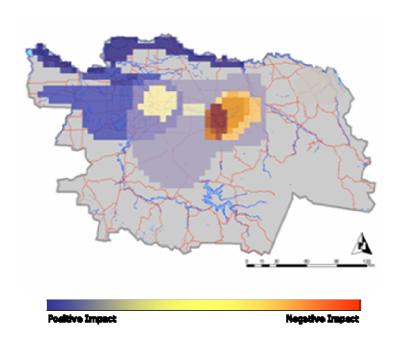


Figure 5-12: Example of an average spatial disaggregation (ASD)

In average spatial disaggregation (ASD) maps the opinion of all stakeholders are considered equal and therefore it can be affected by bias. Taking into consideration that bias is an aspect that all research should evaluate (Leedy *et al.* 1997), a factor called Z, to qualify the validity of the entries by each stakeholder, has been developed. This factor is determined for each stakeholder and is a measure of the independence and consistency of the entries by each stakeholder. It is considered that a stakeholder with a high degree of consistency between two results is an informed one, and therefore his or her input to the system should be weighted higher than that produced by a stakeholder where there is a low degree of consistency in the results. A full explanation of factor Z and the method used to determine it is presented in chapter 6 (section 6.6). Factor Z is the alternative proposed in this thesis to validate community knowledge.

Using the factor Z, the average spatial disaggregation result produces a validated spatial disaggregation (VSD), which is a weighted average estimation of beneficiaries and entities affected for each of the options in the conceptual framework.

Table 5-3 shows a summary of the core map results developed with the conceptual framework.

Table 5-3: Summary of core map results in the conceptual framework

Name	Acronyms	Description	Apply to
individual consequence disaggregation	ICD	individual spatial disaggregation for each consequence, in each option	Each stakeholder
individual option disaggregation	IOD	Spatial disaggregation of consequences of an entire option	Each stakeholder
area of agreement and disagreement	AAD	Areas of agreement and disagreement between stakeholders	Each option
average spatial disaggregation	ASD	Spatial disaggregation of consequences developed by averaging IOD results	Each option
validated spatial disaggregation	VSD	Spatial disaggregation of consequences with validation of entries using the Factor Z	Each option

Derived map results

In order to support the human aspects of public decision making, maps showing a relationship between entities affected and boundaries are proposed under the conceptual framework. These maps are created using the core map results and the prior available spatial information for the study area.

Derived map results could be very useful to uncover hidden relationships between beneficiaries and low-income populations, or they can support the development of analysis concerning the environmental sustainability of a particular species.

As the possibilities for generating derived map results are endless and depend on the issues involved in the policy proposals, to specify derived map results for all decision making is not possible.

Therefore, derived maps should be based on the stated needs or interests of the stakeholders and the availability of required spatial information. In section 7.3.2 several examples of derived map results are presented. These examples are part of the analysis conducted during the case study for Lake Mokoan.

New indicators for decision-making

The conceptual framework supports the option to also generate numerical indicators in order to rank policy options. In contrast to the indicators produced with CBA, the proposed indicators do not represent the benefits of each option from an economic point of view. They rank alternatives from other points of view such as equity and environmental sustainability.

Using the validated spatial disaggregation of consequences (VSD) and a map of population density, the total number and level of people benefited can be determined to produce the indicator of the population beneficed (IPB). This indicator is calculated using equation 5-1:

$$IPB = \frac{\sum_{i=1}^{n} P_i * B_i}{Tp}$$
 equation 5-1

where P_i is the population in polygon i, B_i is the benefit in polygon i (value between 0 and 1), n is the total number of polygons and Tp is the total population in the study area.

Similar to IPB it is possible to calculate an indicator for costs or negative effects. The indicator of population negatively affected (IPN) represents a relation between the total numbers of people affected in each option. This indicator is calculated using equation 5-2:

$$IPN = \frac{\sum_{i=1}^{n} P_i * (-C_i)}{Tp}$$
 equation 5-2

where P_i is the population in polygon i, C_i is the negative impact in polygon i (value between 0 and -1), n is the total number of polygons and Tp is the total population in the study area.

By combining these two indicators (IPB and IPN) it is possible to calculate the population benefit-cost ratio (P-BCR). This indicator is calculated using equation 5-3:

$$P - BCR = \frac{IPB}{IPN}$$
 equation 5-3

Those options with an IPR greater than 1 are considered to produce more benefits per population than cost as a net value. In contrast, those options with an IPR less than 1 produce more costs per population than benefits as a net value.

Using similar procedures to those presented for IPB and IPN indicators, additional equations could be developed to analyse equity by substituting the total number of population by the wealth or income in each polygon. This indicator of equity in each option, called indicator of option equity (IOE), is calculated with equation 5.4.

$$IOE = \frac{\sum_{i=1}^{n} income_{i} * impact_{i}}{T_{i}}$$
 equation 5-4

where $income_i$ is the income or measure of the wealth in polygon i, $impact_i$ is the measure of the impact for polygon i (value between 1 and -1), n is the total number of polygons and Ti is the total income for the study area.

It is also possible within the conceptual framework to calculate the level of agreement, in terms of the spatial disaggregation of benefits and costs, between the stakeholders. This indicator, called the option level of disagreement (OLD), is a normalised figure that gives an estimation of the conflict between stakeholders when considering each option. This information is not used only for decision-making, but also as support for the implementation phase. OLD indicator is calculated using equation 5-5:

$$OLD = \frac{\sum_{1}^{n} stdDv_{i}}{\max(stdDv) * n}$$
 equation 5-5

Where $stdDv_i$ is the standard deviation of the level of agreement and disagreement (AAD) in cell i, n is the total number of cell in the raster AAD map

and max(stdDv) is the maximum standard deviation in all AAD maps for the options considered.

Table 5-4 shows a summary of the proposed new indicators to be applied in public decision making after a spatial disaggregation of consequences is obtained.

Table 5-4: Summary of new indicators for public decision-making proposed in the conceptual framework

Indicator	Description
Option Level of Disagreement (OLD)	Normalised measure of the disagreement between stakeholders. Values close to 1 represent high disagreement
Indicator of population beneficed (IPB)	Measure of the relationship between spatial consequences and the population advantaged in the study area.
Indicator of population negatively affected (IPN)	Measure of the relationship between spatial consequences and the population <i>negatively</i> affected in the study area.
Population benefit- cost ratio (P-BCR)	Relationship between the populations beneficed and negatively affected. P-BCR = IPB / IPN
Indicator of Option equity (IOE)	Measure of the relationship between beneficiaries and income.

5.3.6 Tools required to implement the conceptual framework

In order to implement the conceptual framework in a practical situation, negotiation, economic and spatial tools are required. These tools should be based on computational procedures to optimise resources and minimise processing time.

Figure 5-13 shows the type of tool that is required in each of the parts of DISCUSS.

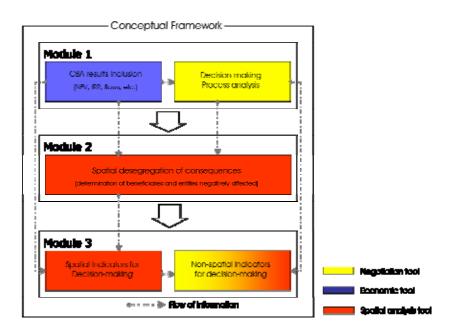


Figure 5-13: Tools required to apply the conceptual framework

In order to process the information from the CBA, simple economic tools are required. For most of the cases spreadsheet software (such as Microsoft Excel) could be used. If more sophisticated statistical analyses are required, specialised software packages such as SPSS might be needed. In any case, for these initial activities in the conceptual framework, an expert in the technical economic knowledge of CBA and its basic theories is required.

For the selection of stakeholders, followed by the selection of policy alternatives to be analysed, the use of group decision-making tools, such as multi criteria analysis or the analytical hierarchy process (Saaty 1995), are required. In any case, the sophistication of the tools required for the selection of stakeholders and alternatives depends directly on the objectives of the institution applying the conceptual framework.

Undemocratic selection of stakeholders has proven to bring more difficulties than benefits to public decision making (Walters *et al.* 2000). Therefore, and considering that the conceptual framework has been designed to create a negotiation environment that facilitates consensus, having democratic procedures in all stages is highly desirable.

5.4 REVIEW

Using prior experiences in the literature, and recognising the new interests of governments, a conceptual framework for disaggregating effects in an economic evaluation and to improve public participation was developed. This conceptual framework is used as a research instrument to test the hypothesis in this thesis, which proposes that community knowledge, combined with rational information using decision support systems (DSS) based on geographic information systems (GIS), generates an accessible, practical and low-cost alternative to spatially disaggregate economic, environmental and social consequences.

The conceptual framework has been designed to support both the technical and political aspects of the decision-making process by creating and presenting a picture of the perception of each stakeholder about the policy options.

The central principle of the conceptual framework is the combination of spatial information acquired from technical procedures (satellite images, environmental models, aero photography, etc.) with subjective or soft information from experts and the community. This combination of information, along with corresponding validation methods, permits the analysis of technical and political spatial effects at a low cost and in a wide range of situations.

6

DISCUSS

DECISION INFORMATION SYSTEM FOR COMMUNITY UNDERSTANDING OF SPATIAL SCENARIOS

6.1 Introduction

After developing the conceptual framework, which was based on the hypothesis proposed, the need for an IT tool, capable of processing spatial information and supporting the implementation of the conceptual framework was evident. DISCUSS (Decision Information System for Community Understanding of Spatial Scenarios) is the result of this analysis, and it constitutes the practical implementation of the conceptual framework.

This chapter is dedicated to explaining DISCUSS, focusing mainly on its technical characteristics to acquire and represent community knowledge and methods to obtain map results.

6.2 WHAT IS DISCUSS?

DISCUSS is a decision support system (DSS). DISCUSS fits under the particular class of DSS called spatial decision support systems (SDSS) as the basis for the analysis of spatial information. Considering that an important objective of DISCUSS is to achieve a better interaction between stakeholders in public decision making, DISCUSS could be considered to be a PGIS.

PGIS are computer based systems with a wide variety of objectives. PGIS could be used to map the location of stakeholders, to explain technical results in a spatial form or to be a portable tool for supporting planning in rural areas. Most PGIS supply data and analysis options to people. As DISCUSS is designed for acquiring and processing the community knowledge required in the conceptual framework, it is in many ways a new type of PGIS, called geographic information systems for community knowledge (GIS-CK). The definition and characteristics of this particular class of PGIS were explained in section 4.1 of this thesis.

Figure 6-1 shows the location of DISCUSS in relation to the different classification of DSS currently available.

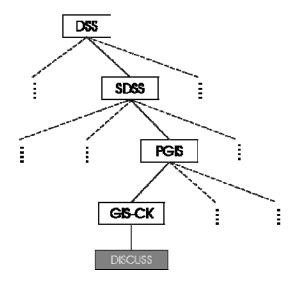


Figure 6-1: Classification of DISCUSS as a GIS-CK

6.3 OBJECTIVES OF DISCUSS

The main objective of DISCUSS is to be a research instrument to test the hypothesis proposed and present an alternative approach to solving the research problem. In addition, DISCUSS has the following particular objectives:

- to facilitate the procedures proposed in the conceptual framework using GIS and related technologies
- tTo be an IT system capable of interacting with stakeholders with different backgrounds and levels of computer literacy
- to be a tool for creating map results and new indicators demanded by the conceptual framework.

6.4 TECHNICAL CHARACTERISTICS

6.4.1 Software

As DISCUSS was required to support common spatial operations and to provide personalised analyses for acquiring community knowledge, ArcGIS was used as the underlying development platform. ArcGIS is a commercial GIS suite produced by ESRI (www.esri.com).

ArcGIS allows the development of customised applications using the existing commands in the software and Visual Basic programming language. The addition of new spatial operations is made possible by using Visual Basic for Applications (VBA), which allows access to a wide number of programming classes and subclasses by a product called ArcObjects. The initial version of ArcGIS used to develop DISCUSS was 8.1, but at the end of the project DISCUSS was converted to version 8.3.

Most of the final code for creating these particular commands came from developments by the author. However, in some circumstances, existing code in C++ and Visual Basic from the ArcGIS user forum (http://support.esri.com) was used and modified.

The use of ArcGIS as the development platform saved time in developing the application; permitted sophisticated spatial analysis according to the characteristics needed; and supported a flexible visual interface. However, DISCUSS is not a stand-alone application; ArcGIS must be installed before it can run.

6.4.2 Hardware

ArcGIS is software developed for Windows desktop computers and as DISCUSS is built into ArcGIS, the minimum requirements for ArcGIS apply also to DISCUSS. According to the manufacturer, the minimum system requirements of ArcGIS for Windows XP operational systems are a Pentium processor with a CPU Speed of 450 MHz and 128 Megabytes in RAM memory (http://support.esri.com).

DISCUSS is used mainly for two tasks: acquiring the community knowledge from the stakeholders and processing this community knowledge into core map results. For the first task, a portable computer with the minimum system requirement is needed. For the second main task, a more powerful computer is desired, as a significant number of processing operations are required.

6.5 ACQUISITION OF COMMUNITY KNOWLEDGE WITH DISCUSS

In order to acquire and process the information from the stakeholders, a moderator acting as system operator is required. This system operator of DISCUSS should be capable of understanding basic GIS software, and be familiar with the decision-making process. The selection of the system operator is especially significant as he or she should facilitate the use of DISCUSS by stakeholders without interfering with their opinions. Therefore, the system operator should not have links with any stakeholder.

6.5.1 DISCUSS interface

DISCUSS runs on Windows desktop machines by opening an ArcGIS file (.mxb extension). This file contains a customise arrangement of ArcGIS toolbars and the table of content (TOC). This file also adds a new toolbar called DISCUSS. Figure 6-2 is a screen shot of a typical window or work are in DISCUSS.

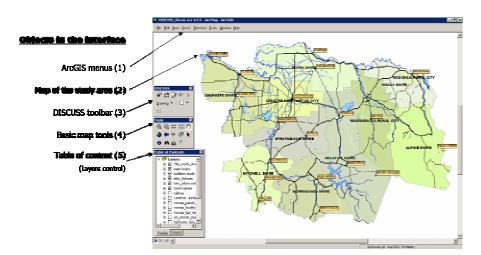


Figure 6-2: Interface between DISCUSS and stakeholders

The main objective in the visual presentation of DISCUSS is to assign the largest possible amount of screen space to the map of the study area (object 2 in Figure 6-2).

The map that appears in the screen can be customised according to stakeholders' preferences. The TOC (object 5 in Figure 6-2) is used to turn on and off different layers in the map. With the TOC layers such as roads, railway lines, rivers, political boundaries, towns, etc. are controlled.

The interface also contains the basic tools available in ArcGIS to work with maps (object 4 in Figure 6-2). Among others, tools such as zoom in and out, pan, measure distances, identify geographic entities and show map full extent are available. These tools, as well as the TOC, can be used by stakeholders if they have the computer literacy and desire to do it.

If at some stage the system operator or stakeholder requires using some of the advance spatial analysis tools available in ArcGIS, they can be accessed by using the menus at the top of the screen (object 1 in Figure 6-2).

6.5.2 Inputting soft information from stakeholders

Uran and Janssen (2003) have advocated that SDSS be designed in such way that awareness of the needs and limitations of users is always present. In this respect, a reality in most public decision-making processes is that stakeholders do not have the same level of computer literacy. The incorporation of a system operator in DISCUSS partially covers some limitations that stakeholders might have. However, GIS-CK systems require especial attention in terms of the methods to obtain information from users.

In consequence, DISCUSS was designed to permit two types of methods for inputting from stakeholders: digital input and paper-based input.

Digital input corresponds to the situation in which the stakeholder uses directly the computer input devices (mouse and keyboard) to draw in DISCUSS the location of benefits and costs of the policy option. Figure 6-3 contains a picture of the digital based input system. In digital-based interaction the system operator sits next to the stakeholder to support him or her and deal with technical questions about the computer system.



Figure 6-3: Digital input method in DISCUSS

The paper-based method was created to make DISCUSS more user-friendly for stakeholders with a low degree of computer literacy. Doran and Lees (2003) have conducted an analysis of the different methods to input spatial opinions from people for the relationship between crime, disorder and fear of crime. Considering the benefits found by Doran and Lees (2003) in using paper based methods for inputting opinions from the public, a portable arrangement of a laptop computer, a paper screen and a digital projector was designed in order to permit a more flexible input into the DISCUSS application. Figure 6-4 and Figure 6-5 contain pictures of the portable arrangement for the paper-based input in DISCUSS.

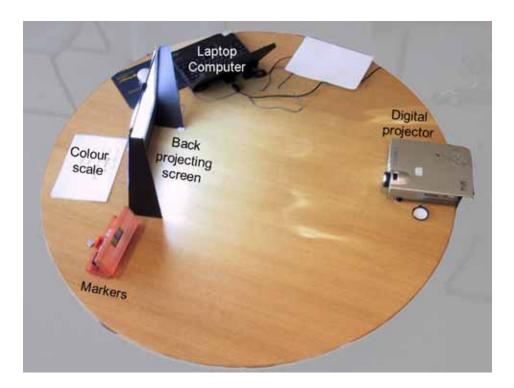


Figure 6-4: General arrangement for the paper-based input method

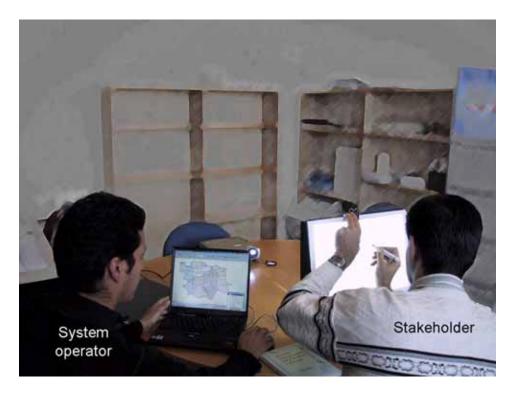


Figure 6-5: Location of the stakeholder and system operator in the paper-based input method

In the paper-based input system a digital projector is used to display on a transparent screen the image of the DISCUSS interface. In front of the transparent screen is located a 70gsm white bond paper sheet. Stakeholders sit in front of the screen and, using paper markers, draw on the paper sheet their interpretation of the spatial distribution of consequences.

The system operator controls a laptop computer connected to the digital projector, making the modifications to the displayed image in accordance with the desires of stakeholders. For example, stakeholders might request the system operator to add or remove a specific geographic layer or to zoom to a specific area. The system operator also displays some visual references when stakeholders are interacting with the map in order to allow calibrations of the input during the digitising process.

6.5.3 Interviewing the stakeholders: an example

The process of interviewing the stakeholders in order to obtain their interpretations of the spatial location of consequences is simple. However, many features of DISCUSS contribute to its accessibility to the stakeholder and the system operator.

Next is presented a practical example in order to explain all the features of DISCUSS used during the interviewing process. In this hypothetical case, which is similar to the one presented in section 2.1, the government is conducting a decision-making process where two policy options for improving the transport in a city are under consideration: the construction of a new bridge or the extension of the train network. For this particular example two consequences will be studied: changes in travel times (impact 1) and changes in land values (impact 2). It is important to clarify that the following example is a fictitious situation.

Having selected the options to be considered and the consequences to be studied in each option, the stakeholders can be interviewed. The first step of the interview is to set in DISCUSS the name of the participating stakeholder. Then the system operator selects one of the options and describes it. This description could be written on a display window in DISCUSS or could be in paper form. The source of this description is normally the CBA reports. The system operator restricts his participation at this stage to providing information, without influencing the stakeholders.

Then the operator will display a map of the study area on the screen and will ask the stakeholder:

> - According to your experiences and considering only travel times, what areas in the map on the screen will reduce their travel times (benefit) and what areas will increase their travel times (cost) if a new bridge is constructed?

For this example it is assumed that a technical estimation exists, therefore the system operator will show the technical estimation (Figure 6-6) and add:

- According to technical estimations, this is the distribution of benefits or costs in terms of travel times (some explanation of this technical distribution might be added at this time such as description of the scale colour or information about the modelling technique used). Do you agree with this estimation?

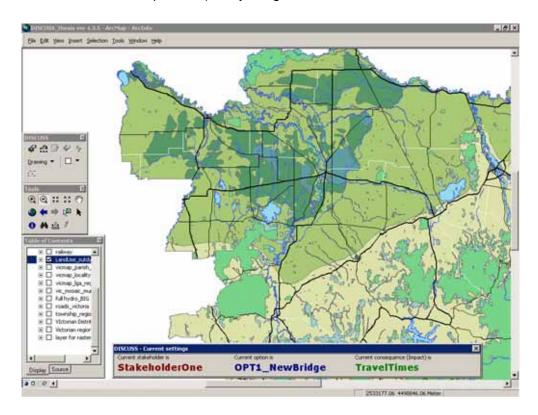


Figure 6-6: Screen shot of DISCUSS when presenting a technical disaggregation

It is important to note that showing any technical disaggregation to stakeholders in DISCUSS involves only making visible a layer in the TOC. In addition, during the development of the interview, DISCUSS always displays an information window that can be moved but not closed. In this, the system operator and the stakeholder observe which option is under consideration and which consequence is been estimated (see Figure 6-6). This window is also designed to be highly visible in order to encourage stakeholders to focus their attention on only one option and on only one consequence.

If stakeholders agree with the technical disaggregation presented, the system operator will move to the next consequence to be analysed. However, if stakeholders disagree with any part of the technical disaggregation (or there is no technical disaggregation available for a particular consequence), the system operator will activate DISCUSS to permit either a digital input or paper-based input.

In both input systems stakeholders have a five-colour scale to draw their opinion. This scale is:

- Black = High positive impact
- Blue = Medium **positive** impact
- Brown = Not affected
- Yellow = Medium negative impact
- Red = High **negative** impact

This colour scale can be modified in accordance with the stakeholders' desires. However, for simplicity at the post-processing stage, it is recommended to have the same scale for all stakeholders in the analysis.

For this hypothetical example, let's assume that after showing the technical disaggregation of travel times, the stakeholder did not agree with this estimation and developed a personal estimation. Figure 6-7 shows this input to DISCUSS.

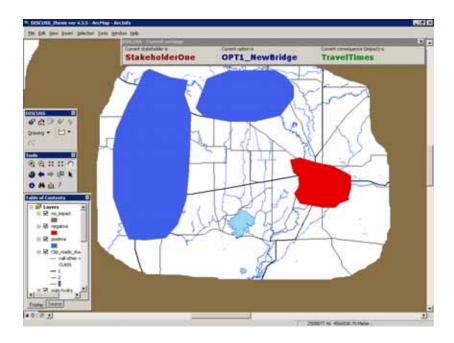


Figure 6-7: Screen shot of an example of a stakeholder's input using the digital based method in DISCUSS

In the example presented in Figure 6-7, the input from stakeholders was purely in a spatial form. However, with it DISCUSS is also able to consider beneficiaries outside the area of study or those that do not have a clear spatial reference. For example, the stakeholder could say that the benefits of a particular consequence are located in a jurisdiction outside the study area or in entities such as the environment, which has a spatial location difficult to identify.

After an opinion for all the consequences has been obtained, stakeholders are interrogated about their estimation of the entire option. In this case the question is:

- if option one 'construction of a new bridge' is implemented and considering all the consequences (positive and negative) that could be generated after implementing this option, who are the beneficiaries who is going to be negatively impacted?

Once stakeholders has in-putted their opinions about consequences and totality of the option, then the system operator moves the process to the other policy options in analysis.

These steps are then repeated with all the stakeholders participating in the conceptual framework.

6.5.4 Processing inputs

Before final results can be obtained with DISCUSS, input from stakeholders need to be transformed in such a way that they can be compared. Inputs made with the digital input method can be directly processed by DISCUSS to obtain results. Those inputs that use the paper-based input method require a manual digitisation. This digitisation is a simple process as DISCUSS records the scale and location of the image used by the stakeholder when they drew on the paper. Figure 6-8 shows an image of the digitising process.

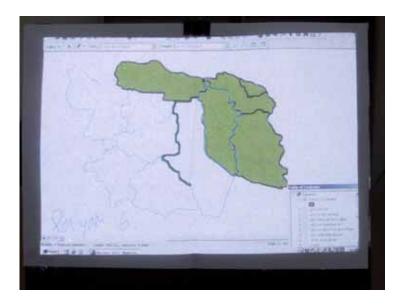


Figure 6-8: Image of the digitising process in DISCUSS

Once the paper based inputs have been digitised, all the inputs from the stakeholders are in vector layers in DISCUSS.

These inputs contain polygons representing zones receiving a positive or negative impact; or not receiving any impact. Those areas not covered by a polygon are zones of uncertainty in terms of the type of impact (benefit or cost). In these zones the stakeholder could not determine if a positive, negative or no impact situation was going to be generated.

Figure 6-9 contains an example of a typical input from a stakeholder where the areas with a white background represent those of uncertainty.

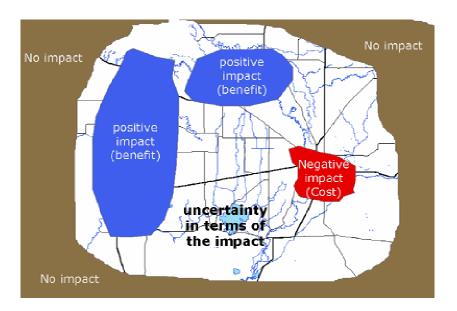


Figure 6-9: Areas of uncertainty in inputs from stakeholders

6.5.5 Fuzzy logic method to solve uncertainty in inputs

In order to generate results capable to be compared, all zones in the study area need to be covered with some degree of positive or negative impact; or at least with *no impact*. Assuming *no impact* in those areas not identified by the stakeholder in the study area could be considered as an interference with the stakeholder's opinion since he or she had the option to assigning a *no impact* and did not used it.

Several alternatives are available to resolve uncertainty such as linear distance interpolation (Fotheringham *et al.* 1994). However, considering that typically part of the area is identified and part of it contains uncertainty (part of the input is fuzzy and part is crispy), the preferred option was to develop a geographical adaptation of fuzzy logic to solve these uncertainties.

The use of fuzzy logic in spatial information is not new. Openshaw and Openshaw (1997) have developed a summary of the different applications of fuzzy logic where a spatial dimension is included. In this summary the use of fuzzy logic as a tool to model sophisticated systems such as transport networks by incorporating fuzzy membership functions is notable.

However, in this research, the intention was to model an entry using a fuzzy logic method so the entries can be later 'defuzzified' to produce a map without uncertainties. To do this DISCUSS converts the vector input to a raster form and

calculates a fuzzy number for each cell affected by uncertainty. These fuzzy logic numbers are created using the distance of each cell to all the nearest the two nearest polygons with different levels of impacts. Figure 6-10 represents the distances d1 and d2 that DISCUSS will use to generate the fuzzy number for the cell **A** according to its proximity to the two zones with level of impact **y1** and **y2**. This level of impact could be a number between -1 and 1, where negative numbers represents a cost and positive a benefit.

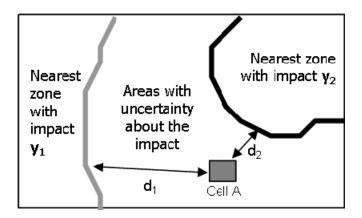


Figure 6-10: Definition of distances in the fuzzy logic method for solving uncertainty

Figure 6-11 shows the graphical representation of the fuzzy logic membership function for the cell A. The x-axis represents the distance from cell A to the zones with level of impact y1 and y2. The y-axis is the degree of membership.

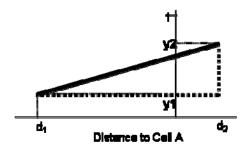


Figure 6-11: Fuzzy logic membership function for each cell in the input raster map

For each individual cell the fuzzy numbers are created. Finally, a crisp value is generated for all the cells using the 'centre of gravity' method for defuzzication (Yager *et al.* 1992).

Figure 6-12 shows the interface in DISCUSS that uses the fuzzy logic method for solving uncertainty in input maps. In this interface the user defines the input vector layers and the characteristics of output raster layer to be produced. DISCUSS also allows users to define the mathematical parameters for the fuzzy logic solution such as maximum distance to be covered and type of membership function to be used (linear or quadratic).

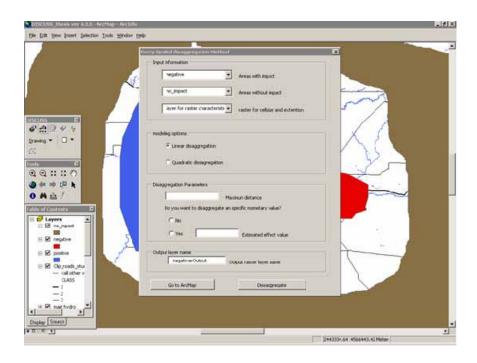


Figure 6-12: Interface in DISCUSS to apply the fuzzy logic method for solving uncertainties in inputs

Figure 6-13 is an example of a raster solution using the fuzzy logic method in DISCUSS. A linear membership function definition was used to develop this solution and the input was the vector layer presented in Figure 6-9.

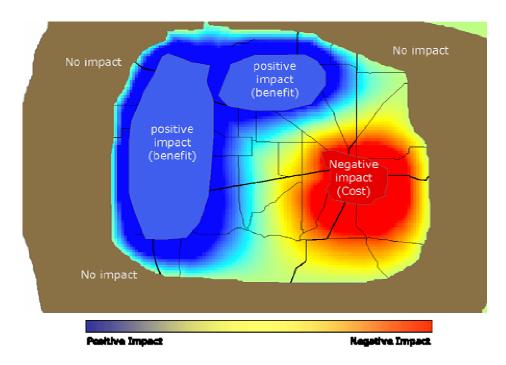


Figure 6-13: Example of a solution using the fuzzy logic methodology in DISCUSS

The final result from the fuzzy disaggregation method are always normalised by DISCUSS, which means that the maximum positive impact is 1 and the maximum negative impact is -1.

As the value of the benefits and costs (based on the CBA) is the same for all stakeholders, DISCUSS distributes this value among the positive and negative cells receiving it. This distribution depends on the level of impact assigned by the stakeholder (see the colour scale used for inputs described in page 129). The value of the benefit or cost that each cell receives will depend on the level of impact that it is receiving and the total number of cells totally being affected.

For example, if a stakeholder assigns a negative impact to a small area, those cells affected will have a high value in terms of the cost when compared with another stakeholder that for the same negative impact selected a larger area. Figure 6-14 contains a representation of the distribution of benefits and costs among the cells affected. In this graphical example the total value to be disaggregated is a benefit of \$100 and the total number of cells in the study area is 25.

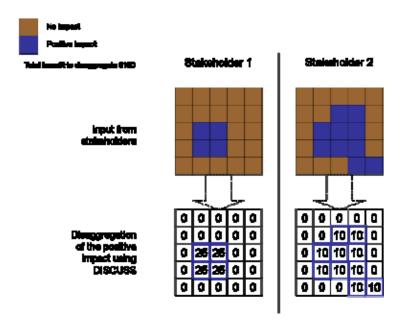


Figure 6-14: Example of a spatial distribution of a monetary benefit using DISCUSS

6.6 Processing results

Once the inputs from stakeholders have been processed in such way that the entire study area is covered and the value of the benefits and costs has been assigned to each cell, map results for the conceptual framework can be obtained.

Most of the map results are calculated using simple map algebra and by implementing the basic operations available in the map calculator function in ArcMap, which is one of the components of ArcGIS. Technical information about map algebra and the use of map calculator in GIS products is explain by Mitchell (1999).

The map algebraic formulas used by DISCUSS to calculate each of the map results are as follows:

Core map result of the areas of agreement and disagreement (ADD)

For each consequence and for the options:

$$MapADD = std_deviation(MapC_1, MapC_2, ..., Map_n)$$
 Equation 6-1

where $MapC_i$ represents the map result for the specific consequence or option for stakeholder i and n is the total number of stakeholders.

Those cells where the standard deviation is high have greater disagreement between stakeholders.

Core map result of the average spatial disaggregation (ASD)

For each consequence and for the options:

$$resultASD = \frac{\sum_{i=1}^{n} map_i}{n}$$
 equation 6-2

where map_i represents the map result for the specific consequence or option for stakeholder i and n is the total number of stakeholders. This formula is equivalent to calculating the average or arithmetic mean between maps. Figure 6-15 represents graphically the calculation of the average spatial disaggregation using the map calculator.

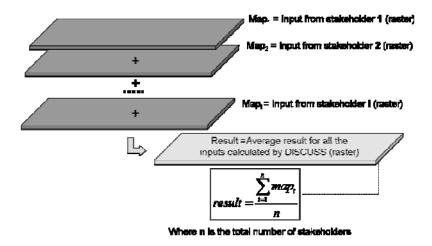


Figure 6-15: Calculation of the average spatial disaggregation

Core map result of the validated spatial disaggregation (VSD)

For each consequence and for the options:

$$resultVSD = \frac{\sum_{i=1}^{n} map_{i} \cdot z_{i}}{\sum_{i=1}^{n} Z_{i}}$$
 Equation 6-3

where map_i represents the map result for de specific consequence or option for stakeholder i, Z_i is the Z factor value for stakeholder i and n is the total number of stakeholders.

Figure 6-16 is a graphic representation of the validated spatial disaggregation (VSD) using the map calculator

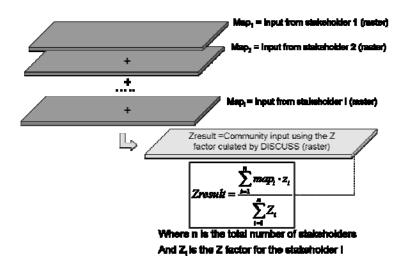


Figure 6-16: Graphic representation of the map calculation to obtain the validated average disaggregation (VSD)

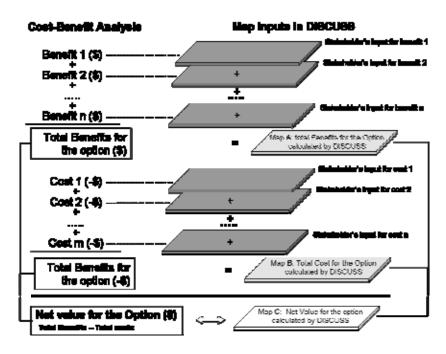


Figure 6-17: Comparison between cost-benefit analysis and the input from the stakeholder

For the factor Z, consistency is the main concept for identifying well informed stakeholders without bias towards any option. This factor was defined considering that in the conceptual framework there is a cost-benefit analysis (CBA) as an existing non-spatial methodology for evaluating options. In a CBA, the net value for the option is equal to the net value of subtracting the sum of all the cost from the sum of all benefits. Figure 6-17 shows the relationship between the CBA and the maps of inputs for each stakeholder.

Each stakeholder can input to the system a map of perception for each effect in the CBA. DISCUSS can then calculate map A (see Figure 6-17), which represents the total perception of benefits for the option analysed. In the same way map B is calculated tallying the costs. Map C is a representation of the net benefit for the option, and is calculated by subtracting from the total benefits (map A) from the total costs (map B). In is important to note that maps A, B and C are calculated by DISCUSS.

In addition to these individual maps for benefits and costs, the user inputs a map of his or her perception for the entire option, which is called map D. This means the user has to express, considering all the possible effects, where the benefits and costs will occur if the option is implemented. The assumption is that a well informed stakeholder with no bias for a particular benefit or cost will produce an entire map for the option (map D) consistent to map C, which is calculated by DISCUSS and depends on individual identification of effects.

Having these two maps, and considering that maps C and D are in a raster form, a map of the difference between C and D is calculated (map E) and then the indicator T is the total sum for all the cells in map E. The assumption is that if T is small, the input was consistent and therefore a consistent interpretation of the future impact.

Having the indicator T, the Z Factor for each stakeholder is calculated by applying the following equation:

$$Z_i = 1 - \frac{\max(T)}{T_i}$$
 equation 6-4

where Zi is the factor for stakeholder i, max(T) is the maximum value for all the stakeholders analysed and Ti is the indicator T calculated for the particular stakeholder.

Using this evaluation of Z, the stakeholder whose value of T was the maximum obtains a Z value of zero, meaning that his inputs will have no effect in the final result.

The derived map results are generated by adding a new layer to DISCUSS without doing any spatial operation. The type of analysis with each of the derived map results depends on the available spatial information for the study area. In any case, as DISCUSS is embedded in ArcGIS, advanced map symbology and representations can be developed for the derived map results depending on the stakeholders' demands. Examples of derived map results are presented in the next chapter, where advanced cartographic representations where used in a real decision-making situation.

As the production of derived map results is widely dependent on the case where DISCUSS is used, it is expected that the system operator have an advanced knowledge of spatial analysis and cartography.

6.7 REVIEW

DISCUSS is a decision support system capable of implementing the conceptual framework proposed in chapter 5 for disaggregating effects in a economic evaluation of public policies and for allowing interaction with community representatives.

DISCUSS is based on GIS, which is a computational technology capable of developing the required calculations with geographic information.

The main objective of DISCUSS is to be a research instrument to test the hypothesis proposed and present an alternative in order to solve the research problem. Inputs to the system can be made using a digital method or a paper-based method, which is believe to be more user-friendly for those stakeholders with a low degree of computer literacy.

Entries from stakeholders are processed in such way that uncertainty is reduced by using a spatial adaptation of fuzzy logic. This adaptation of fuzzy logic permits the system to cover areas in the map where the user was uncertain on the type of impact affecting it. Once all the stakeholders have been interviewed, core map results are processed and obtained directly from DISCUSS. Derived map results require additional advanced spatial operations and cartographic presentation using the available tools in ArcGIS.

In order to test the methodology in a real situation, a decision-making situation in the state of Victoria was selected. The next chapter presents the case study used to test the conceptual framework and DISCUSS in a public decision-making process.

Chapter 6 concludes the *model development* section of this thesis. The next two chapters describe the *model experimentation and discussion* in this research.

7

LAKE MOKOAN PROJECT

7.1 Introduction

In order to test the hypothesis proposed in this thesis, DISCUSS was tested in the Lake Mokoan project, a public decision-making situation in the state of Victoria, Australia, where this PGIS tool was implemented, based in the principles and methodologies developed in the conceptual framework described in chapter 5. This chapter presents, in three parts, the Lake Mokoan case study.

The first part describes all the procedures conducted to implement DISCUSS for the Lake Mokoan project. The second part presents the results obtained including maps and new indicators developed to complement the information in the decision-making process. The third part of this chapter analyses the surveys conducted and workshop developed with stakeholders to determine their impressions about the conceptual framework and DISCUSS.

7.2 THE CONCEPTUAL FRAMEWORK AND DISCUSS IN LAKE MOKOAN

7.2.1 Background situation

The river system in the south-east part of Australia is interconnected between states. The Murray River, the main hydrology resource in this region of Australia, borders the states of Victoria and New South Wales until it enters South Australia. Victoria, conscious of the environmental importance of this river for itself and other states, agreed with New South Wales, South Australia and the

Commonwealth government to develop the required works to increment the flows to the Murray river by 70 Gigalitres over a period of ten years.

In order to achieve water savings to implement this decision, the Victorian government chose to develop an analysis of the Bulk Water System, being the catchment area for the Murray River in the north part of the state.

The Bulk Water System is composed of several water bodies. The most significant are the Broken, Goulburn, King, Campaspe and Ovens Rivers; and the lakes Eildon, Nillahcootie and Mokoan. In Victoria, the water industry is at a mature phase where resources are largely developed and committed to existing users (SKM 2000). Therefore, when the Victorian government decided to analyse a policy for achieving significant water savings in the northern part of the state, a detailed analyses of different alternatives was needed.

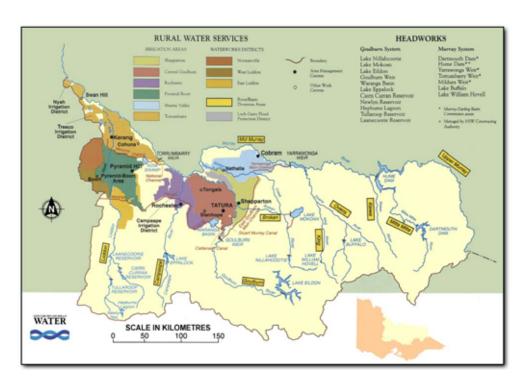


Figure 7-1: Bulk Water System (http://www.gvwater.vic.gov.au/)

In the year 2001, the firm Sinclair Knight Merz (SKM) was contracted by the Victorian government to conduct preliminary studies for evaluating alternative water saving policies. In these preliminary studies, the main options for saving water were determined and a proposal to change Lake Mokoan produced the largest net water saving (SKM, 2002).

Lake Mokoan is a man-made water body. Among other alternatives, the most significant options proposed by SKM were either to return Lake Mokoan back to a wetland (decommissioning the lake) or reduce its current capacity.

Using these preliminary results, the government decided to concentrate all its efforts on water savings in Lake Mokoan and surrounding areas by developing a decision-making process to evaluate the different options and to decide which action to take. This choice-making process was called the Lake Mokoan Project.

After analysing the initial development of the Lake Mokoan project, it was clear that this public policy evaluation was an ideal case study to trial the conceptual framework and DISCUSS, because the consequences of the alternatives had a significant spatial component and current government practice requires participation of a significant number of stakeholders with different interests in this type of decision-making situation.

7.2.2 The Lake Mokoan project

From the initial studies conducted in 2001, the Government of Victoria determined that important savings in water could be obtained if changes in Lake Mokoan were conducted. Lake Mokoan is a very shallow water body which produces high levels of evaporation during the summer period. At the same time, and because of abrupt emptying and filling of the lake in the early 1990s, the quality of the water stored in this body is poor and appearances of blue algae contamination is common (SKM 2002).

However, Lake Mokoan is an important reservoir because during the winter periods water is stored to be released for irrigation in dry seasons. In addition, Lake Mokoan is part of the tourist industry of the region and supports activities such as water skiing, duck hunting and fishing all year around.

Mainly two types of interventions were proposed for the lake to save water for the Murray River: return the hand-made water body to a swamp (the initial state in 1970) or divide the lake with a split bank, reducing its areas with shallow water.

In any type of intervention, stakeholders surrounding and downstream of the lake, and those using the lake for irrigation activities, would be affected by modification of their existing water allowances and uses of the lake.

Current policy-making developments in Australia have demonstrated a move toward participatory resource management, especially for natural resources and rural development (Walker et al. 2002). Following this trend, and conscious of the sensitivities involved in the Lake Mokoan project, the Government of Victoria decided to develop a decision-making process where full access of information was given to the community and where the consultant firm (selected to conduct the technical evaluation of the options) was to receive permanent feedback from the stakeholders.

The Minister for Environment and Natural Resources commissioned the Goulburn Broken Catchment Management Authority as the manager of the studies. The Minister also appointed a steering committee as the technical body to support the consultant firm and a reference committee to involve the community in the process.

Throughout the Lake Mokoan project, the government maintained a website (http://www.lakemokoan.com) to publish all the technical information and press releases related to the project. The main intention of this webpage was to make all the information relevant to decision making widely accessible.

From the beginning of the process, the central government clarified in a press communication that the role of the public participation was to elicit community views so they could be taken into account in the formulation of the final report produced by the consultant firm contracted. However, the government established that decisions in this case were to be made by the Minister for Environment and Natural Resources. (Lake Mokoan project, press release 'Lake Mokoan study gets Underway', http://www.lakemokoan.com, accessed 30/03/2005).

After a public process, the firm URS was elected to conduct the required studies in the Lake Mokoan project.

7.2.3 Time frame and conditions to the involvement of this research in the Lake Mokoan Project

The author conducted this research in the Centre for SDI and Land Administration at the Department of Geomatics, The University of Melbourne. This Centre is continuously collaborating with the Victorian Government, and most of its funding is provided by Land Victoria and the Spatial Information

Group, which are the state bodies overseeing the production and maintenance of spatial data in the state of Victoria.

The Victorian Department of Sustainability and Environment (DSE) recognised that the DISCUSS represented an innovative approach in terms of public participation and allowed testing of it in the Lake Mokoan Project, with some restrictions agreed, and following the conceptual framework. The interviews with the stakeholders and a workshop to present the final result were conducted after the final results from the CBA were obtained, but before a final decision regarding this situation was taken. The state government was to have access to the final results before they were released publicly.

It was also agreed that the testing of DISCUSS would not interfere with the time frame established for the decision-making process and that a low profile would be maintained by the academic researchers during the development of the CBA in order to avoid interference with public relations. The researchers also agreed that they must remain impartial, with no bias towards any stakeholder group.

In addition, the fact that the DISCUSS represented an innovative approach to the existent practice in terms of public participation, the state government was to have access to the final results from DISCUSS before they were released publicly.

All these conditions for the involvement of this research were adopted as they all conformed to the principles governing the conceptual framework. In addition, it was mutually agreed that the participation of DISCUSS and the researcher should be impartial and beneficial for all stakeholders involved in the Lake Mokoan project, including the government, academia, the private sector and in general those in favour of and opposed to interventions to the Lake Mokoan.

7.2.4 Initial trials

DISCUSS was pre-tested, in two phases, in order to observe the possible difficulties that could arise during the field interviews. In the first phase, five interviews were conducted with postgraduate students and academics at The University of Melbourne. For this trial a hypothetical decision-making situation was used.

This first trial identified the necessity of developing an expanded explanation to the participants of each of the policy options and consequences considered in the analysis. This was intended to improve the confidence of stakeholders during the interviewing process.

For the second, trial two interviews were conducted with persons close to the Lake Mokoan project who did not participate in the reference committee. This second phase of the trial was even more beneficial for adjusting the system, as it identified the difficulties of persons who lacked a background related to spatial information in understanding the fuzzy logic methodology used to resolve uncertainties in the system and with some of the spatial technical procedures conducted with DISCUSS.

Therefore, it was concluded that during the interviewing process stakeholders were to be given a general view of DISCUSS and the conceptual framework guiding it, but not excessive details about the technical procedures. The intention was to reduce confusion about the spatial analyses, and at the same time diminish doubts about the usability of the results.

In addition, from these trials the importance of documenting the entire interview process became obvious so a record of the spatial and non-spatial opinions is kept. An example of the form developed for documenting opinions during the interview process is presented in appendix 11.1.

The trial interviews established 15 minutes as the approximate time required to analyse a standard policy option with five consequences, giving as a result that an interview in a process with three policy options will require approximately 45 minutes.

7.2.5 Selection of stakeholders, policy options and consequences to analyse with DISCUSS

Once the CBA results from the Lake Mokoan project were finalised, the involvement of this research in this decision-making process could begin by obtaining the required information for module 1 of the conceptual framework (more detail regarding task in module 1 can be found in page 104 of chapter 5). One of the principal activities in module 1 is sub-task **1.b.1** (selection of stakeholders).

During the decision-making process, the government appointed 17 persons as members of the reference committee. The selection was not conducted using a democratic or participative process, and no documentation exists.

This reference committee was continuously in the decision-making process. On a monthly basis, the reference committee met with members of USR Corporation (the consultant firm) and with government representatives.

By the time results from the CBA were obtained, the members of the reference committee had a good understanding of the decision-making process and especially of the option proposed. Therefore, the government proposed to use the members of the reference committee as stakeholders for the conceptual framework.

Analyses of the composition of the reference committee revealed that its members did not represent evenly all the factions involved in the Lake Mokoan project. More specifically, it appeared that the main objective of the selection of reference committee members was the inclusion of those factions opposing decommission of Lake Mokoan (also called option 1). In addition, government officials representing the state level were not present in the reference committee.

In order to follow the principles proposed in the conceptual framework for DISCUSS, a participatory election of stakeholders was considered. However, constraint in the time frame for this research project along with difficulties in convincing government officials to incorporate new persons as stakeholders in the process led to the decision to form a group of stakeholders by selecting some members of the reference committee, who were considered to represent evenly the most important factions.

Eventually, 17 people were selected as stakeholders to take part in the additional analysis using DISCUSS. These 17 stakeholders were representatives of local governments, private farmers, land owners surrounding the Lake Mokoan, irrigators downstream from Lake Mokoan in two regions, water regulation bodies, recreation associations, non-government environmentalist organisations and the state central government. Determination of the ideal process for stakeholder identification and selection was beyond the scope of this research. Nevertheless, the final group was seen to well represent the diversity of public and government interests.

At the end of the CBA analyses, URS consultancy firm produced detail analysis for four broad options. These options were (URS 2004):

- Option 1: Decommission the lake and re-establish Winton Swamp.
- Option 2: Reduce lake area by partitioning storage, lowering the lake service level or a combination of both and operate as normal.
- Option 3: Reduce the lake area by partitioning storage, lowering the lake service level or a combination of both and operate as an annual storage.
- Option 4: The proposal of the Save Lake Mokoan Working Group for retention of the lake in its present form with changes to the operating rules.

In addition, the consultancy firm considered three configurations of partitioning (contour bank, spit bank and combined contour and spit bank) producing three sub-options for options 2 and 3.

Using the NPV as main indicator for decision making, the options were ranked after analysing the different costs and benefits for a period of 50 years. Appendix 11.2 contains a summary of the economic analysis developed by URS for all the options.

Once the group of stakeholders was selected, the next step was the selection of the options and consequences to be considered. To conduct this, an agreed selection of options between stakeholders, by using methods such as the Analytical Hierarchical Process (Saaty 1995) for group decision making, was proposed. However, it was not possible for the state government to settle a date and venue to conduct this selection of options and consequences to be analysed.

Therefore, the author had to depend on the public minutes of the reference committee and personal interviews to obtain general perceptions of the stakeholders about the options. After this analysis, and considering the time constraint and the fact that 17 stakeholders were to be interviewed, the two best options ranked under the CBA, and the most acceptable option within the community, were selected. In consequence, option 1 (decommissioning the lake), option 2B3 (dividing the lake with a spit bank and use it as an annual store) and option 4 (changes to the operating rules) were selected for the analysis.

7.2.6 Interviews



Figure 7-2: Picture of the equipment arrangement during the interviewing process in rural areas during the Lake Mokoan project

After individually interviewing the majority of the stakeholders, it was clear that they wanted five main consequences to be analysed. The consequences selected were:

- · changes in land values
- changes in recreational activities
- changes in water security and availability
- changes in operational costs of the lake and other water bodies
- changes in infrastructure.

Selection of the consequences to be analysed finalised the required task in module 1 of the conceptual framework.

Module 2 of the conceptual framework, and therefore the use of DISCUSS, began with the interviewing of the participating stakeholders. The interviewing was conducted in accordance with the designed plan established in the conceptual framework and DISCUSS (see sections 5.3.4 and 6.5 in the present thesis); and following the proposed steps by Leedy *et al.* (1997, p. 195) for successfully programming and handling interviews in research projects. These steps, which are designed to reduce bias in acquiring information from people, are:

- 1. The interviews were set up well in advance.
- 2. An Agenda and questionnaire were sent in advance to stakeholders.
- 3. The date was confirmed in writing.
- 4. A reminder was sent to stakeholder few days previous the interview.
- 5. At all time the agenda was followed during the interview.
- 6. Copies of the results of the analysis were sent to participants.

The interviewing of the stakeholders took place over a period of ten days, and was conducted in urban and rural places. On average, for the 17 stakeholders, the interview time for each of the options was 23 minutes. The total time expended, on average, with each stakeholder was 68 minutes. However, it is important to note a trend in the time spent interviewing the stakeholders: it appears to reduce for those interviewed last (see Figure 7-3).

As the system operator is an active participant in the interview, this trend in Figure 7-3 suggests that practical experience reduces the interviewing time as the system operator gets better skills in using the system and interacting with stakeholders.

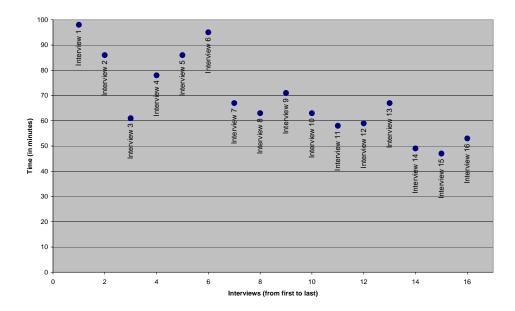


Figure 7-3: Time used for each interview (from first to last)

Results were not obtained for all the 17 stakeholders, as for one stakeholder the interview process did not produce an effective outcome. This particular stakeholder was unable to interact with the system in a spatial form. Furthermore, the understanding of maps was limited by the lack of understanding of cartographic symbols.

This unsuccessful interview demonstrates that information in a spatial form, when compared to other types such as graphs or tables, is not always more accessible for stakeholders.

In terms of the chosen method to input information, out of the successful 16 interviews, 13 chose to use the paper-based method. On three occasions the stakeholder preferred to interact directly, using the input devices of the computer. In each such case, the stakeholder was a government official with an executive or technical position and with a significant degree of computer literacy.

7.2.7 Processing of results

Once the interview process was completed, all the inputs were transferred from the laptop computer to a desktop computer to be processed.

The initial task was to digitise those inputs made using the paper-based method. Initial estimation considered that the digitisation process would take around two hours per stakeholder since 12 maps required digitalisation. At the end of the process, it was found that over five hours of work were required to digitise the spatial input of one stakeholder. Considering that 13 stakeholders' input required digitalisation, over 49 extra hours of work were used in this process. This extra time makes an important impact in the time frame for the analysis of Lake Mokoan project, as all the activities had to be delayed for over a two-week period.

With all the inputs from the stakeholders in a digital form, production of spatial results and new indicators for decision making was possible. This task extended for a period of one week without mayor delays. However, the production of results in the conceptual framework proved to be a task for GIS advanced users, as advanced spatial analysis operation needed to be created in order to optimise the process.

7.3 MAP RESULTS AND NEW INDICATORS PRODUCED FOR LAKE MOKOAN PROJECT

7.3.1 Map results

Table 7-1 presents a summary of the core map results obtained for the Lake Mokoan project.

The inputs from stakeholders are in a vector form, and the final results are presented in a raster form. The basic vector cartography layers used during the interviewing process permitted the author to produce core map results with a cell resolution of one kilometre (1000 X 1000 meters).

Results produced at this resolution allowed identification of individual parcels or specific zones in the study area. However, the general principles in the conceptual framework establish that the main source for producing core map results is community knowledge, which is not capable of identifying single parcels. Even more, the maps in the DISCUSS system encourage stakeholders to observe each option from a broad perspective. In addition, evaluation of the paper-based input method demonstrated that the digitalisation of these inputs contained a possible error of at least two kilometres in all directions.

In consequence, the author decided to aggregate all the results to a cell resolution in the raster map of five kilometres (cell size of 5000 X 5000 meters) in

order to distribute some of the error in the digitalisation process and minimise the potential to use the results to determine whether a specific area (such as a parcel) received a positive or negative effect.

Figure 7-4 shows an example of a map produced with a cell size of one kilometre and Figure 7-5 shows the same result but with a cell size of five kilometres.

Table 7-1: Summary of core map results in the conceptual framework

Name	Acronyms	Description	Apply to
individual consequence disaggregation	ICD	individual spatial disaggregation for each consequence, in each option	Each stakeholder
individual option disaggregation	IOD	Spatial disaggregation of costs and benefits of an entire option	Each stakeholder
areas of agreement and disagreement	AAD	Areas of agreement and disagreement between stakeholders	Each option
average spatial disaggregation	ASD	Spatial disaggregation of consequences developed by averaging IOD results	Each option
validated spatial disaggregation	VSD	Spatial disaggregation of consequences with validation of entries using the Factor Z	Each option

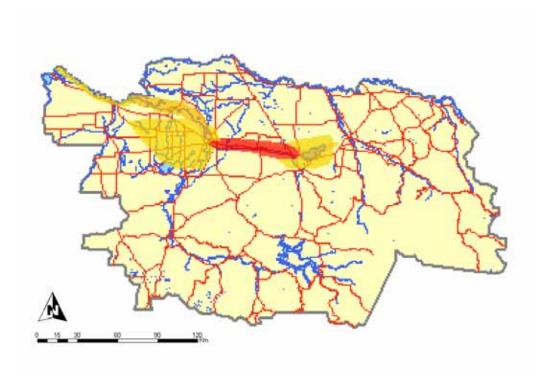


Figure 7-4: Example of a map result with a resolution of one kilometre.

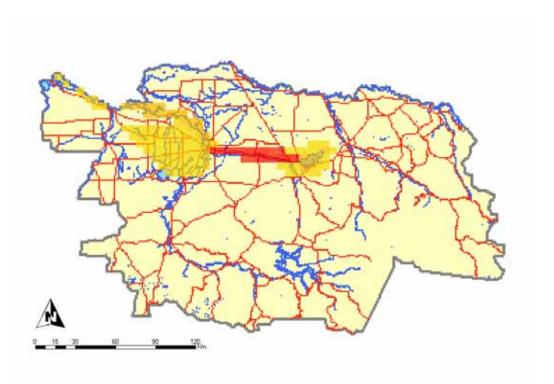


Figure 7-5: Example of a map result with a resolution of five kilometres

Maps of individual consequence disaggregation (ICD) and individual option disaggregation (IOD)

In the Lake Mokoan project and for individual consequence disaggregation (ICD) core result, 15 maps were produced for each stakeholder (five maps for each of the three options analysed). A total of 240 ICD maps were produced for Lake Mokoan.

For the case of individual option disaggregation (IOD) map results, three maps were produced for each stakeholder, giving a total of 48 IOD maps for the Lake Mokoan project.

At the beginning of the Lake Mokoan project, the author agreed with the government and stakeholders to keep the individual opinions confidential. Because of the fact that IDC and IOD map results represent individual opinions, these maps were not made public in the public presentation of the results of DISCUSS and, therefore, they cannot be presented in this thesis.

Maps of areas of agreement and disagreement (AAD) for Lake Mokoan

Areas of agreement and disagreement (AAD) maps were fully disclosed to the public. AAD maps remove the possibility of identifying individual opinions, without restricting the possibilities for analysing the human factors affecting the decision-making process.

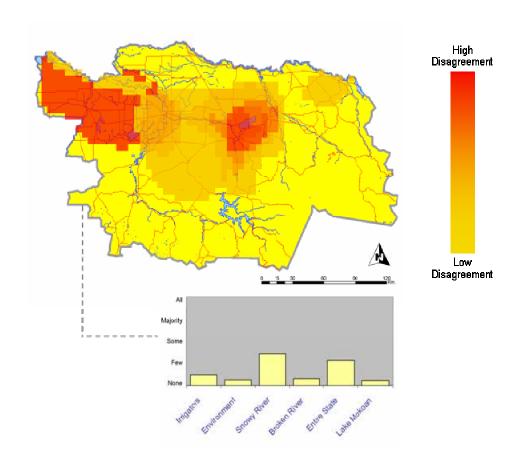


Figure 7-6: ADD map for option 1 (decommissioning the lake)

ADD maps were produced in the Lake Mokoan project for the entire effects in each of the three options analysed and for each of the five consequences. Each ADD map is complemented by a bar graph with any other identified cost or benefit receiving entities without spatial representation in the study area map. This additional graph for each ADD map was developed in order to juxtapose the spatial and non-spatial factors in the public policy evaluation. In the bar graph, a verbal scale (from few to majority) was used to indicate the proportion of stakeholders agreeing about particular beneficiaries. The entities in the bar graph are either located outside the selected study area (such as the Snowy River or the entire state) or their location in the map is not completely known.

Figure 7-6 shows the ADD map for option 1 (decommissioning Lake Mokoan) and the corresponding bar graph for the non-spatial entities. For two important areas in the study map (zones around the Lake Mokoan and in the north-west part), high disagreement existed between stakeholders. For these two zones,

some stakeholders considered that option 1 produced a beneficial impact; while for others considered option 1 would impact these zones negatively.

The result in Figure 7-6 contains also a bar graph with six entities identified as beneficiaries of option 1. The Snowy River and the entire State of Victoria are notable, as an important proportion of the stakeholders agree with these wider benefits.

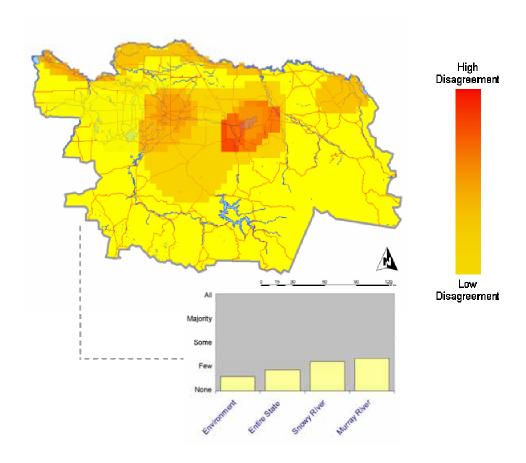


Figure 7-7: ADD map for option 2B3 (spit bank, annual storage)

For option 2B3 (spit bank, annual storage) (Figure 7-7) the areas of intense red (which represents high degree of disagreement) are smaller than for option 1 (Figure 7-6). However, for option 2B3 areas surrounding the lake produced high disagreement, a situation found also for option 1.

In terms of the non-spatial entities identified as beneficiaries is Lake Mokoan, option 2B3 had a very similar result compared to option 1. Nevertheless, for all these entities only few stakeholders identified them as receiving benefits.

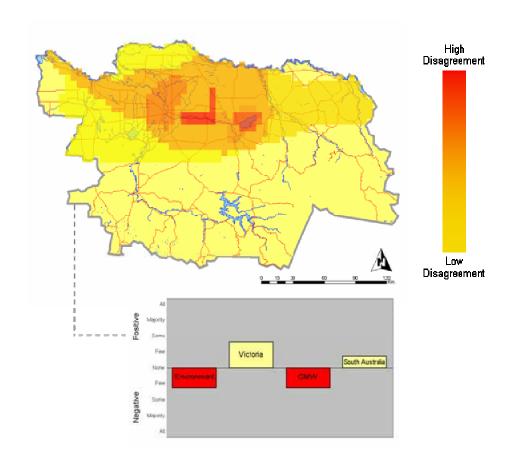


Figure 7-8: ADD map for option 4 (changes to operational rules)

For option 4 (changes to operational rules), Figure 7-8, fewer areas of agreement and disagreement are found compared with options 1 and 2B3. Nonetheless, the medium level of disagreement was spread around the northern part of the study area.

For the non-spatial entities the situation in option 4 was very different, compared with options 1 or 2B3, as some stakeholders identified not only beneficiaries, but other entities receiving a negative impact as a consequence of implementing option 4.

In the bar graph present in Figure 7-8, some stakeholders considered that the environment and Goulburn-Murray Water (GMW), which is the state body in charge of administering the hydrological resources in the area, are going to be negatively affected if option 4 is implemented. On the other hand, an important proportion of stakeholders found that the entire State of Victoria would receive a benefit from the implementation of this option and a small group of stakeholders

considered that the neighbouring state of South Australia could benefit from Option 4.

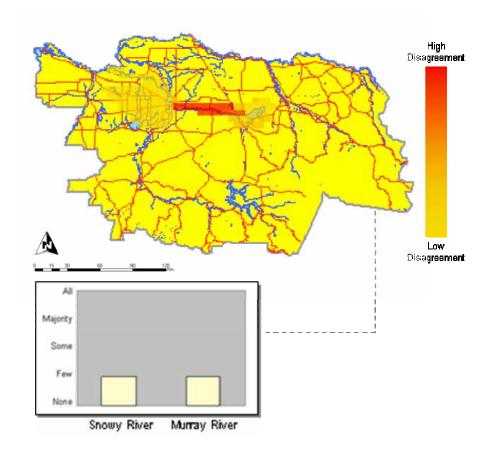


Figure 7-9: ADD map for the changes in water security and availability (option 1)

Considering apprehension of the stakeholders towards the impact of changes in water security and supply of option 1, the author decided also to analyse the specific ADD maps for this individual consequence (Figure 7-9). From this it was evident that important proportion of the disagreement focused on the future effects on water security and availability that could be caused to the Broken River downstream of Lake Mokoan before joining the Goulburn River (the red area in the centre of the map in Figure 7-9) In addition, an important proportion of the stakeholders considered that the beneficiaries of water saving under option 1 are mainly the Murray River and the Snowy River, which are water bodies outside the study area.

Maps of average spatial disaggregation (ASD) for Lake Mokoan

The average spatial disaggregation (ASD) map represents the spatial disaggregation of consequences for Lake Mokoan project averaged over all stakeholder inputs.

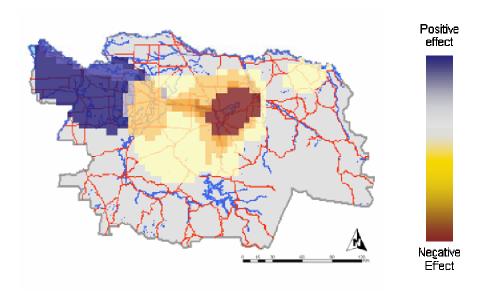


Figure 7-10: ASD map for option 1 (decommissioning the lake)

Figure 7-10 shows the ASD map for option 1, where areas in blue represent where the stakeholders, on average, considered that a positive impact would be produced if option 1 is implemented. Areas in dark brown represent where stakeholders considered a negative impact could be produced and areas in light yellow or grey are where the net effect is considered close to zero (this colour scale is used in all ASD maps produced, and is relative to each map).

For option 1, stakeholders on average considered the areas north-west of Lake Mokoan (mainly areas of irrigation) as benefiting if Lake Mokoan is decommissioned. On the other hand, areas surrounding the lake (brown zone in the middle of the map) are considered to be impacted negatively.

For option 2B3 (Figure 7-11) stakeholders considered that the benefits were mainly in the areas surrounding the Murray River (blue areas at the top of Figure 7-11) and that the negative effects are located in adjacent areas downstream of Lake Mokoan.

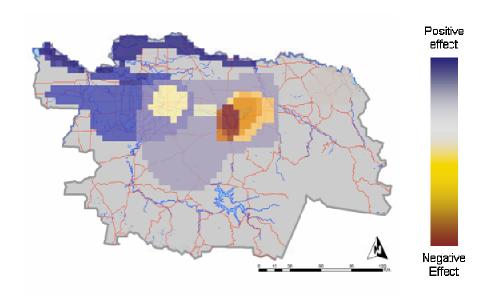


Figure 7-11: ASD map for option 2B3 (Spit bank, annual storage)

For Option 2B3 the map shows a more extended distribution of benefits as more areas are covered by blue than those found for option 1.

Figure 7-12 contains the ASD map for option 4, where the negative and positive effects are nearly inverted, compared with option 1.

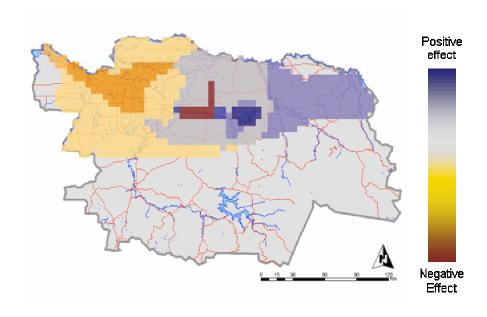


Figure 7-12: ASD map for option 4 (changes to operational rules)

For the stakeholders, option 4 produces a positive effect in the areas surrounding the lake and a negative effect for those located downstream of the lake where irrigation is the main agricultural activity.

Maps of validated spatial disaggregation (VSD) for Lake Mokoan

In order to produce validated spatial disaggregation maps, individual inputs from stakeholders were weighted by assigning a factor called Z (see section 5.3.5). For each stakeholder, three Z factors where calculated (one for each of the three policy options considered in the analysis).

The factor Z depends on the consistency of the stakeholders' inputs in their individual consequences mapping (ICD) and their overall option assessment (IOD). The range of values for the Z factor is between 1 and 0, where values close to 1 mean the stakeholders had a high consistency in inputs and therefore their inputs are considered more in the production of VSD maps. In the opposite case, Z values close to 0, stakeholders demonstrated a low consistency of inputs and therefore their inputs have a nominal consideration in VSD maps.

Stakeholders were not aware of the validation method with the Z factor until final results were released. This protected DISCUSS from manipulation, since stakeholders are not aware of the measures taken to detect bias.

Next the analysis of these Z factor values found for each option is presented. In the graph, the stakeholders are referred to by number, as their actual names or associated organisations cannot be disclosed.

Figure 7-13 shows a bar graph with the 16 Z factors obtained for option 1 organized from the lowest (left) to the highest (right). The average for the Z factors in option 1 was 0.57 and the standard deviation 0.36.

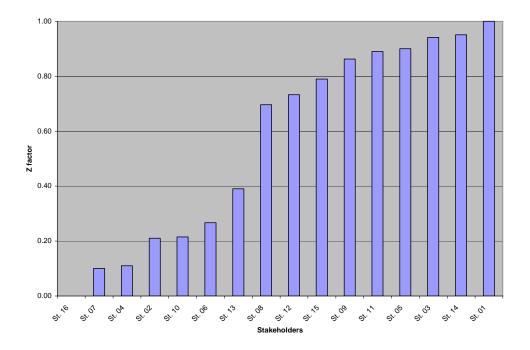


Figure 7-13: Z factor values for option 1

This bar graph shows that the Z factor values for option 1 can be grouped into two main clusters, one representing those with high values for Z (between 0.65 to 1) and in the other with low values (0 to 0.4). These results for option 1 show that more than half of the stakeholders in the Lake Mokoan project either had poor knowledge about the future consequences or were biased by specific interests which led to inconsistent ICD/IOD map production.

Figure 7-14 shows a bar graph with the 16 Z factors obtained for option 2B3 organised from the lowest (left) to the highest (right). The average for the Z factors in option 2B3 was 0.54 and the standard deviation 0.32.

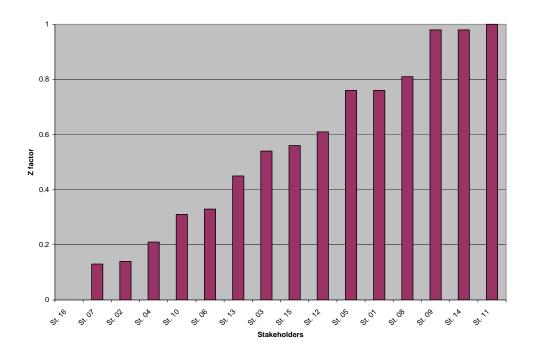


Figure 7-14: Z factor values for option 2B3

For option 2B3 the Z factor values encountered cannot be clustered as its distribution is close to linear between the values 0 and 1.

Figure 7-15 shows the Z values for option 4, where a distribution of values similar to option 2B3 can be found.

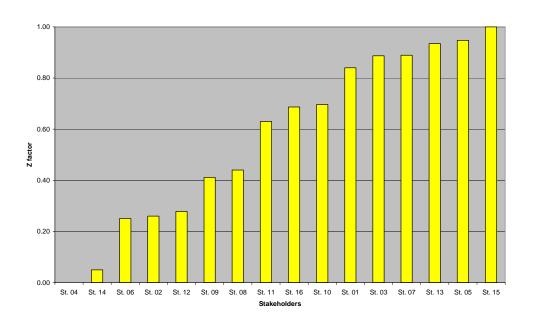


Figure 7-15 Z factor values for option 4

When the Z factor values for options 1 and 2B3 are plotted in the same graph (Figure 7-16), significant similarities appeared. Those stakeholders that obtained a high Z factor value for option 1 also score a high value in option 2B3. For the low Z factor values the similarities are even greater, as all stakeholders obtaining a value of 0.5 under option 1 also obtained a value under 0.5 in option 2B3. Even more, the stakeholder number 16 obtained 0 for both options.

However, the results for option 4 did not correlate with those found for options 1 or 2B3. Figure 7-15 shows the three Z values found for each stakeholder in option 4. For some stakeholders (for example St.14 or St.07) the Z value for option 4 was opposite to those for options 1 and 2B3.

Interestingly, the government, the community and the private sector all had representatives obtaining both high and low values for the Z factor.

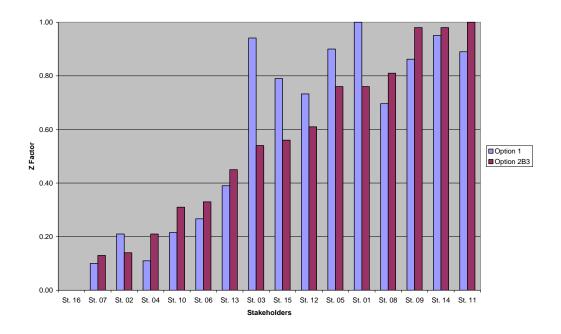


Figure 7-16: Comparison of the Z factor values in options 1 and 2B3

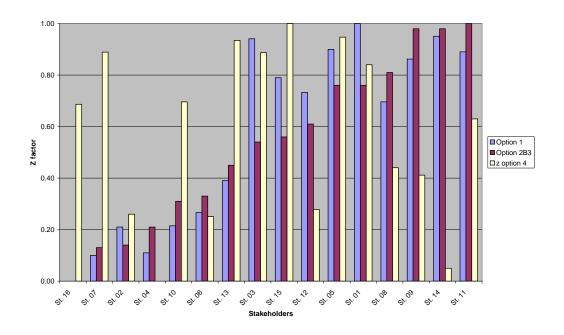


Figure 7-17: Comparison of the Z factor values in options 1, 2B3 and 4

Using the Z factors obtained for each stakeholder, validated spatial disaggregation (VSD) maps were produced for the three policy options analysed in Lake Mokoan project. These maps are the prime result after applying the conceptual framework and using DISCUSS as a computational tool.

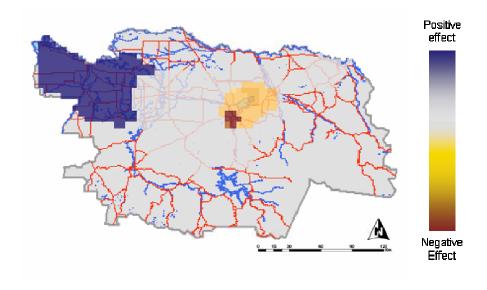


Figure 7-18: VSD map for option 1 (decommissioning the Lake)

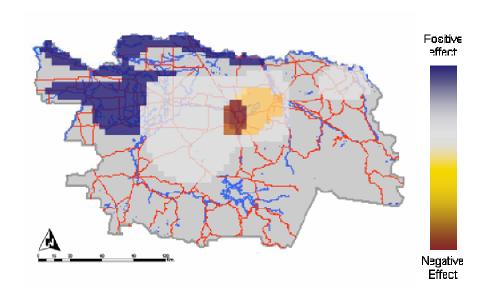


Figure 7-19: VSD map for option 2B3 (spit bank, annual storage)

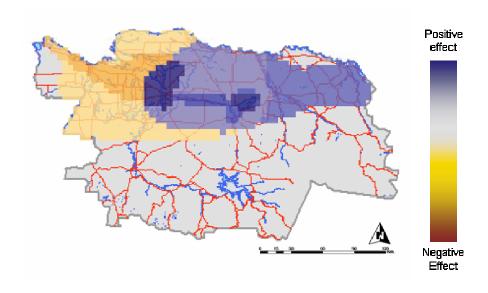


Figure 7-20: VSD map for option 4 (changes to operational rules)

7.3.2 Derived map results

Using the validated spatial disaggregation of consequences (or VSD maps) obtained for the Lake Mokoan options, derived map results were produced for each option to help analyse the environmental, social and political factors.

Examples of these derived map results are presented as a demonstration of the spatial analytical possibilities that DISCUSS provided to the public decision making.

Figure 7-21 shows the spatial distribution of consequences for option 1 with the current political boundaries for the study area.

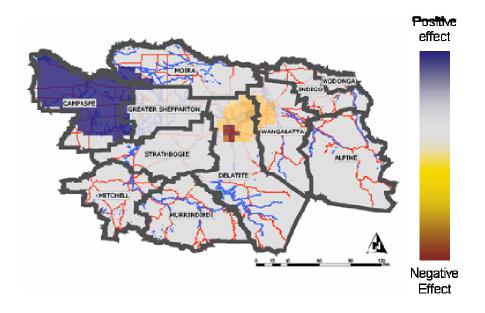


Figure 7-21: Spatial disaggregation of consequences for option 1 integrated with political boundaries (local government areas)

From this derived map it is possible to obtain additional graphical representation for decision making. Figure 7-22 condenses the information related to consequences and political boundaries in a bar graph for option 1.

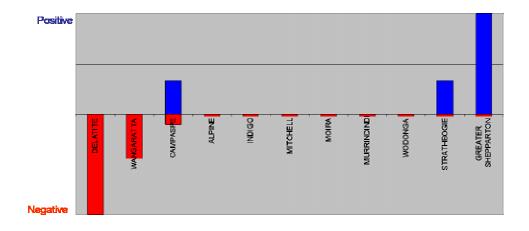


Figure 7-22: Impacts (positive and negative) for each Local Government Area if option 1 is implemented

In order to evaluate environmental implications, a comparison between native vegetation and areas of negative effect was conducted. Figure 7-23 shows a map of the areas covered with native vegetation and the spatial estimation of impacts for Option 2B3.

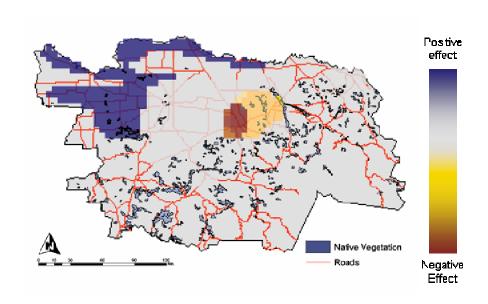


Figure 7-23: Relationship between native vegetation and impacts for option 2B3

7.3.3 Indicators results

Using the formulas described in chapter 5 (page 112), additional indicators for decision making were produced for the Lake Mokoan project. These indicators are intended to complement the traditional indicators created from the CBA (NPV and IRR) and to cover other aspects to be considered for decision making, such as equity and environmental sustainability.

Table 7-2 shows the indicator produced for the Lake Mokoan project and the results obtained for each option analysed.

Table 7-2: Indicators for decision making in the Lake Mokoan project

Indicator	Description	Option 1	Option 2B3	Option 4
Option Level of Disagreement (OLD)	Normalised measure of the disagreement between stakeholders. Values close to 1 represent high disagreement.	0.89	0.61	0.56
Indicator of population beneficed (IPB)	Measure of the relationship between spatial consequences and the population advantaged in the study area.	0.53	0.56	0.31
Indicator of population negatively affected (IPN)	Measure of the relationship between spatial consequences and the population negatively affected in the study area.	0.61	0.31	0.11
Population benefit- cost ratio (P-BCR)	Relationship between the populations beneficed and negatively affected. P-BCR = IPB / IPN	0.86	1.80	2.81
Indicator of Option equity (IOE)	Measure of the relationship between beneficiaries and income. Values close to 0 represent more equity.	0.21	0.38	0.14

7.4 Workshop with stakeholders

After completing the analytical procedures with DISCUSS, map results and new indicators for decision making for the Lake Mokoan project were published in a web page and presented to the state government. However, comments by government officials encouraged the development of a stakeholder workshop to explain the results and find possible justifications for the levels of disagreement regarding the options analysed. In particular, government officials were interested in understand better the results for option 1, which was the preferred option from the economic point of view.

In addition, informal interviews with some of the stakeholders demonstrated that the results were not easy to understand and a complementary explanation was required. A communication informing the stakeholders of the workshop, along with a condensed result from the three options analysed, was send to all stakeholders. A copy of this communication can be found in appendix 11.3.

The workshop was conducted in the town of Benalla, which is the main population centre close to Lake Mokoan. Twelve stakeholders attended. They were also asked to complete an additional survey analysing the benefits that they found in the conceptual framework. Analysis of these surveys is presented in the next section.

After presentation of the final results obtained with DISCUSS, an interesting debate took place (lasting over two hours), focused on option 1 and the consequences of considering changes in water security and availability. A lack of understanding of the technical analysis made by the USR consultant was evident, especially for those areas in which some stakeholders were particularly interested.

This was a surprise to the government official, who considered that the stakeholders, who were mainly members of the reference committee, had a clear understanding of the technical models and consideration made during the CBA analysis. The reality was that in most of the cases stakeholders (especially those representing local communities) did not fully comprehended the estimations made in the rational models conducted by URS.

In addition, the results from DISCUSS that showed a high disagreement around the lake demonstrated to the stakeholders (and in particular to the state officials) the necessity of better understanding of how these areas would be affected, especially for the land values and water security consequences.

Due to time constrains the discussion was cut short; leaving unsolved many issues that the stakeholders wanted to discuss after having seen the results from DISCUSS. However, the workshop demonstrated the benefits of the process in creating a better environment for discussion. The stakeholders could concentrate on the major issues of disagreement uncovered by the map results.

7.5 SURVEYS

A series of surveys were developed as part of the research, in order to evaluate the hypothesis. These surveys were conducted during the interviews with the stakeholders and at the workshop for results discussion. The surveys focused on the level of understanding by the stakeholders of the conceptual framework, as well as estimating the level of acceptability and usability of the results produced.

As there were only 16 stakeholders, the surveys were not statistically meaningful, but revealed general trends and allowed some generalisations about the experiences of the conceptual framework and DISCUSS in application to the Lake Mokoan issue.

7.5.1 Survey during the interviewing of stakeholders

Before each interview, stakeholders where ask to rank from 0 (poor) to 5 (excellent) their:

- understanding of proposed option 1 and its consequences
- understanding of proposed option 2B3 and its consequences
- understanding of proposed option 4 and its consequences.

The average reported levels of understanding were option 1 (4.3), option 2B3 (3.1) and option 4 (4.5). The majority of the stakeholders believed that they had a good understanding of options 1 and options 4. This was probably because of the emphasis that the government had placed on option 1 as the preferred option from the economic point of view, and because option 4 was proposed by a working group within the community.

After stakeholders interacted with DISCUSS, they were asked to again assess their understanding of the different options proposed and to comment openly about the benefits they derived from using the system.

For options 1 and 4, results before and after the interviews are very similar. However, results for option 2B3 showed an increase in the understanding of this option as a consequence of the interaction with DISCUSS. This could be related to the fact that in the interview process, stakeholders were encouraged to observe carefully the existing information about the options and to analyse the

positive and negative consequences of each option. However, it is important to clarify that the interview process did not add any new facts about the options considered.

This suggests that the interview process could be used by the government to improve the comprehension of those options where stakeholders have a low degree of understanding.

When the stakeholders were asked to assess the usability for them of the interaction with DISCUSS, the majority expressed a good acceptability of the IT system, especially to broaden their perception of each option.

Some stakeholders mentioned a good appreciation for the paper-based input method and their approval for the approach used to protect privacy of opinions.

In conclusion, the surveys conducted during the interview process showed that the conceptual framework is a good alternative to improve the understanding of those options which are otherwise not clear to the stakeholders and provide a method to encourage stakeholders not only to focus on their particular area of interest, but on the entire study area to observe, in a broader form, the location of beneficiaries and entities negatively affected.

7.5.2 Surveys during the workshop with stakeholders

Two surveys were conducted during the development of the workshop with the stakeholders in order to determine the perception of the results before and after the formal explanation and discussion took place. Appendices 11.4 contain a copy of the pre-meeting and post-meeting questionnaires.

In the answers to the pre-meeting questionnaire, stakeholders expressed their lack of understanding of the results sent prior to the meeting by mail and those posted on the Internet. When the stakeholders were asked about the areas of agreement and disagreement (AAD) maps, the majority expressed a lack of understanding of the colour scale used, as well as the meaning of the different red and yellow areas in the map.

The results from the surveys were similar for the average spatial disaggregation (ASD) maps, showing the difficulties of stakeholders to interpret by themselves the results. Nevertheless, during the pre-meeting questionnaire, half of the

stakeholders agreed that the analysis conducted was very useful for the Lake Mokoan project.

After the explanation of the results and discussion about the different spatial disaggregation of consequences, stakeholders expressed in the post-meeting questionnaire a good understanding of the maps presented and the results obtained. This demonstrated that the conceptual framework needed to be explained to stakeholders, not only during the interviewing process, but also in a formal presentation.

The most important result from the post-meeting questionnaire was that stakeholders increased their understanding of the positions of others in the process. This is a very significant result, since one of the principal objectives of the methodology is to encourage better opportunities for stakeholders to discuss and find consensus.

In addition, a majority strongly (10 out of 12 participations) agreed that the conceptual framework was useful to the decision-making process related to Lake Mokoan. Even more, a considerable proportion of stakeholders (eight out of 12) estimated that the analysis would be of great advantage to other choice-making situations in Victoria and other parts of Australia. Stakeholders also felt confident about the procedures to protect the privacy of the opinions. On the other hand, stakeholders reported that the workshop did not help them to better understand, or change their positions about, the options proposed for Lake Mokoan. By the time of the workshop, stakeholders had been dealing with the options proposed for more than two years and had generally firm positions. However, their improved understanding of the views of others is positive in terms of moving forward.

7.6 SUMMARY OF RESULTS FOR THE LAKE MOKOAN PROJECT

The principles of the conceptual framework established that its main objective is to support public decision making by giving information about the human factors affecting the selection of the best option. The conceptual framework, in contrast to CBA, does not assess options in such a way that the most feasible option to be implemented is identified. Instead, the application of the conceptual framework produces results for decision makers to inform their personal positions in the human factors affecting the public policy analysis.

Considering the importance for decision makers of having a summary of the analysis conducted following the proposed conceptual framework and using DISCUSS as the main tool to produce results, a condensed one-page summary of the results was produced. This summary incorporates the principal results found for each option with DISCUSS, as well as the economic results from the CBA.

This summary is presented in the next page as an example of the condensed information given to decision makers after DISCUSS was applied to the Lake Mokoan project.

7.7 REVIEW

The opportunity to have access to a real government decision situation was significant for this thesis. In this regard, this case study had a CBA developed as part of the decision-making process; the government was interested in developing a public participation process; and full access to the information was provided. All these characteristics made the Lake Mokoan project an exceptional case for testing the conceptual framework and the IT system DISCUSS.

In addition, the Lake Mokoan case was politically very sensitive, giving an important opportunity to test the socio-political results that the system was able to produce.

Testing the conceptual framework and DISCUSS in a real situation provided important feedback about their validity and practicability. The conceptual framework encouraged careful observation among stakeholders of all the different perceptions about future consequences. The conceptual framework and DISCUSS were found capable of producing a better environment for public participation and tools to produce relevant social, environmental and political information for decision making.

The application of the conceptual framework in the Lake Mokoan project presented some challenges in the research. In particular, adaptations of the methodologies proposed were required for the selection of stakeholders and options considered.

8

DISCUSSION

8.1 Introduction

The research problem investigated in this thesis is the current lack of an effective, accessible, practical and low-cost method to spatially disaggregate consequences in public policy, program and project evaluations. After considering, in the background chapters, the reality of public decision making, and the current trends for SDSS and public participation, a hypothesis was proposed: that the use of community knowledge combined with rational information in a PGIS permits spatially disaggregation of economic, environmental and social consequences in an effective, low-cost and accessible manner. This hypothesis was tested, using the conceptual framework and the DISCUSS software, in the Lake Mokoan project, which was a public choice-making process conducted by the Government of Victoria, Australia, and CBA was used as the main economic methodology for assessing options.

This chapter contains a critical analysis of the results found during the Lake Mokoan project. The objective is to analyse the validity of the hypothesis in the context of the Lake Mokoan project and for other public policy evaluations. In particular, the chapter analyses the individual testable aspects of the hypothesis (described in section 5.2.2) and the practicality of the principles proposed for the conceptual framework.

The basic objective of this chapter is to determine whether the assumptions made to solve the research problem can be justified, not only from a theoretical perspective, but also through a practical test. An effort is made to generalise the results found for the Lake Mokoan project and determine the applicability of

DISCUSS in other public decision-making situations in Australia and other developed and developing countries.

Conclusions from this critical analysis are reserved for the following chapter.

8.2 THE CONCEPTUAL FRAMEWORK AND DISCUSS IN THE CONTEXT OF PUBLIC DECISION MAKING

8.2.1 DISCUSS and CBA

It is widely understood within public institutions that there is a need to develop complementing analyses to CBA in order to cover areas that these analyses cannot consider. Is DISCUSS (and the conceptual framework which supports it) capable of delivering such additional information to decision makers without contradicting or substituting the economics analysis made with CBA? Compatibility with CBA is important, as current trends in governments around the globe and multinational institutions such as the World Bank encourage the use of CBA as the primary axis in public decision making (Farrow 1998), creating the possibility to use DISCUSS in a wide variety of situations.

The Lake Mokoan project was an acceptable situation for testing this compatibility of DISCUSS with economic analyses, since the Sate of Victoria (which was the government institution leading the decision making) used CBA as the basic methodology in its evaluation of the project.

Attainment of results with DISCUSS did not require modifications or changes to the CBA methodology. One of the important reasons for this was that the conceptual framework, which guided the application of DISCUSS in the Lake Mokoan project, proposed that active public participation should be undertaken only after economic results from CBA were achieved.

Indeed, DISCUSS, applied under the principles of the conceptual framework, compliments CBA by providing information in spatial and non-spatial forms about concepts not evaluated by the economic methodology. These include equity and environmental sustainability.

Furthermore, results produced with DISCUSS provide information to be used by stakeholders to measure the implications of each policy option, but the analysis

using DISCUSS does certainly not conclude in the recommendation of a most desirable option, something that CBA is capable of doing.

In the particular case of Lake Mokoan, the CBA clearly recommended option 1 as the most desirable option, as it produces the biggest economic return to the society (the biggest NPV of all options). On the other hand, DISCUSS informed stakeholders and decision makers about some implications of each option (such as the level of disagreement between options or the effect in political jurisdictions). It is up to individual decision makers to decide how to use this additional information.

This approach of informing decision makers about future consequences without giving a final recommendation is not new. Other systems such as GOVERNe (Quintana *et al.* 2002) have also produced this type of results with their main objective being to allow economic analysis to make recommendations about the distribution of scare resources, and other complementing analyses to broaden the information base and to support discussion between stakeholders.

It should be noted that DISCUSS does not have the same capacity for temporal analyses as CBA. DISCUSS results are aggregated in time in such a way that they relate to the net value for the period of time of the project, policy or program as perceived by the stakeholder. This is similar to what is generated with the NPV, as in this indicator all the costs and benefits of the policy options are converted to a present value using a discount rate. However, using annual flows, CBA methodology permits, estimations of net benefits at different times during the life of the project or policy, something that is not possible with DISCUSS. The technical analysis of spatial disaggregation could, with sufficient resources, be also disaggregated temporally. Therefore, DISCUSS could potentially be extended to ask stakeholders to consider different time intervals (individual years or groups of years).

From a practical perspective, this is problematic since the consideration of each additional time period would increase the interviewing time by around a half hour. It is uncertain first whether stakeholders would be capable of effective simultaneous spatial and temporal disaggregation of their perceptions of the project, and second whether they would be willing to extend the interview period substantially.

CBA also allows comparison between diverse options from different sectors. Net present value (NPV) can be computed and hence compared across any set of projects, programs or policies. DISCUSS, however, was designed for public evaluation of individual projects. Limited extension is, however, possible. Within a broad policy area like water management, DISCUSS-based analyses could be undertaken on projects in different regions and compared (at least qualitatively) on measures such as levels of stakeholder agreement.

8.2.2 DISCUSS and the characteristics of public decision-making practice

Apart from the continuing importance of CBA and other economic methodologies, public decision-making practice is particular for each government institution (Simon 1997). DISCUSS was designed for those situations or institutions in which public participation is regarded as important for decision making and, therefore, community knowledge is part of the information necessary to properly assess options.

DISCUSS can accommodate the use of community knowledge to produce different results depending on the interest of each institution. For example, if a particular institution has a tradition of considering historical factors as fundamental, DISCUSS could be adapted to produce map results that focus on informing decision makers about the impacts of the consequences from a historical perspective.

However, if a particular governmental institution approaches each decision-making situation in the search of SEU theory (cases of perfect utility where uncertainty does not exist) by accepting only considerations from rational analysis and discarding the use of community knowledge, then the use of DISCUSS is limited for this organisation.

However, the sole use of SEU theory in public decision making is not common, as governments also understand that the best decisions are not only derived from economic assessments. The sustainability of the decisions brought by having public support is something that decision makers also consider when choosing an alternative, making it important for them to know implications of each alternative during the doing or implementation phase.

In this regard, the areas of agreement or disagreement (AAD) map results and the indicator of option level of disagreement (OLD) seek to cover this interest of decision makers in the sustainability of the decision by providing information concerning the support or opposition that a policy option could have if implemented.

For the particular case of Lake Mokoan, option 1 was the most feasible from the economic point of view. However, it had the highest OLD result among the three options analysed (0.81). This tells decision makers that implementing option 1 would cause more disagreement within stakeholders than option 2B3, which was ranked second in the economic analyses and with an OLD figure of 0.61. This, for example, might have some political consequences that could affect the perception of the options among decision makers. However, as discussed before, DISCUSS does not recommend or rank options according to this information about difficulties in the implementation phase. The information is provided to stakeholders for them to analyse individually and as a support for discussion.

For those institutions with a strong consideration for public participation and community knowledge, many authors (Jankowski and Nyerges 2001; Walker *et al.* 2002) have suggested that the future of decision making lies in group decision making exercises between the community and the government. Sauter (1997) has identified that for undertaking group decision making, DSS should provide communication channels as well as a voting system.

DISCUSS is capable of facilitating channels between the community and the government. This was found in the Lake Mokoan project during each of the interviews conducted and in the workshop when stakeholders acknowledged that the methodology facilitated their comprehension of the options proposed and the opinions of other factions.

However, the conceptual framework does not include a voting system to select the most desirable option using the additional spatial information generated. Therefore, the scope of the conceptual framework and DISCUSS should be restricted to a PGIS level 1 (Information Handling Support) where the system is dedicated to managing information, visual aids and group collaboration and supporting discussion (Jankowski and Nyerges 2001, p. 104).

DISCUSS also explored the benefits of having spatial and non-spatial information in PGIS as inputs and results. The approach in this thesis was sensitive to the fact that in policy making, some people prefer (and understand) spatial

information while others may not. However, when capturing the opinions from stakeholders, DISCUSS only accepts spatial inputs, something that carries some limitations.

The fact that one stakeholder in the Lake Mokoan project was not able to interact with the spatial method used during interviews demonstrates that the generalisation made, that everyone is capable of disaggregation of consequences in a spatial form, was incorrect. However, for the Lake Mokoan project, this single stakeholder represented a low proportion, since the other 16 stakeholders successfully identified beneficiaries using maps.

Nevertheless, future applications of DISCUSS (and in general of PGIS) need to acknowledge this limitation and contingency measures might be considered. An option is to replace this representative with another person capable of interacting with the spatially-based methods. However, this might not always be possible, and alternatives such as written questionnaires or numerical tables need to be examined.

Application of a decision-making process to the Lake Mokoan project, based on the conceptual framework, was not without problems. The main difficulty was the selection of stakeholders, which for the Lake Mokoan project occurred when the reference committee was appointed by the government. A stakeholder group had been previously selected by the government as its reference committee. This may not have been ideally composed according to the principles of the conceptual framework, but was sufficient to demonstrate the adaptability of the approach.

Finally, another area of concern of DSS (such as DISCUSS) in the current reality of decision making is their accommodation to legal and statutory requirements in each of the different jurisdictions when public decision making takes place. In the particular case of this thesis, the Lake Mokoan project was bound by the 2001 Victorian Environmental Act, which establishes some important principles, not only for environmental protection, but also in terms of public participation. This Act asserts that public participation procedures should be created to allow real opportunities for the public to participate, and creates a framework in which public institutions should conduct decision making (Cook 2003).

For the particular case of Lake Mokoan, the principles of the conceptual framework (which guided the use of DISCUSS) are in concordance with the current legislation for decision making in the state of Victoria, Australia since DISCUSS increased the opportunities for the community affected to understand better the options proposed and individually assess each of them from many different points of view. Consequently, the use of the conceptual framework appears not to require modification in order to meet current practice or regulations in the State of Victoria and for those cases where similar regulations for the public participation are present.

8.3 COMMUNITY KNOWLEDGE AND INDIVIDUAL OPINIONS

During all previous chapters of this thesis, the term 'community knowledge' (in the context of public decision making) has been a reference to what community members know about a particular area and their interpretation of future consequences if new policies are implemented. DISCUSS is a PGIS designed to acquire and obtain community knowledge in order to produce spatial disaggregation of consequences, taking as a basis the prior economic analyses.

Of course the degree to which community members 'know' the spatial implications of a policy option can vary. Their knowledge may be based on careful study, direct observation, press reports or discussions with neighbours. In some cases this knowledge might be truly believed but not truly accurate. It is more properly regarded as an individual opinion. At this individual level it could be argued that opinion and knowledge are part of a continuum, and that the distinction lies only in the degree to which the opinion is supported by verifiable precepts. In this thesis the term 'community knowledge' has been used as the analytical end point of the process of acquiring individual opinions from the community, which were aggregated and validated to produce this knowledge. Community knowledge was formed from community opinions.

Despite this, community knowledge and community opinions are different concepts with different uses in DISCUSS. While community knowledge was focused on producing the spatial disaggregation of consequences (from which the geographic location of beneficiaries can be determined) community opinions were used to provide stakeholders with additional information about human factors influencing public decision-making.

In this section, the production and usability of community knowledge and community opinions in DISCUSS are discussed.

8.3.1 Community knowledge

One of the principles of the conceptual framework was to established full freedom for community members to accept or discard technical or rational disaggregations of consequences. The objective of this freedom was to encourage stakeholders to openly express their real concerns, so community knowledge could be perceived.

The assumption made for acquiring community knowledge was based in the honesty of community members to truly reject a technical or rational model only when they considered that these estimations were not correct and their experiences and personal knowledge made them believe that their own forecasting of impacts were more accurate or precise that those deduced by the technical personnel.

This freedom of stakeholders also carried the real possibility of bias, which is always present in all stakeholders, and even manipulation of the system. Critics of community knowledge (such as Bickerstaff *et al.* 2002; Few 2001; Hanley 2001) have placed bias as the main reason to discard its use for choice-making, especially in public situations when broad benefits for the community should be always over-ride individual desires.

To reduce this bias, community knowledge was validated using the Z factor. In this factor, consistency of inputs was used as a parameter to identify bias towards a consequence or an option. Analysis of the Z factor (section 7.2) showed coherencies in this approach since stakeholders obtained either low or high values of Z across options.

Although more research is required to complement the Z factor in validating community knowledge, the results from the Lake Mokoan project support the need for developing alternatives to reduce bias in the acquisition of community knowledge in order to make it more valid for decision making. In the future, proven validating methods could convert community knowledge to a type of information fully comparable to that obtained with rational methodologies, something that potentially benefits the government (by reducing costs) and the

community (by allowing them greater influence in the final outcome of the process).

In addition to bias, another difficulty of community knowledge is that individuals may exhibit myopic behaviour. Myopic behaviour in public policy evaluation emerges when stakeholders are only concerned with the direct impacts of policy options on their agenda, constituency or group, and do not appreciate how a decision will affect other sectors or institutions (Averch 1990, p. 142). Good and transparent public decision making is commonly seen as distributing the resources in such a way that the greatest possible number of members of the community benefit. Myopic behaviour in pubic decision making is against this goal, as stakeholders act in their own interests, or within a single dimension of the issue, something not desirable if wide public benefit is wanted.

To test whether the conceptual framework reduces the occurrence of myopic behaviour, stakeholders were asked in questionnaires if they found the conceptual framework and DISCUSS useful in better visualising the 'big picture' of each option. Fourteen out of 16 confirmed that the conceptual framework was a useful tool in the Lake Mokoan project to appreciate the benefits and costs of the options from the point of view of other stakeholders. In consequence, the results from Lake Mokoan project support the statement that PGIS could also be directed to generate better community knowledge by reducing the myopic behaviour of stakeholders.

8.3.2 Individual opinions

As explained before, individual community opinions were used primarily as bases to produce community knowledge. However, community opinions also were used directly by DISCUSS to produce information about disagreement between stakeholders. As expressed in section 8.2 of this chapter, this information is considered useful to support decision makers in determining the public support that an option will have if adopted.

However, community options bring to decision making some concerns that also need to be discussed. One of these is the protection of privacy that PGIS systems should provide for individual opinions. The conceptual framework and the spatial aggregations developed through DISCUSS provide a means to protect the privacy of opinions by aggregating individual opinions into maps from which

analyses could be conducted. Maps such as the average spatial disaggregations (Figure 7-10, Figure 7-11 and Figure 7-12) showed that results produced using community opinions do not require links to individuals or institutions to produce information for analysing sensitive aspects such as political or social affectations. As with any public survey, however, normal procedures must be followed for ensuring individual inputs are not released.

DISCUSS has the potential to support stakeholder consensus by drawing out individual opinions. It makes perceptions explicit and creates a spatial focus for the disagreement. This may. in turn. lead to new options or implementations being developed. However, DISCUSS does not directly create consensus; it is limited to the generation of a better environment for discussion from where a good moderator could lead the group of stakeholders to the achievement of consensus. For example, during the workshop at the end of Lake Mokoan project, two important aspects—water security and availability—which were generating discontent among stakeholders, were discussed by stakeholders and clarified by government officials. This, at the end, generated consensus for the estimation made and also for the need for more information in some particular aspects of water security. Another area directly related to consensus and individual opinions in decision making is the difficulties in encouraging stakeholders to debate the real issues that affect them.

One of the principle criticisms of using purely rational methods to evaluate alternatives (such as CBA) is that they can divert discussion from the real issues. Rational analysis can be manipulated to produce the result that each party desires (Carley 1980), creating space for stakeholders to argue against a policy option by attacking the technical procedures used to calculate benefits and costs, rather than presenting their real issues of concern. Principle 6 of the conceptual framework seeks transfer of the central debate from the uncertainty of the technical analyses and procedures to the real issues, so that an open and transparent discussion can take place to promote a common consensus.

Indeed, in the workshop with Lake Mokoan stakeholders, the discussion was concentrated on the consequences of the policy alternatives (principally water security and availability) and not on the technical procedures made to obtain results. This suggests that the methodology conducted could create a more elaborate mechanism for people to express their opinions, regardless of their rationality or objectivity. This, at the same time, could benefit the process since

governments and community members could visualise better why the different factions prefer one option over another, despite the recommendations of the economic analysis.

8.4 HUMAN FACTORS IN PUBLIC DECISION-MAKING

In addition to testing the conceptual framework under the characteristics of current decision making, examining it with respect to human factors is also important, since for many authors these human factors are vital for decision makers when making decisions about the different options.

Human factors include both political and social dimensions. For the Lake Mokoan project, the derived map and graph results (page 179) in which the political boundaries were compared with the areas positively and negatively impacted, presented a possibility to support political considerations. For example, if a local mayor can determine whether his or her constituency is going to be positively affected under each of the policy options, this information could be politically useful.

Social factors (such as equity) are also important and are directly related to demographics, income and the spatial distribution of effects. In this regard, DISCUSS produces not only derived map results, but also numerical indicators that help identify the social implications of the policy options analysed. For instance, option 1 obtained a value of 0.21 for the indicator of option equity (IOE), while option 2B3 obtained a value of 0.38 and could potentially benefit more people with lower economic income than option 1. This information may be influential, according to individual social values.

These results used to provide information about the human factors affecting decision making were based on spatial disaggregation of consequences, which at the same time are based in the community knowledge. This community knowledge, as explored in the previous section, has some limitations that affect the validity of the considerations made for the other factors.

Despite this, the approach proposed in this research for factors such as equity could, in the future, with the availability of more methods to validate community knowledge, constitute a base to expand the economic information for decision making according to the social and political interests.

8.5 PRACTICALITY AND TECHNICAL ISSUES OF DISCUSS

This final section of this discussion chapter presents an analysis of the practicality of the conceptual framework and DISCUSS. The focus in this section is to observe if the procedures conducted in the Lake Mokoan project can be applied in other decision-making situations. Some discussion about technical issues associated with DISCUSS is also presented.

8.5.1 Map results and new indicators

The maps produced with DISCUSS were based on a raster resolution of five kilometres. Some of the input from stakeholders had a lower resolution. However, all maps were aggregated to this resolution in order to imply that results from DISCUSS constitute general information of possible areas to be negatively and positively affected, rather than individual estimations at the farm level.

The final maps produced tend to suggest that the resolution selected was correct to allow generalisation of the results. However, in the process of aggregation some particular areas of wider interest were lost. In particular, during most of the interviews stakeholders zoomed in to the areas surrounding the lake to make very specific identification of beneficiaries. When the final results were produced, these very specific estimations were aggregated, making it difficult to determine a difference or identify a disagreement between opinions.

Nevertheless, only areas surrounding Lake Mokoan were specifically targeted by stakeholders to identify effects, suggesting that the resolution selected was appropriate to the broader context. However, future applications of DISCUSS should consider this aspect and study the possibility of producing results using differential resolutions depending on the input from stakeholders.

In terms of the new indicators proposed to inform stakeholders and decision makers, one challenge is the inclusion of a suitable definition (or as part of the result) of the polygons used to obtain results.

In the case of Lake Mokoan, and in order to determine the population in each area and the level of income of this population, Australian Census Collection Districts (CCD) were used (more information about this particular boundary for demographic information can be found in http://www.abs.gov.au/).

CCDs were used, since these polygons represent the smallest determination of demographic data in Australia, meaning that few aggregations and interpolations were required to apply the spatially disaggregated outputs to the CCD.

However, the selection of the summary polygon can potentially modify the indicator results. If, for example, the Index of Option Equity (IOE) that was calculated for option 1 using CCDs had a value of 0.21, this same index calculated for the same option using the aggregated population for each Local Government Area (LGA) is 0.26.

Although the different results for this particular case of option 1 appears not to be significant, this needs to be considered when developing results with DISCUSS. Probably the best option is to use the smallest disaggregation of demographic data available. However, this might not be in accordance to the interests of stakeholders and therefore the opportunity to develop the analysis to a different level should be presented.

8.5.2 Workshop for discussion

The main objective of the workshop with the stakeholders was to explain to them the results (spatial and non-spatial) from DISCUSS. Many reasons could be attributed to the lack of understanding of the results without the workshop. Primarily, stakeholders tend to restrict their interest to a few pages, giving very little room to researchers to explain sophisticated spatial analyses such as those conducted with DISCUSS. Appendix 11.3 shows the communication sent to stakeholders.

Comprehension was also restricted because little detail was given to stakeholders about the intended results during the interviewing process. During the interviews many graphical aspects (such as colour scales or complementary graphs for non-spatial entities) had not yet been developed, giving no possibility to show an example of the final results.

Based on the experience of the Lake Mokoan project, a recommended activity during interviews is to show (to stakeholders) examples of typical outputs, so cartographic elements could be understood without the requirement of an additional workshop.

However, the workshop in the Lake Mokoan project had other benefits.

In particular, important discussion about future consequences took place during the workshop. The DISCUSS results were critically important, not only to guide the argument, but to open the minds of stakeholders to appreciate more openly the policy alternatives presented.

As well as in the selection of the system operator, some vulnerability of the conceptual framework for manipulation could exist in the selection of the workshop moderator. In the Lake Mokoan project a government official was used, as in other similar public participation processes in Australia (Stock and Bishop 2003). Although this was successful, consideration should be given in the future to the use of workshop moderators with a neutral position, whose primary focus is on encouraging open discussion.

8.5.3 Other methodologies for spatial consequences and community knowledge

Comparison of DISCUSS (and the conceptual framework) with other applications is difficult, since the approach presented in this thesis took features from many different researchers and did not follow any traditional line of investigation in PGIS.

Some similarities exist with the work of Sieber (2002) whose research also focused on helping the political process by providing information in addition to economic indicators. However, not only the environment but the general consideration of community knowledge is different. In DISCUSS the results are used to produce a final spatial disaggregation of consequences from which further information is derived.

Bateman *et al.* (2003) provide a genuine example of a complete and dedicated spatial disaggregation of consequences. In this case, researchers developed a very accurate web of technical and rational models that produced maps with a similar significance to those produced with DISCUSS, but with a superior level of detail (see page 60 for examples of these maps).

To accomplish this very detailed spatial disaggregation of consequences, Bateman *et al.* (2003) recognised the need for substantial economic resources and technical capacities in order to produce the models then aligned in a

temporal and spatial form for production of final results. In addition, this particular spatial disaggregation of consequences was created in a developed country where extensive datasets existed prior the research to support the technical spatial disaggregation.

From a practical perspective, results from the Lake Mokoan project and from Bateman *et al.* (2003) have the same potential to produce new indicators for decision makers. However, new indicators produced using the results of a technical spatial disaggregation have the support of all the models and scientific knowledge that produced them, whereas in the Lake Mokoan project the results were heavily based on community knowledge.

However, if future methodologies to acquire and validate community knowledge improve community knowledge to the point that in can be appreciated by decision makers as sufficient for the distribution of economic resources, this advantage (in terms of credibility) of technical spatial disaggregations might be reduced.

This could permit governments in developing countries, with restricted access to economic and technical resources, to develop spatial disaggregation of consequences and include all the benefits that this could bring to public decision making, such as the evaluation of equity and environmental sustainability,

It should be noted that purely rational disaggregations of consequences restrict the development of discussion among stakeholders concerning the approval or non-approval of the methodologies, algorithms and scientific knowledge used to produce them: something that could raise difficulties for some stakeholders without the necessary technical background to understand the resulting analysis.

8.6 REVIEW

The application of DISCUSS in the Lake Mokoan project raised several questions relating to the approach of the incorporation of community knowledge in public policy evaluations and its applicability in current governmental practices in Australia and around the world. This chapter explored these questions, focusing primarily on those aspects analysed in the literature as the more relevant characteristics of current public decision making.

In this regard, DISCUSS proved adaptable to unexpected changes in choice-making situations as well as promoting a better environment for discussion and, therefore, facilitating consensus. DISCUSS also demonstrated independence from the CBA results while at the same time complementing them, as the primarily target of DISCUSS is the analysis of human factors affecting public decision making and the consideration of concepts with spatial dependencies.

From a practical perspective, vulnerabilities of the conceptual framework and DISCUSS were identified. Principally, future applications should focus on the timing of the conceptual framework with the choice-making process; the selection of stakeholders and system operator; and tests of acceptability among stakeholders of the procedures for spatially disaggregating consequences as proposed in this thesis.

9

CONCLUSIONS

9.1 Introduction

This final chapter of this thesis presents the conclusions from this research. It also includes a summary of the contribution of this thesis and some recommendations for future research activities.

9.2 CONTRIBUTIONS OF THIS RESEARCH

The conceptual framework, which was used as a research instrument to test the importance of community knowledge, after having been used for the Lake Mokoan project, constitutes an alternative approach to spatially disaggregate consequences in cases where CBA has been used. As a result, this research has created a new conceptual framework for disaggregating effects of an economic analysis of public policies.

The adoption of this conceptual framework will allow decision makers to identify more clearly the beneficiaries of the alternatives proposed and at the same time to have a clearer perception of the equity and environmental sustainability of the project, policy or program.

In addition to the conceptual framework, this research also developed a decision-support system for spatial analysis. This IT tool, called DISCUSS (Decision Information System for Community Understanding of Spatial Scenarios), permits government officials, community members and representatives of the private sector to apply the conceptual framework in public decision-making processes.

Additionally, contributions of this research were diffused internationally. Four papers (Paez *et al.* 2003, 2004a, 2004b, 2005) were presented in international journals and conferences.

Also, the International Federation of Surveyors (FIG) awarded in two consecutive years (2003 and 2004) a FIG Foundation Grant to support the analysis of DISCUSS as a tool to reduce decision-making costs in developing countries.

9.3 CONCLUSIONS FROM RESEARCH

The aim of this research was to propose an alternative to remedy the current lack of an accessible, practical and low-cost methodology for spatial disaggregation of consequences in public decision making. The hypothesis to be tested was that community knowledge, combined with rational information in a PGIS, was able to generate this accessible, practical and low-cost alternative.

The approach proposed in this research involved a conceptual framework that guides the implementation of DISCUSS. The conceptual framework and DISCUSS are based primarily in spatial analysis and community knowledge.

Considering that community knowledge from affected stakeholders is available in most of public decision making, DISCUSS uses this type of knowledge as an alternative to reduce implementation costs by not relying heavily on scientific or technical information and models, which are normally expensive to acquire and maintain. This allows DISCUSS to be a less costly alternative for spatially disaggregation of consequences, compared with methodologies based only in rational or technical procedures.

Computational tools to support decision making should be able to be used in practical situations. Governmental decision making is currently evolving, and public participation is becoming not only an important component of the process, but an aim of decision makers to achieve sustainable development by reducing possible opposition during implementation.

To be practical, and considering that public decision making is a human process where rational models are only a part of the considerations that decision makers must integrate, DISCUSS focuses on community knowledge not only as a means to generate spatial disaggregation of consequences, but also as a tool to promote a better environment for discussion between stakeholders.

Bearing in mind that community knowledge is a result of effective public participation, DISCUSS supports public participation by acquiring, processing and developing results based on the information that the community has about the alternatives proposed. Enhancement of the environment for discussion is provided by presenting map representations of the location of disagreement about opinions between community members and government officials. These maps of disagreement have the potential to focus the discussion between stakeholders on those areas where opinions are opposed, creating a more dynamic exploration of choices for consensus.

In addition, the spatial disaggregation of consequences achieved with DISCUSS were also used to generate new indicators for decision making that enable the visualisation of other concepts (such as equity and environmental sustainability), considered fundamental for achieving sustainable development.

Despite this, DISCUSS is not designed to provide decision makers with a ranking of policy options or to select the best alternative. DISCUSS informs stakeholders (using soft information from the community and the available scientific information) about the spatial location of beneficiaries and about other possible human factors—such as political or social—normally affecting decision-making.

PGIS should facilitate transformation of the public from being passive listeners to active decision-makers. Human factors (especially in the political and social areas) are supported by approaching stakeholders in such a way that their opinions can be presented and discussed without requiring a formal or technical justification. Sometimes real issues affecting stakeholders are hidden behind discussions about the technical procedures. With DISCUSS, the environment for a debate about the real issues concerning stakeholders is also created, which facilitates the search for consensus.

However, human factors affecting public decision-making are normally complex, sometimes irrational and very personal to each individual involved in the process as a stakeholder and/or a decision-maker. DISCUSS is not an attempt to model, represent or reveal publicly these factors.

DISCUSS does not diminish the importance of technical and scientific models to predict future consequences. On the contrary, the conceptual framework proposed, which guides the application of DISCUSS in public choice-making cases, considers as a starting point the need for rational methods to assess policy options.

Considering that CBA is a popular and well known methodology in most nations and the need of the proposed approach to be accessible, the analyses conducted with DISCUSS are complementary to CBA or other methods to rationally rank policy alternatives. Rational methodologies are normally directed to reduce uncertainty and create a rational justification to distribute scarce resources. DISCUSS complements this analysis with a better environment for public participation and by providing information related to human factors affecting the decision.

More particularly, the results from DISCUSS can be seen as support for CBA focussed to cover those areas which cannot be directly processed by this economic analysis (such as equity and environmental sustainability) and, therefore, reduce the discontent generated in some situations by the absence of these considerations in economic analysis.

In addition, this approach presented in the form of a conceptual framework and materialised with DISCUSS, also reduces the myopic behaviour in public decision-making (where only individual interests are considered) and promotes in stakeholders the appreciation, not only of those benefits and costs impacting on them, but the 'big picture' encompassed by the options.

The use of GIS in DISCUSS principally as an analysis platform allows use of background spatial information to facilitate gathering of impressions from community members and in condensing this information for better comprehension. GIS also facilitates interaction of public institutions with the community and the spatial disaggregation of consequences.

In conclusion, the aim of this research was accomplished since the methodology followed allowed DISCUSS to support the development of an alternative to spatially disaggregate consequences in the Lake Mokoan project.

The results from this case study also support the perception of community knowledge as usable information to generate accessible, practical, effective and

low-cost methodologies for spatial disaggregation of consequences. Therefore, the research hypothesis proposed was supported by the practical findings in the decision-making process studied.

9.4 RECOMMENDATIONS

Acerch (1990, p. 147) has noted the importance of including the time dimension in the selection of policy alternatives. In order to include the time dimension in the analysis conducted with DISCUSS, important research would be needed in the area of temporal GIS, a promising area for spatial sciences (Longley and Batty 2003). The inclusion of the time dimension in the selection of alternatives, although an important factor, was outside the scope of this thesis.

Further computational developments of DISCUSS to make it capable of acquiring and processing the information in real time could be another area for future development. A real-time format in DISCUSS would permit a more dynamic interaction, since stakeholders could modify their opinions while appreciating the level of disagreement that they have generated, something desirable to encompass a more active discussion.

However, the inclusion of a real time approach to DISCUSS requires a careful analysis of the consideration to protect privacy and the fact that public expression of opinions might inhibit stakeholders from openly communicating their opinions.

Additional testing of the methodology to validate community knowledge (the Z factor approach) is also required, as it was conceived specifically for the social conditions in the Lake Mokoan project. Further developments are also required to make it practical in situations where expert spatial analysts are not available to act as system operators.

Finally, the literature review conducted and the experiences obtained during the development of DISCUSS suggest that the demand for new IT developments in the area of decision support is increasing. Decision makers require tools to reduce uncertainty. At the same time, they desire more adaptability to public participation and more information about the human factors affecting public policy evaluations. Designers of DSS are encouraged to consider the desires of users, which today involve community members as active decision makers and a focus on supporting the evaluation of concepts related to sustainable development.

However, the pressure on future DSS is not only to adapt to the changing trends in governmental decision making. Most users also desire the latest technologies available. The challenge for researchers in the future is to incorporate these demands without falling into developing DSS that are only used by politicians to justify decisions that have already been taken in their minds before any analyses are conducted.

10

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11

APPENDICES

11.1 FORMS FOR ACQUIRING INFORMATION DURING THE INTERVIEW PROCESS.

11.2 EXECUTIVE SUMMARY OF THE LAKE **M**OKOAN PROJECT

11.3 COMMUNICATION SENT TO STAKEHOLDERS

11.4 EXAMPLE OF THE SURVEYS CONDUCTED DURING THE WORKSHOP WITH STAKEHOLDERS

DISCUSS

Decision Information System for Community Understanding of Spatial Scenarios

Lake Mokoan

Decision Process Analysis Stakeholder pre-meeting questionnaire

Please indicate the extent to which you agree or disagree with each statement:

For the Agreement – Disagreement analysis (yellow maps on the top of the page):

I understood the colo	ur scale (from ye	ellow to red) used in th	nese maps	
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
I understood the relati	tion between the	maps and the graphs	of other entities i	dentified
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
I understood the diffe	erences between	the two yellow maps		
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
In general, I understo the participants in this		of this analysis of ac	greement and disa	agreement made for
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
I found useful this an	alysis made for t	he Lake Mokoan decis	ion process	
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
For the spatial peropage)	ception of effe	cts analysis (blue –	grey maps at	the bottom of the
I understood the colo	ur scale (dark br	own to blue) used in t	hese maps	
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
I understood the diffe	erence between t	he two blue-grey map	S	
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
In general, I understo	ood the meaning	of these analyses of s	patial perception	of effects
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly

DISCUSS

Decision Information System for Community Understanding of Spatial Scenarios

Lake Mokoan

Decision Process Analysis

Stakeholder questionnaire (after information session)

Please indicate the extent to which you agree or disagree with each statement:

For the Agreement - Disagreement analysis (yellow maps): I understood the colour scale (from yellow to red) used in these maps Strongly Agree Neutral Disagree Agree Disagree Strongly I understood the relation between the maps and the graphs of other entities identified Strongly Agree Agree Neutral Disagree Disagree Strongly I understood the difference between the groups analysed Strongly Agree Neutral Disagree Disagree Strongly In general, I understood this analysis of agreement and disagreement between participants in the research study Disagree Strongly Strongly Agree Neutral Disagree Agree For the spatial perception of effects analysis (blue - grey maps at the bottom of the page) I understood the colour scale (dark brown to blue) used in these maps Disagree Strongly Agree Neutral Disagree Strongly Agree I understood the difference between maps of average perception Neutral Disagree Strongly Strongly Agree Agree Disagree In general, I understood the meaning of these analyses of spatial perception of effects Strongly Agree Agree Neutral Disagree Disagree Strongly

I now can understand better the different perceptions between stakeholders and between stakeholders and government officials

For the methodology used:

stakeholders and gov	ernment officials						
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly			
I found this analysis	useful for underst	tanding the Lake Moke	oan issues				
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly			
I consider it useful to	apply this analys	sis in other future deci	sion process				
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly			
After the analysis, I understand better the options for Lake Mokoan							
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly			
I consider my privacy was respected in the results presented							
Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly			
Any additional comments:							