MULTI-OBJECTIVE DECISION MAKING APPLIED FOR WATERSHED DEVELOPMENT PLANNING OF ZARQA RIVER BASIN IN JORDAN

by

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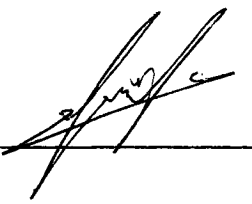
SIGNED: 

DEDICATION

This work is dedicated to my dear parents for their love and guidance through my life, and to my wife and my children, whose patience and encouragement have made it possible.

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ABSTRACT

In developing natural resources, decision makers are seeking to achieve different objectives, which cannot be reduced to a single objective such as economic efficiency, this covers only part of the problem. Tradeoffs between multiple objective of unequal importance is unavoidable in the process of selection or ranking of alternative developmental projects or plans.

Multiobjective technique has the ability to deal with qualitative and quantitative objectives, also it enhances the planning process by involving broader segments of the society in the process of decision making. Compromise programming (CP) and utility worth analysis (UWA), two multiobjective methods were applied on Zarqa River Basin Project (ZRBP) in Jordan. Their appropriateness and suitability as decision aiding tools was examined in this study. For the purpose of the study, five criteria were developed to serve as a basis for the evaluation and 61 farmers and 15 technicians, planners and decision makers were interviewed.

High consistency was observed among the results of ranking the six alternatives when both methods were applied, at the same time the ranking of the alternatives according to benefit/cost ratio and the internal rates of return as economic efficiency measures showed no agreement with the multiobjective ranking.

CHAPTER 1

INTRODUCTION

Statement of the Problem

In attempting to increase food and fiber production, developing countries have adopted farming and production systems that tend to exploit the soil resources, create air and water pollution and reduce the land productivity.

The development of natural resources on a sustainable and integrated basis within the watershed management concept is rarely adopted in developing countries. Watershed management and soil conservation projects are difficult to be economically justified by applying the single objective measure, such as economic efficiency, where all discounted benefits must exceed the discounted costs.

Therefore, a multiobjective decision making (MODM) approach needs to be adopted, which considers all the objectives, direct or indirect, tangible or intangible, and all the project impacts, in a manner that allows the decision maker to have more indepth information, when they make their decisions.

Purpose of the Study

The goal of this study was to develop a multiobjective decision-making methodology which will aid decision makers and planners in developing countries to identify and evaluate different alternative

management plans, and to aid in selection of the best compromise of different developmental alternatives.

The notion of integrated and sustainable watershed management will be stressed in this study, and the participation of different people concerned and affected by the decisions will be incorporated in the procedure. In doing so the Zarqa River Basin Project (ZRBP) in Jordan will be taken as a case study. Two multiobjective decision making techniques will be applied on the project for temporal phasing (ranking) of six watershed management units (WMU) for implementation purposes, (i.e., the WMU's will be dealt with as alternatives), but in this study all the alternatives will be implemented in different time periods. In addition to the multiobjective ranking, the alternatives will be ranked according to two economic efficiency measures and the results of multiobjective technique abd economic efficiency will be presented and compared.

Method of Study

To achieve the study objectives, the impact of soil erosion, including the economic problems of soil conservation practices, and its relation to sustainability in watershed management will be presented. The watershed as a unit for planning and management will be examined and evaluated.

The history, concept, and the process of multiobjective decision making will be reviewed and discussed, and will be applied to the Zarqa River Basin Project (ZRBP) in Jordan. Two of the most promising

multiobjective techniques compromise programming and Nutzwertanalyse (utility worth analysis) techniques will be applied and their appropriateness examined.

In doing so, the author has spent one month in the Federal Republic of Germany and four months in Jordan to collect data and interview different people affected and involved in the decision making process; this included 61 farmers from the project area, and 15 technicians, planners, and decision makers in Jordan.

CHAPTER 2

SUSTAINABILITY AND WATERSHED DEVELOPMENT

Impact of Soil Erosion

Most of the developing countries are trying to increase their food and fiber production to achieve self-sufficiency, which often leads to the adoption of farming and production systems that exploit the soil resources and reduce their productivity. In addition to that, the massive cut of forest trees for fuel wood and other purposes, and the high population growth rates in the developing countries force the cultivation of new, often marginal lands, which are then abused.

A new concern has been added in recent years in addition to the age old problem of erosion and deposition. Eroded soil is now recognized as a major cause of air and water pollution. Soil erosion produces dust clouds and muddy water, and the eroded soil particles carry plant nutrients and other chemicals that contaminate water. Erosion changes the soil's physical, chemical, and biological properties. Such changes usually reduce the water and nutrients available for plant use, which limits production. Both soil erosion and productivity can be considered outputs from a system that integrates the effects of environmental factors, management factors, and soil properties.

The relation between soil erosion and soil productivity is clear; have shown that there is a direct, positive correlation between depth of topsoil and crop yield (Sfier-Younis, 1985).

Historically, soil productivity and food production are indicators of the development of a nation's civilization. The ability of nations to conserve their soil from erosion and keep its productivity is shown to be an important prerequisite for the maintenance of their civilization.

Of the three requisites for a thriving civilization, namely, a fertile soil, a dependable water supply, and relatively level land with reasonable rainfall which would not cause erosion, it is likely that the third factor is considered the most important. Evidence is mounting that soil degradation has toppled civilizations as surely as military conquest (Kelley, 1986). Finally, as Brown (1981) put it "Civilization can survive the exhaustion of oil reserve, but not the continuing wholesale loss of top soil." The on-site and off-site impacts of soil erosion is illustrated in Table 2.1.

Quantifying Erosion's Impact

Unwise land use activities often accelerate soil erosion. The resulting impact can be assessed most easily in terms of physical or biological changes that occur on or off a site. Perrins and Trustrum (1985) described three techniques to measure or estimate erosion's impact:

1) Direct measurements. To be useful, direct measurements, such as the depth of sediment in a reservoir or the areal extent of soil erosion, must clearly show the inference that can be drawn from them. For example the soil loss measured on a plot for one year be used as a guide to estimate long-term erosion over

Table 2.1. Soil erosion impacts, Perrens and Trustrum (1985).

Type	On-Site	Off-site
Direct	soil loss	sedimentation of reservoirs
	nutrient loss	sedimentation of farm lands,
	stream bank erosion	roads, rivers and culverts
	crop damage (wind, water)	deterioration of air and water quality
	productivity loss	damage to ecosystems (fish, birds)
	damages to existing structures	altered hydrologic yield
		loss of life and property
Indirect	reduction of option for land use	reduction of reservoir life
		increased flood frequency
	need for remedial structures	
	need for remedial land management	

a region or such measurement be extrapolated to other soil types?

2) Statistical sampling. Often measurements of the extent and severity of soil erosion throughout a region are impossible. In these cases useful information can be gathered from a statistically planned sample. Inference then can be drawn about the problem's extent and the confidence with which estimates were made.

3) Descriptive model. Where neither the resources nor the manpower are available for measurements or sampling, inference may be drawn from the generalized data gathered in other countries. For example, research throughout the world has shown that the erosion rate on bare soil is roughly proportional to the square of the land's slope for slopes up to 20 percent. Such information can be used as a basis for qualitative assessment of the soil erosion hazard.

Transformation of data, information, and technology also provides useful basis for predicting the impacts of soil erosion. The basic processes of erosion operated in all areas, although the process that dominates may vary. In principle, detailed process models can be used in other locations, provided that they have been calibrated and tested at the new site. Models such as the Universal Soil Loss Equation (USLE), include the major factors that affect erosion. Because of their statistical basis, these relationships need derivation of a new locality before they can be used with confidence.

Movement of soil from the landscape, through a river system and into a reservoir is a complex physical process that varies with space and time. This presents special difficulties for measuring and interpreting data related to soil erosion processes and impact. For example, the scientists in one attempt to derive national estimates of soil loss in the United States noted: "The bases of these estimates ... are obscure, inadequate and variable. Thus, the debate as to whether soil erosion on cropland has increased or decreased since the 1930's cannot be resolved" Larson et al. (1983).

Three factors, in particular, are important in assessing the impact of soil erosion:

1) Scale. Many factors that affect soil erosion such as soil type, vegetative cover, slope, slope length, and land management, vary over short distance. Therefore, it is important to adopt an appropriate scale for a particular analysis. How well can data from a one-acre plot be applied to a scale (Rogowski et al., 1984)? The scale at which data will be used also must be considered.

2) Stochastic effects. Soil erosion and sediment movement are highly stochastic processes. At Gunnedah, Australia, for example, 72 percent of the soil loss occurred as a result of four storms in a twenty-six year period (Edwards, 1980). Estimates of long-term, average soil erosion must account for such events.

3) Trend effects. Any long-term land use trends, such as the gradual agricultural development of a watershed, or sudden, short term impact must be recognized and analyzed as part of any impact assessment.

Soil Erosion in the Near East

The "Near East" term is used generally to denote the area located between Europe, Asia and Africa. Data about soil erosion in the Near eastern countries are limited but soil erosion problem is very clear in most of the countries.

The fact is that most of the area is experiencing moderate to severe erosion. Severe, moderate, and little combined wind and water erosion cover 32%, 60% and 8% of the total area of Iraq, respectively. Studies conducted by Kettaneh et al. (1982) also show that there is a loss of 1 mm of top soil per year from steep mountains, while the rate is 0.5 mm/year in the foothills and plains.

In Syria, the erosion was estimated at 50 ton/ha in southeastern Lattakia. Rill erosion contributes 56 percent of the total soil erosion in the area (Zought, 1978). Studies of Zarqa River Basin Project in Jordan show that an average sediment content of 1% can be expected from the floods with a value of four million cubic meter. The yearly amount of accumulated sediment in the reservoir of King Talal Dam has been estimated at one million cubic meter, these sediment come from an area of around 350,000 ha (GTZ, 1984).

Older civilizations in the region practiced soil and water conservational measures. These measures, and the structures associated with them, were abandoned later when their nation collapsed. The remains of bench terraces in humid areas and water structures in dry areas can be found all over the region. Examples of these measures can be found in Jordan, Lebanon, and Yamen at the site of Mareb Dam (Abido, 1985).

People Participation in Watershed Development

Many projects have not obtained their true potential because they focused too heavily on the creation of formal administrative structures that wind up inducing the performance of project activities, rather than facilitating collective decision making and subsequent performance. In some cases, investments have been capital intensive and implemented by technicians imported from outside the community when they did not have to be. Several of these projects have been defined as failures (USAID, 1981).

The involvement of local people in the development activities in developing countries is mostly considered as a make up or luxury activity, and it is mostly done to satisfy the aid agencies or some political groups. Hanson and Erbaugh (1987) stated that the governments of the third world countries tend to implement projects directly rather than involving local communities in the process, much less in the decision making which precedes implementation. This may occur in part because of the overconcern for efficiency goals, such as obtaining quantifiable outputs within a relatively short time frame. In other cases, it occurs

because government agents do not appreciate the considerable resources and decision making capacity which are found in the impacted rural communities. Still more serious, in other cases, it occurs because government bureaucracies operate at a level which effectively separates them from local populations, a situation which precludes effective dialogue. Lack of involvement and responsibility for project success usually will result in project failure because commitment to maintaining project inputs is lacking. In addition, the exercise of social control by villagers over one another is likely not to occur because of the absence of collective responsibility.

As a geophysical entity, the watershed possesses a basic structure and a topographic pattern that, together with the laws of gravity and the flow of water, shape its biotic and abiotic characteristics and processes with considerable regularity. Given this regularity, it is perhaps not surprising that human societies in different parts of the world have frequently adapted to the watershed landscape in similar manners. Indeed, there are often structural parallels between the ways in which human groups are organized and spatially distributed and the natural physical pattern of the watershed (Hamilton and King, 1984).

Rural populations in many countries can be divided into different groups on the basis of adaption to different portions of the watershed as a whole. Figure 2.1 is a simplified model of human-environmental relations in the watershed contest.

The participatory approach is mostly constrained by serious obstacles which exist at the agency, community, and societal levels

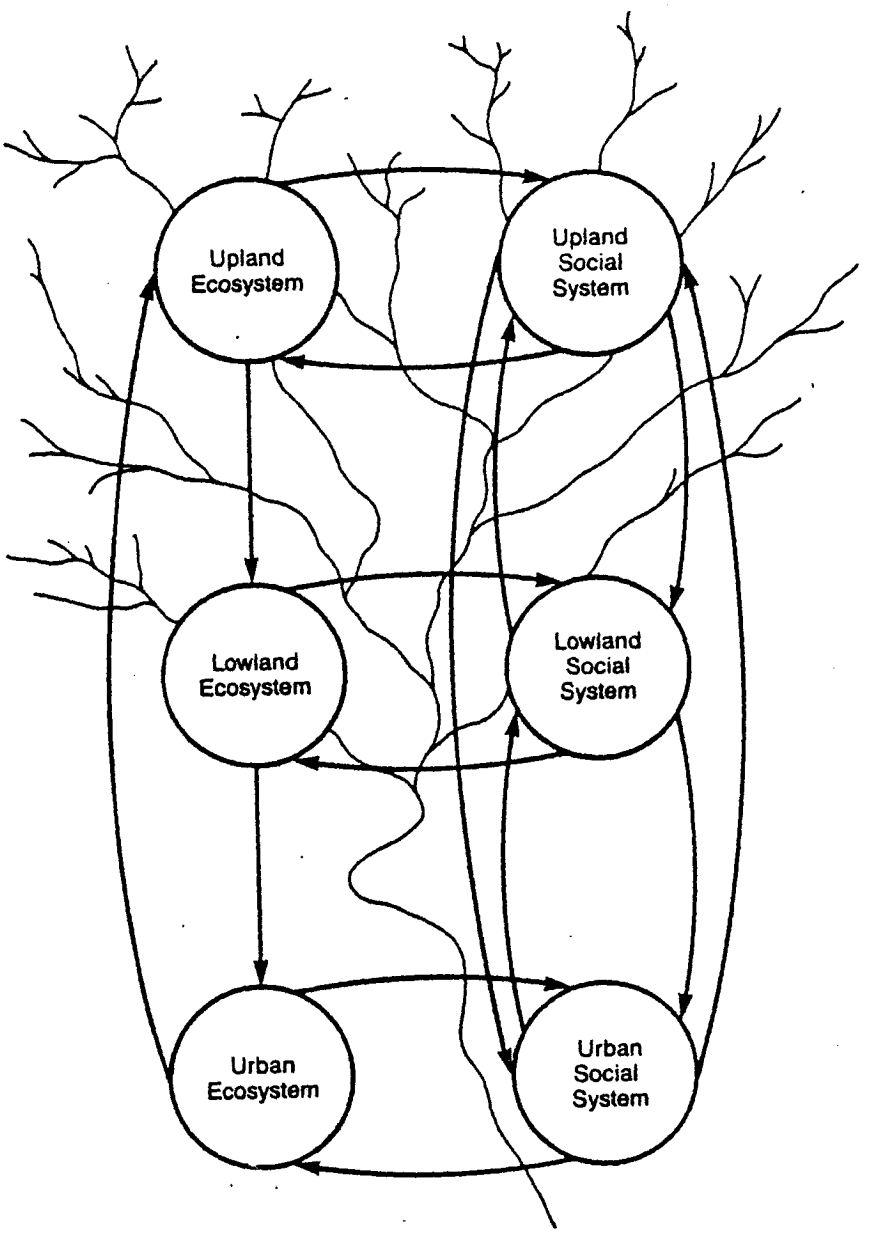


Fig. 2.1. A simplified model of human-environmental relations in the watershed context (Hamilton and King, 1984).

(Korten, 1981). Obstacles within implementing agencies include centralized decision making. Values and attitudes that overestimate the agency's influence and underestimate villager's skill and intelligence; in appropriate value systems that stress bureaucratic objectives; and frequent transfer of personnel that prevent villagers and officials from developing mutual understanding and respect.

Within the rural poor communities, the participatory approach is laced by the lack of the appropriate local organizations and leadership, poor infrastructure, internal conflict among the villagers and lastly there are the obstacles within the society as a whole, these include the political objections by the resource-rich to the transfer of resources to the resource-poor, lack of incentives, absence or inappropriateness of legislation, and centralized control by central government. All the above obstacles result in the failure of watershed and rural development projects.

Success (in participatory approach) requires transformations in the way an agency performs its task, in the way community members relate to each other and to the agency, and the way society views the poor, their needs, their capacities, and their right. Such transformation is inevitably slow and liable to set backs, but the reasons for seeking participation are compelling (Korten, 1981).

The Notion of Sustainability

"We have not inherited the World from our forefathers, we have borrowed it from our children."

Kashmir proverb

Natural resources are of two kinds: renewable or non-renewable. Renewable resources are those that grow, like fish and forests, or which are replaced by the undisturbed workings of the natural world, such as soil and water. These are being exploited at a frightening state and irrationally abused. Renewable resources could easily be depleted if used in rates higher than the rates of their renewal.

Sustainable development - "development without destruction" - is an old philosophy which is being revived to cope with new economic problems. It says, in summary, that care for the environment is essential to economic progress. Put another way, the natural resources of our planet are the base of all agriculture and industry, and if we sustain that base we can sustain development (Mansfield, 1988).

The concept of sustainability received its greatest boost from the publication of the World Conservation Strategy (WCS) (IUCN, 1980) and a series of related documents (UNEP, 1981) brought the concept of sustainability to the attention of a much wider audience.

"Agriculture Sustainability" has different meanings to different people. Douglas (1985) categorized these groups or schools of thoughts into three. The first group thinks of sustainability a supplying enough food to meet everyone's demand. This is called "food sufficiency" or "productivity" school. Agriculture in this view is primarily an instrument for feeding the world, or at least for feeding those who can afford to buy food on world markets, and preserving the resource base or the culture of rural life is usually of secondary importance.

The second group regards agriculture sustainability as an ecological phenomenon. Douglas (1985) calls this "stewardship" school. Its proponents measure sustainable production not by total outputs or outputs per unit of scarce input during a limited period of time, but by the average level of output over an indefinitely long period which can be sustained without depleting the renewable resources on which it depends.

The third school is the "community" school. This school pays most attention to the effect of different agriculture systems on the vitality, social organization, and culture of rural life. The members of this school are also ecologically minded, but their primary interest is in promoting vital, coherent, rural culture that encourage the values of stewardship, self-reliance, humility and holism.

Conway (1985) defined sustainability as the system's ability to maintain productivity in the face of a major disturbance, such as that caused by soil erosion, farmer indebtedness, an unanticipated drought or a new pest. The loss in sustainability is then expressed through declining productivity or a sudden collapse in the system.

Tolba (1987) identified the components of sustainable development as:

1) help for the very poor because they are left with no option other than to destroy their environment;

2) the idea of self-reliant development, within natural resource constraints;

3) development should not degrade environmental quality, nor should it reduce productivity in the long run;

4) the great issues of health control, appropriate technologies, food self-reliance, clean water and shelters for all; and

5) the notion that people-centered initiatives are needed; human beings, in other words, are the resources in the concept.

There is increasing evidence that sustainable development is not realized unless emphasis is placed at an early stage on a number of relationships. The first is the relation between natural world and human society and its development. The tangible components of the natural world forest, soil, water, and so on together make up the system which supports all life on the earth. The second relationship which must be emphasized in sustainable development should be achieved in the connection between economic growth and development. The fact is that economic growth does not necessarily benefit all sections of the society. The conventional wisdom was that an increase in national income would trickle down to the underprivileged. This is partly because the growth process itself does not necessarily bring about changes in the structure of the society. Third is the relationship between our understanding of the interaction between man and nature, and the designs of development policies and objectives. Interaction between forces of change, such as resources, environment, people, and development make it necessary for governments to think in terms of trade-offs between different courses of action. Developed objectives must be carefully evaluated in order to identify the consequences of each action.

Watershed as a Unit for Planning and Management

The watershed is a logical unit for planning, because it explicitly forces one to recognize that sustained land or resource based development depends on the interaction of all the activities that take place throughout the watershed. Uplands and lowlands are physically linked in a watershed via the hydrologic cycle. Upstream activities affect down-stream opportunities and problems by influencing the flow of water, sediment, and other waterborne materials through the system. Uplands erosion not only leads to long-term losses of upland productivity, but also to losses of storage capacity in reservoirs which in turn leads to lost hydropower production, increased flooding or loss of irrigation capacity downstream. Soil loss creates adverse down-stream impact even when reservoirs are not present. More frequent overbank flows and flood damages will likely result. In addition, lack of adequate water to dilute wastes and general water quality deterioration from uplands results in more serious pollution, including public health problems. In other words, the watershed management concept is an integrated way of looking at land and water uses and the interaction of such in a given area (Gregerson et al., 1986).

Watersheds are also convenient units for performing economic analyses and for considering many physical changes that are linked to resource utilization and development. These watershed problems are especially acute in developing countries, where growing populations are exerting intense pressure on increasingly scarce land and water resources. Most of the people in these areas live and work on the land. So, as rural

populations increase, land formerly farmed extensively are now being farmed more intensively, while formerly fallow lands, usually more susceptible to erosion, are being cultivated. This, in combination with similarly motivated overuse of grazing land, has dramatically increased the potential for erosion and downstream damages.

Deforestation of upland areas, a result of more intensive shifting agriculture and excessive timbers extraction, has also accelerated soil erosion and downstream damages (Easter et al., 1986).

The management of watersheds has been largely unsuccessful, partly because the concentration has been almost exclusively on bio-physical aspects such as slope, soil texture, and vegetative cover, without proper regard for socio-economic aspects. For successful project implementation, economic, social, political, and institutional considerations are paramount. The socio-economic side, although known to be important, is often ignored because of the difficulties involved in dealing with social issues.

Constraints to Adoption of a Watershed Management Approach

The slow adoption of the watershed management approach was mainly because the concept underlying the watershed management framework is not fully understood by development planners and decision makers. Thus, since local political boundaries, the local political institutions that drive development, seldom have recognized the watershed as a workable unit for planning and action purposes. Since the main effect of their water and land use practices of one political unit are often felt by people outside

outside the unit or by future generations who can't vote now, there has been little incentive to actively consider the concept of watershed management that account for these interactions. A common question from upstream land users is: "Why should we carry out watershed management activities when the main benefits occur downstream?" Why should we expect them to, if they are not compensated for the costs of such activities (Brooks, 1987).

The lack of awareness or understanding of watershed management concept and practices by development professionals and the public also has limited the application of watershed management concept. There has been a lack of interaction of technical experts in this field with development practitioners and administrators. Only recently have technical experts made a concrete effort to explain, in language understood by the development professionals. In fact, they (the attitudes) are changing in such organizations as the World Bank, which recently underwent a major reorganization to increase the focus on sustainable development and environmental management in relation to development. What has been recognized - and what a watershed management framework emphasizes - is that economic growth, poverty alleviation and environmental protection can be made to complement each other, or at least a workable optimum compensation can be found, if the appropriate integrating approach and mechanism is used (Brooks, 1987).

CHAPTER 3

MULTIOBJECTIVE DECISION MAKING

History of Multiobjective

Most of the decisions we make in our daily life are multiobjective in nature, where simply we compare between different possible alternatives in terms of several criteria and choose the best one. Early ideas leading to multi-objective analysis of decision problems were brought forth by the Italian economist Pareto (1896). Another early idea appeared in the work of Von Neumann and Morgenstern (1944). Other mathematical bases for multi-objective decision making were provided in the words of Koopman (1951), Kuhn and Tucker (1951), Arrow et al. (1956) and Shapley (1959).

On the conceptual aspect, Simon (1957) introduced the notion that decision makers do not really seek an optimal solution when confronted with a complex problem. Rather they seek a "satisfying" solution.

The first major step toward a multi-objective analysis was developed through the Harvard Water Program, a research enterprise supported by the Rockefeller Foundation, the U.S. Army Corps of Engineers, and the Bureau of Reclamation, most of this work is published in Maass et al. (1962). Haines (1975) identified the principles of regional water resources planning for policy decision making processes at the various hierarchial levels, local, state, regional and federal. David and Duckstein (1976) applied the concept of comfort-discomfort indices to the problem of evaluating alternative water plans, as influenced by several European countries all at the same time (Khalili, 1986). The political

decision-process necessary to water resource problems was given by Major (1969), where changes in federal guidelines were suggested to reflect accurately the interaction of social preference and investment opportunities. Haith and Loucks (1976) and Loucks et al. (1981) reviewed some of the methodologies available to the planner within the multi-objective context. Excellent state-of-the-art textbooks were published in the last ten years (Bechmann, 1978; Cohon, 1978; Hwang and Masoud, 1979; Saaty, 1980; Hwang and Yoon, 1981; Zeleny, 1982; Yu, 1985; Steuer, 1986; Saaty ad Kearns, 1985; Szidarovszky et al. 1986).

Apart from the number of conferences and books published, another major indicator of the rate of development of the theory and practice of MODM during the last ten years is the type and extent of journal articles written on the subject. A staggering number of articles have been published in different journals during this period, as shown among others in Despontin and Spronk (1979), Hwang and Maosud (1979), Bechmann (1980), Hwang and Yoon (1981), Siskos et al. (1983), Evans (1984), Schiederjans (1984), Strassert (1984), Zangemeister et al. (1984), Currant and Min (1986), Ramero and Rahman (1987) and Howard (1987).

During the last twenty-five years, various multiobjective decision making techniques have been developed and used. Tecle (1988) surveyed and identified seventy-one techniques and methods for solving multiobjective decision problems. Appendix (A) includes an edited list of the most available techniques.

Concept and Design of Multiobjective Decision Problem

The basic principle of MODM is simple. A matrix should be constructed whereby its elements reflect the characteristics of a given set of choice possibilities (alternatives which are determined by means of a given set of criteria (Voogd, 1983)). A literature examination reveals various names for such matrix, for instant, project-effect matrix, score matrix, effectiveness matrix, or evaluation matrix. In this study, trade-off matrix will be used. Other essential terms are used to describe a multi-objective problem. It is worth mentioning here that there is no universal agreement on the definition of the terminology used for example, goal, criteria, and objectives are exchangeable used (Hwang and Masud, 1979; Hwang and Yoon, 1981; Ignizio, 1982), while others make distinction in the use of such terms (Gershon, 1981; Szidarovszky et al., 1986; Tecle et al., 1982).

When applying formal techniques to decision problems, alternatives should be compared and ordered by means of a decision-making model that permits estimates to be made and preference to be revealed among them. Thus, construction and use of a model become a part of the decision process (Ozernoi, 1974). There should be a set of two or more mutually exclusive alternatives, one of which must be chosen. There is also a set of two or more criteria that are relevant to the evaluation. The construction of a multi-objective decision model evolves formal and non-formal steps. Multi-objective decision problems can be solved by applying

more than one model. The appropriateness of these models may be tested only in the context of their practical application to real cases. Following is a simple multi-objective decision making model suggested by Ozernoi and Gaft (1977):

$$\{t, S, K, X, f, G, r\} \qquad (1)$$

where:

t = a statement of the problem

S = a set of feasible alternatives

K = a set of criteria

X = the estimated scales

f = a mapping of feasible alternative for vector-valued estimates

G = the decision makers preference system

r = the decision rule.

Six steps were identified in the process of formulation of a multi-objective problem (David and Duckstein, 1976; Duckstein and Opricovic, 1980; Tecle and Fogel, 1986). The steps are:

1) Defining the desired objectives that the system is to fulfill.

2) Identifying the mission requirements or desired specification for such objectives.

3) Selecting evaluation criteria that relates system capabilities to specifications and hence to objectives.

4) Determining measurement scale to describe the range of possible values (quantitative) or relative position (qualitative).

5) Generating alternative schemes for attaining the desired objectives.

6) Formulating an evaluation matrix (trade-off matrix), an element of which represents a particular value or relative position of an alternative in terms of one criterion.

Bell at al. (1977) have provided a diagram shown (Fig. 3.1) for developing and using the multi-objective model in a decision problem. The first step in the model is the statement of the problem (step 1) followed by the establishment of the set of feasible alternatives (step 2), then a list of criteria and empirical indicators will be developed (step 3) and construction of scale (step 4). All alternative estimates are defined in terms of the scale of each criterion (step 5).

(Step 6) and (step 7) include information about decision makers' preference system, where the information is analyzed, verified, and then used to construct a decision rule. The decision rules obtained are used for ordering the set of feasible alternatives (step 8). The results of this ordering are analyzed (step 9), and a check is made to ascertain that the ordering is satisfactory (step 10). Unsatisfactory ordering could be caused by contradictory preference information obtained at various steps, and incomplete set of criteria characterizing the quality of the feasible alternatives, disparity between the estimating scale for certain criteria and measuring potential, or errors in estimating alternatives in scales of certain criteria. Depending on the reason for the unsatisfactory ordering, different measures may be taken to estimate them. It may be necessary to update the problem statement; include new alternatives in the initial set; or, update the list of criteria, their scale, and estimates

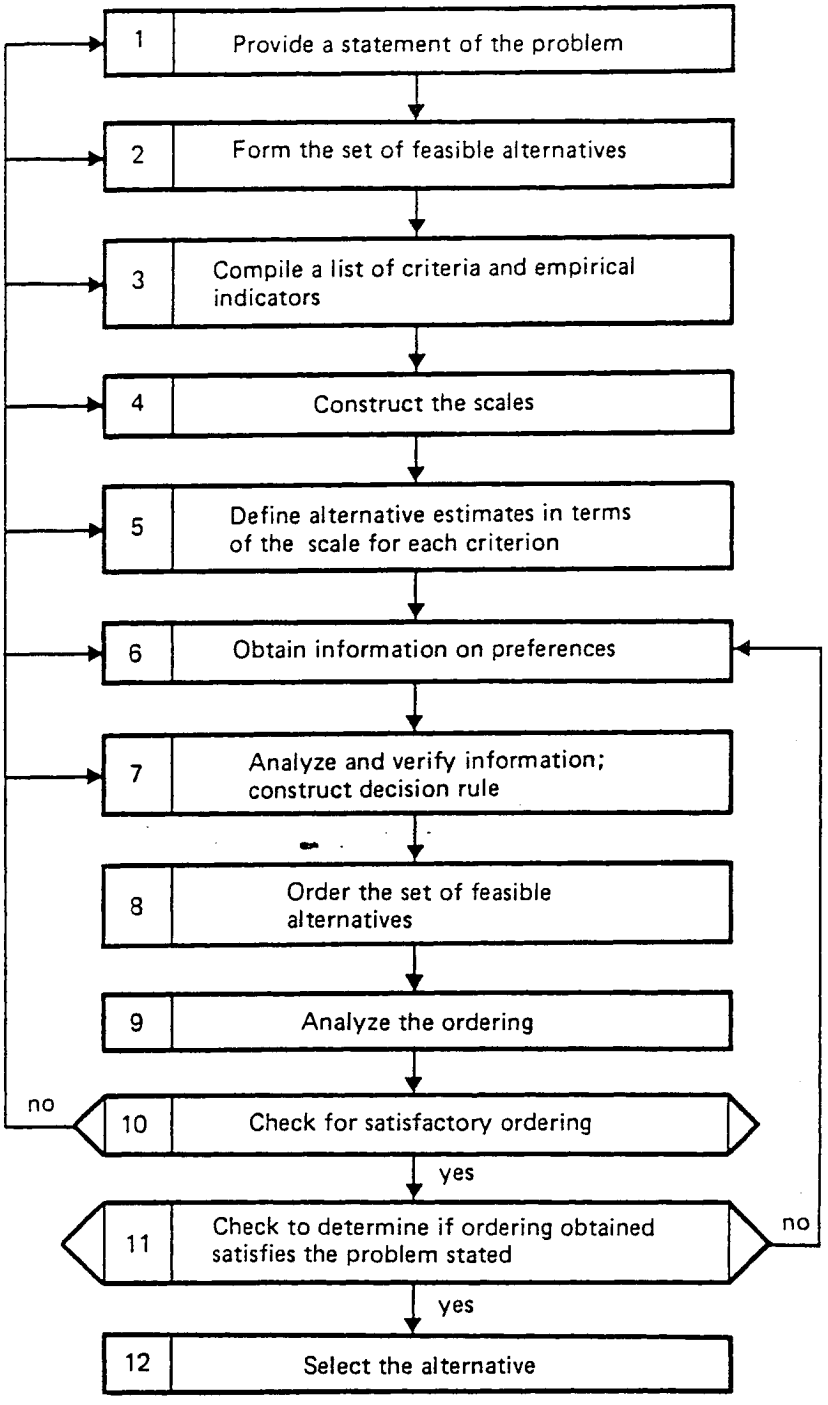


Fig. 3.1. Sequence of 12 steps for developing and using a multiobjective model. (Bell et al. 1977).

of alternatives in terms of new scales. It may also be necessary to correct the information upon which the preference or decision rule is based.

A check should be made to determine if the ordering of the set of feasible alternatives obtained satisfied the problem stated (step 11); if there is no correspondence, some additional preference information should be obtained and a new decision rule constructed. The analysis of incomparable alternatives in the ordering (in step 11) makes it possible to establish the class of information necessary to form a new decision rule. When the ordering of alternatives meets the problem requirements and is accepted by the decision maker as satisfactory, it is regarded as final. If a decision maker behaves rationally, he will make a decision consistent with the ordering obtained (step 12).

Identifying Decision Maker and Decision Analyst

Various actors may be involved in the multi-objective formulation process. A common distinction is that between analyst and decision maker. The decision maker is the person who is formally held responsible for the choice of a certain alternative, as well as its implementation. The analyst has the task for providing scientific assistance to the decision maker during all phases of the planning process.

The possibility of interference and conflict between the decision maker and the analyst is high. In spite of that, a number of labor divisions between analyst and decision maker is possible. One extreme is that the decision maker performs no real part in any of the decision

making steps His responsibility is limited by the outcome of the planning process. An example may be the government official who does not have time to be involved in the many day-to-day routine decisions made in his department. The other extreme is the decision maker who makes decisions without anyone's assistance or advice. In normal working conditions, there should be a share in the commitment, where the decision maker can be involved in some steps while the analyst takes charge of other steps, keeping in mind that the interaction between both sides is essential in most of the steps.

It is clear that a communication gap is probable between decision maker and analyst. This gap may make its presence felt in all phases of the planning process. It may also hinder, therefore, a fruitful accomplishment. It may be expected that the fewer the people involved in the planning, the less the communication difficulties. One should be aware that in many situations, neither the analyst nor the decision maker are single persons. Many policy problems are so complex that they can only be tackled by units consisting of various persons. Besides, various units may be involved in the course of planning (Rietveld, 1980).

Classification of Multiobjective Decision Making Technique

Multiobjective decision making techniques can be classified according to the following criteria:

1) Mathematical Programming versus decision analysis;

2) Quantitative versus qualitative criteria;

3) Timing of preference determination;

4) Interactive versus noninteractive;

5) Comparison of solutions.

1) Multiobjective techniques can be considered to be of either mathematical programming type or decision analysis type depending on the type of problem formulation they are designed to handle (Szidarovszky et al., 1986). Problems that are usually solved using mathematical programming are characterized by:

1a) an infinite or very large set of alternatives;

1b) a set of technological constraints;

1c) a vector of objective functions.

Problems that are solved using decision analysis techniques, on the other hand, can be characterized by (Szidarovszky et al., 1986)

1d) a definite set of discrete alternatives with given attributes;

1e) a set of technological constraints;

1f) a set of constraints across attributes;

1g) problems related to design.

2) Quantitative versus qualitative criteria. Quantitative techniques refers to the techniques that can handle problems only with numerical attributes such as weight, rainfall, sediment yield and costs, while qualitative techniques deal with problems that consist of nonnumerical cardinal criteria. Examples include aesthetics, climate conditions and political preferences. Ordinal measurement scales are used to designate different levels of qualitative criteria in Tecle and Fogel (1986).

3) Timing the preference determination. Some decision makers prefer to reconsider their decisions in the future, according to new information and facts become available to them, other are not. Three types of timing of the requirements for the decision makers preference information vis-a-vis the determination of the set of nondominated solutions are considered. These are a priori (pri), progressive (pro), and a posterior (pos).

4) Interactive versus noninteractive. Due to the trade-offs inherent in multiobjective decision problems and the accessibility and wide use of computers, most MODM techniques have recently been developed as interactive procedures. These techniques allow the DM to play an active role by interacting with the analyst during the entire decision making process (Szidarovszky et al., 1986; Steuer, 1986; Fandel et al., 1986).

5) Comparison of solutions. This technique is based on the kind of solution desired by the DM, the desired solution as pointed out in Szidarovszky et al. (1986) can be one of the following:

5a) a solution which represents the best one with respect to an aspiration level within the feasible solution;

5b) a satisfactum resulting from pairwise (or global) comparison or ranking of the alternatives; and

5c) a comparison solution which is the closest to an ideal point usually located outside the feasible region.

Different characteristics can play a role in the selection of a multiobjective technique. Such characteristics are:

5d) characteristics describing the problem;

5e) characteristics describing the techniques; and

5f) characteristics describing the decision maker.

The Need of MODM in Watershed Management

As mentioned before, watershed management is in reality a complex matter, because resources in a watershed are interlinked in use over space and time. Evaluation of watershed management projects traditionally was single-objective (economic one), where the profitability of the project in terms of money is the base for judgment by the decision maker, whenever the political or other considerations do not prevail. The general common criteria for the project to pass and satisfy the national interest is whether all the discounted reimbursable costs can be met by project discounted revenues over the life span of the project. Economic feasibility is justified by the condition that all discounted benefits must exceed the discounted costs (O'Riordan, 1971). Watershed management projects have different objectives, such as: economic efficiency, equality, improve the quality of life of people, save lives, and employment.

Because the above objectives can not be reduced to a single objective of economic efficiency, planners and decision makers find themselves in the arena of multiobjective decision approach. By using MODM techniques several advantages can be achieved. Cohon (1978), suggested that the multiobjective planning can improve problem solving in at least three ways. First, multiobjective planning can help in decision

process by encouraging appropriate roles for the decision maker. Second, the multiobjective approach typically identifies a wide range of alternatives rather than single objective planning. Finally, multiobjective studies better portray reality.

CHAPTER 4

A MULTIOBJECTIVE WATERSHED MANAGEMENT CASE STUDY

The Zarqa River Basin Project (ZRBP)

The Zarqa River is one of the major rivers in Jordan. It originates from a plateau to the south of Amman, and falls steeply from the source to the dam (King Talal Dam), at a gradient of about 900 m. in 75 km. The Zarqa River Basin encompasses three major catchments, of which the Lower Zarqa catchment (LZC) constitutes the project area under study and covers 82,000 ha. The two remaining catchments are Amman-Zarqa catchment, which is mainly an urbanized area, and the Upper Zarqa catchment, which covers the eastern areas and stretches into Syria (Fig. 4.1). Long term annual rainfall ranges between less than 200 mm/annum in the eastern part to over 500 mm/annum in the western part of the project area.

The total population amounts to around 170,000 people, out of which 52.5 percent live in three Palestinian refugee camps. The rest of the population live in rural areas, with just one smaller town (Jerash) in the center. The average farm family has 7.1 members. Altogether, there are about 5700 families, of these around 40 percent own farms with less than 1 ha. Twenty-four percent of the project area is government owned and 76 percent is private property, the government owned land is managed by the Ministry of Agriculture. The project is divided into four agro-climatic zones (ACZ) as a basis for planning and assessment (Table 4.1).

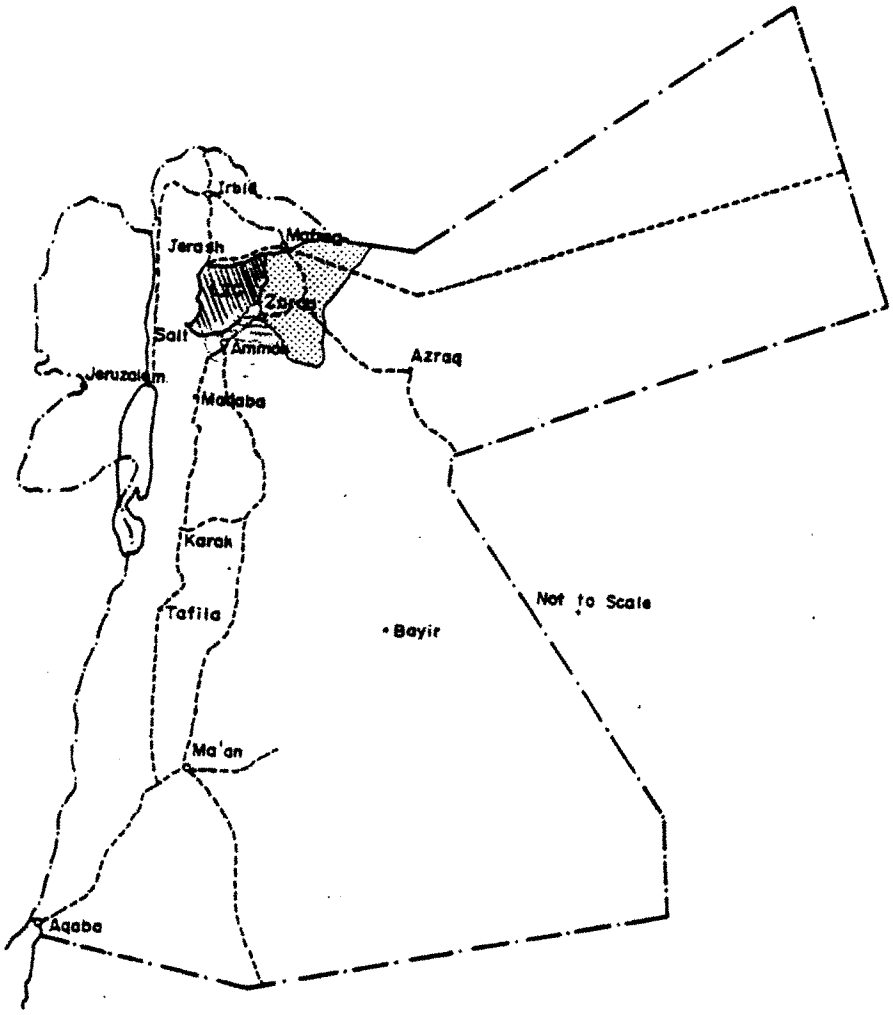


Fig. 4-1. Location of Zarqa River Basin Project.

The Project Components

The existing natural, social, economical, and political environment led to the establishment of the development concept and to the formulation of the project itself, with its three subprojects.

Sub-project 1: On-farm Development, which deals with all privately owned land with the exception of private forests.

Sub-project 2: Forest Development and Drought Reserve, which deals with all government land and privately owned forests.

Sub-project 3: Riverbank Protection, along the Zarqa River.

For planning and management purposes the LZC was divided into six Watershed Management Units (WMU) primarily on the basis of ACZ (Fig. 4.2). Each WMU can be implemented separately and the project cost-benefit analysis is attached for each WMU (Appendix B). On the basis of the extent of private land within each WMU, the number of farm families per WMU and the average farming area per farm family is established in Tables 4.2 and 4.3.

The Project Objectives

The main objectives of the project are to curb the accelerated erosion in the project and, thereby, to stabilize - if not improve - the income of the rural population, to safeguard the production potential, and to reduce the siltation into the reservoir (Project Report, 1986). These objectives are a modified version of the project objectives stated in the preliminary report (1983) and the project agreement (1981) which can be summarized under the heading of "erosion control" (Gutschich et al., 1986).

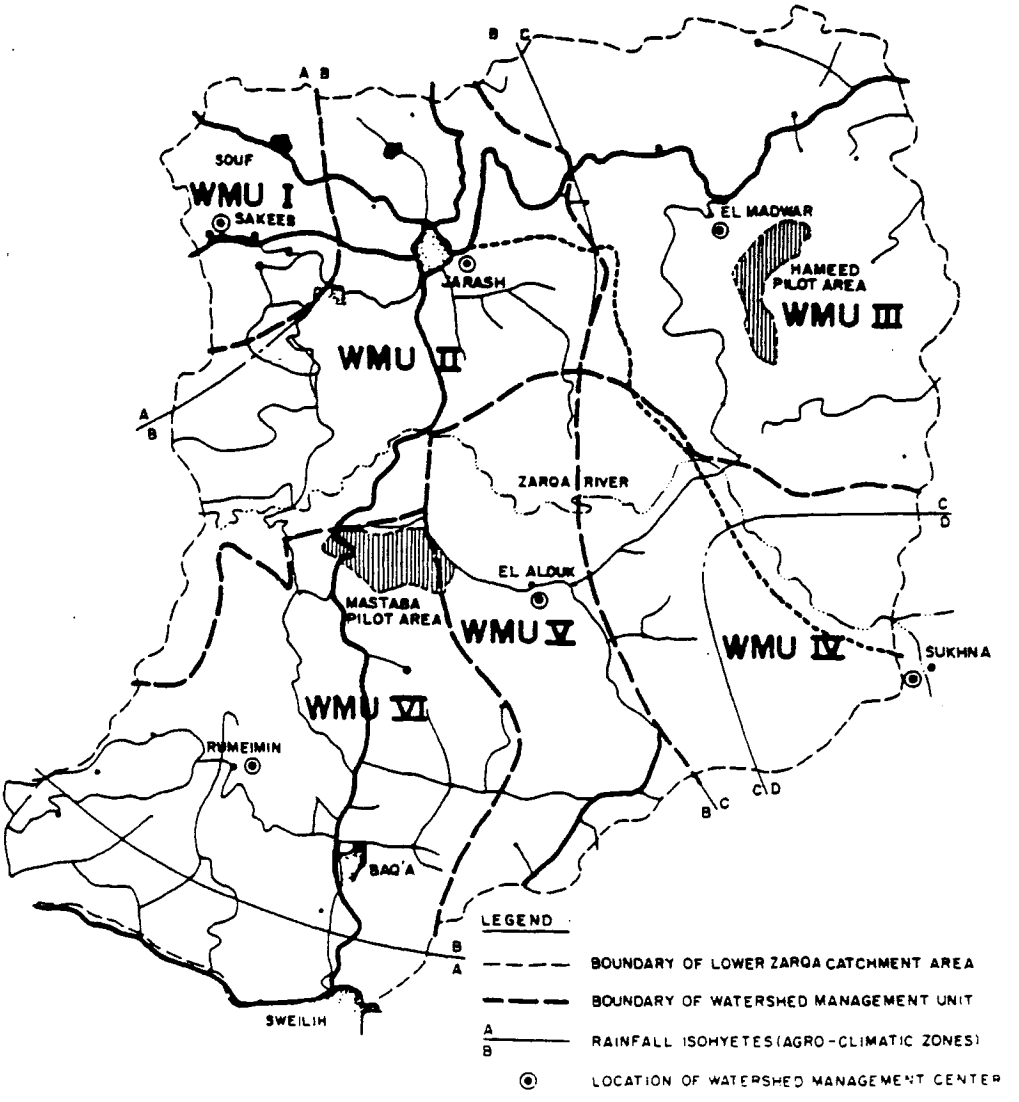


Fig. 4.2. Map of major rainfall zones and Watershed Management Units (WMU).

Table 4.1. Agroclimatic zones in ZRBP and their percentage.

ACZ	Rainfall mm/annum	Percent of LZC
A	over 500	11
B	300 - 500	51
C	200 - 300	30
D	less than 200	8

Table 4.2. Distribution of land in the different WMUs.

Watershed Management Unit (WMU)	Total Area du*	Private Land du[1]	Forest Area du[2]	Agro-climatic Zone (ACZ)
I	42,102	36,250	10,852	A
II	258,051	128,520	29,481	B
III	192,665	126,867	15,798	C
IV	121,408	103,938	12,420	C/D
V	94,395	68,481	25,914	B
VI	211,878	184,966	26,912	A/B
Total	825,499	699,072	126,427	

* du = 1000 m^2.

[1] Excluding private forest area.

[2] Including private forest area

Source: (ZRBP) Feasibility Study, 1986.

Table 4.3. Number of farm families and the holding size in each WMU.

Watershed Management Unit	Farm Families No.	Farm Area du	Average Area Per Farm Family du
I	1,420	36,250	27.2
II	955	128,570	134.6
III	693	176,867	254.1
IV	227	103,938	452.9
V	542	68,481	126.3
VI	1,738	184,966	106.4
Total	5,625	699,072	124.3

Source: (ZRBP) Feasibility Study, 1986.

In spite of the fact that the project feasibility study does not stress the importance of the improvement of the welfare of the population within a rural development approach as an objective, it is well understood that the project can not be justified on the basis of its financial feasibility only. For the purpose of this study and for practical reasons, the objectives of the project will not be changed.

The Problem

In developing the natural resources, Jordan has concentrated its developmental efforts toward the Jordan Valley, which became one of the most sophisticated agricultural schemes in the Middle East. The development in the valley was on the burden of the high lands which has been neglected, leading to the deterioration of the natural resources (mainly the soil), which has eroded in an accelerated rate, and a decrease in the land production potential. After the construction of King Talal Dam in 1979, it was realized that sediments from the catchment will reduce the capacity of the reservoir by around 1 million cubics of water/year.

"The problem in the Lower Zarqa catchment is a process of accelerated erosion, which leads to a deterioration of the agricultural potential within the project area as well as siltation into the King Talal Dam, which stores water of the Zarqa River at the western boundary of the Zarqa Basin. Presently King Talal Dam provides water for irrigation purposes in the Jordan Valley" (Project Report, 1986).

For the purpose of this study, different technical committees were established to discuss, evaluate, and derive some of the technical data

needed for multiobjective decision making and to be used in the questionnaire, which was especially designed to enhance the process of decision making by involving the largest possible segments of the people concerned such as farmers, extension workers, project management, ministries concerned, University of Jordan and private sector (Appendix C).

The Criteria

Intensive and detailed discussions took place to identify and derive the criteria from the project objectives, these discussions were mainly with local and foreign project staff as individuals and as groups. It was not possible to involve the farmers in this stage, because this is a pure technical work and needed people who understand the project and the interrelations between the project objectives and criteria.

The project criteria were characterized as follows:

1. Improve the standard of living of the people in the project area.
2. Acceptability by target groups "adoption rate."
3. Increase production of the annual crops, orchards and meats.
4. Soil erosion hazard.
5. Creation of job opportunities.

The Indicators

The above criteria have different indicators. For the first criterion, the average income increase per capita was considered as indicator. The figures used were derived from the figures in the project

feasibility study (1986). For the second criterion, the adoption rate figures in the feasibility study were found not relevant because the study assumes the same adoption rate in all WMU's and is estimated at 65 percent., therefore a committee of extension workers working in different WMU's and project management was established and suggested the figures in the questionnaire.

The increase in production was measured by kg/du of the farm land and the figures were derived from the feasibility study. The soil erosion hazard is a descriptive one and was derived from the potential soil erosion hazard map for the project by the author in cooperation with the specialists in ZRBP. The indicator for the final criterion of job opportunities is the number of man days created by each 1000 JD invested.

The Alternatives

For the purpose of this study, the six WMU's were considered as alternatives, in this case, no alternative will be excluded, but they will be implemented in different time-periods, the highest rank alternative will be the first to implement and the lowest will be the last.

The Weighing and Scoring

The five criteria were given (100) points, where the respondents asked to distribute the (100) points on the five criteria according to the importance of each criterion to them.

The respondents were asked to give a score from 0 to 10 to indicate the impact of each alternative on the criterion as shown in Table 4.4.

Application of MODM to the Case Study

Utility Worth Analysis

Utility worth analysis is the English translation of the German (Nutzwertanalyse), which is a system technique for the evaluation and selection among alternatives or projects, (within a multidimensional concept), when the outputs can not be measured by the same unit (Zangemeister, 1973). This technique was introduced by Zangemeister (1973) and Bechmann (1978), where the Zangemeister method is known in the literature as the first generation and the Bechmann method is known as the second generation utility worth analysis. The utility term is used to refer to a quantified assessment of the decision makers preference. The preference is measured on a scale from the least desirable outcome to the most desirable outcome. Utilities can be displayed readily as a graph which is called the utility function.

The decision process in utility worth analysis consist of the following steps (Strassert and Turowski, 1971):

a) formulation of the alternatives (A),

b) identification of criterion (objective)(k),

c) assigning weights for the criterion (g),

d) assigning the degree of satisfaction of each alternative to the criteria (eij),

e) calculation of partial utility for each alternative (tij), tij = eij x gi,

f) summation of the partial utilities for each alternative (Nj) which is the total utility of alternative j for all criteria i, and

Table 4.4. Trade-off matrix for the ZRBP.

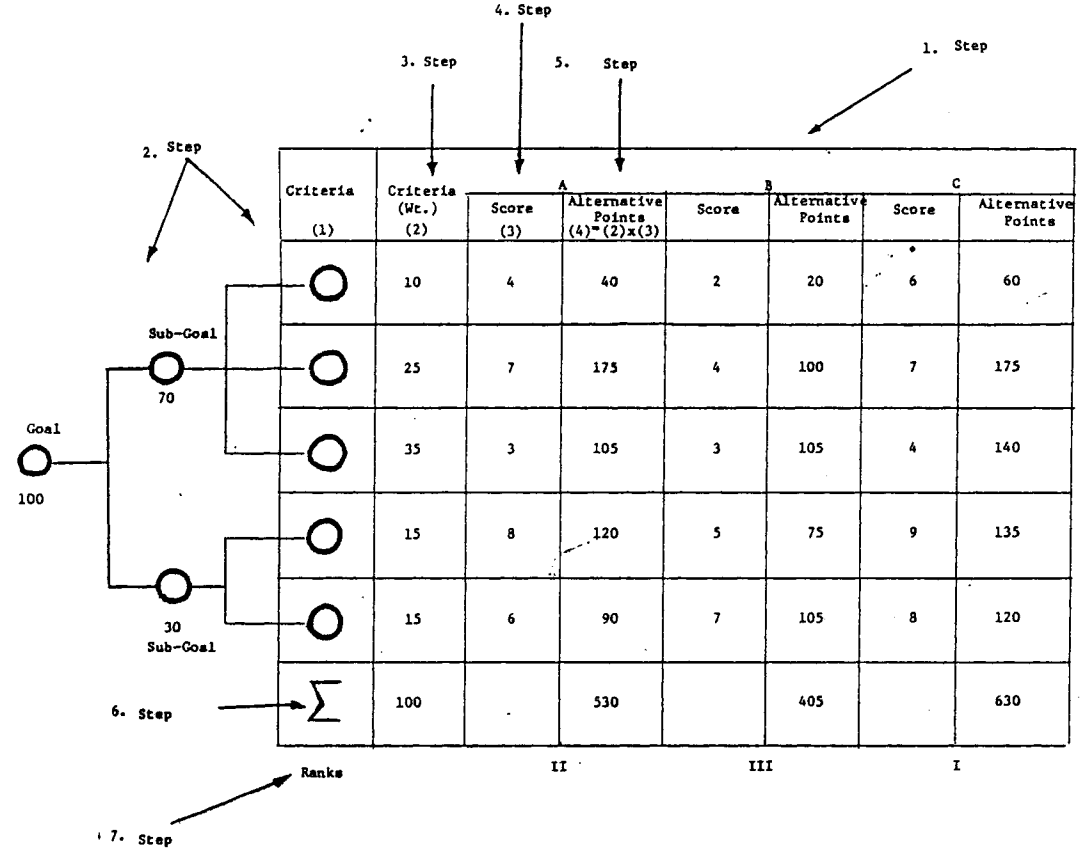
Criteria	Weight	Alternatives					
		I	II	III	IV	V	VI
Income increase		0-10	- - - - - - - - - - - - - - - - - -
Adoption rate		0-10	- - - - - - - - - - - - - - - - - -
production increase		0-10	- - - - - - - - - - - - - - - - - -
Erosion hazard		0-10	- - - - - - - - - - - - - - - - - -
Creation of jobs		0-10	- - - - - - - - - - - - - - - - - -
Total	100						

g) ranking of alternatives according to their points.

Figure 4.3 is a diagram which illustrates the procedure of utility worth analysis through the trade-off matrix, and shows its different steps.

This method assesses a series of alternatives, usually projects or programs, in terms of how well each of these projects or programs meets or achieves each set of objectives. This information is most conveniently portrayed by a table or matrix, with the alternatives represented by columns and the objectives (criteria) by row.

The different criteria will be assigned different weights by the participants this weights reflect the importance of each criterion. Normally a 100 point is distributed by the participant over the criterion. Weighing is a judgmental process which might be performed by the planners, but logically it should involve participation by an advisory group on even survey by affected parties. The variety of weighing techniques includes asking participant to make a "pointwise" comparison as a percentage of one particular criterion, or to distribute a given set of points over the full set of criterion in a manner similar to allocating a budget (Miller, 1980). The criteria have to be stated in measurable terms such as dollars gained, lives saved, access and improvement. Criteria indicators are usually different, which means that once the initial table is filled out, alternatives can be compared with each other in terms of how well they address or achieve one particular criteria. A value representing predicted performance of each alternative with respect to the criteria is entered in to the appropriate cell.



Criteria (1)	Criteria (Wt.) (2)	A Score (3)	A Alternative Points (4)=(2)x(3)	B Score	B Alternative Points	C Score	C Alternative Points
	10	4	40	2	20	6	60
	25	7	175	4	100	7	175
	35	3	105	3	105	4	140
	15	8	120	5	75	9	135
	15	6	90	7	105	8	120
Σ	100		530		405		630

Fig. 4.3. Diagram illustrates the procedure of utility worth analysis (Dubbba et al. 1984).

Once the alternative scores and the criterion weights are determined, the criterion weight will be multiplied by each alternative score, and then each alternative score is summed to provide an overall performance score. Those scores can be compared not only to determine which of the alternatives receives the best score, but how much better or more attractive that alternative is relative to the other alternatives.

Compromise Programming

Compromise Programming (CP) is a distance based technique in which the solutions are determined in reference to some point in space. This point is mostly referred to as the ideal point (Tecle et al., 1986). By using CP techniques, solutions are defined by their closeness to the ideal point by some distance measure (Zeleny, 1973, 1974, 1982; Starr and Zeleny, 1977; Duckstein and Opricovic, 1980; Szidarovszky et al., 1986; Tecle and Fogel, 1986). An ideal solution, in general, can be defined as the vector $f_i^* = [f_1, f_2, \ldots f_n]$, where the f_i^* values are the solution to the problem stated as $\text{Max}_x f_1(x)$, $i = 1, 2, \ldots, N$. In a discrete setting, however, the ideal solution is defined as the vector of best values selected from the trade-off matrix.

One of the most commonly used measured of closeness in a family of LP metrics (Duckstein and Opricovic, 1980; Zeleny, 1982; Goicoechea et al., 1982), can be expressed as

$$\min[Lp(x) = [\sum_{i=1}^{N} wpi(f_1^* - f_1(x))^P]^{1/P}]$$

$$\text{subject to } x \Sigma x$$

where the weights $w_i > 0$ indicates the relative importance of objectives to DM. For $P = \alpha$, the largest of the deviations completely dominates the distance measure (Duckstein et al., 1980; Tecle and Fogel, 1986). Consequently, the above equation can be reduced to the expression:

$$\min[L_\alpha(x) = \max w_i(\overset{*}{f}_i - f_i(x))], \text{ for } i = 1, 2, \ldots N$$

In this study, only three points of the compromise set, that is, corresponding to $p = 1$, 2, and α, are calculated.

CHAPTER 5

RESULTS AND DISCUSSION

Seventy-six individuals were interviewed for the purpose of the study, out of which sixty-one were farmers, eight technicians, five planners and three decision makers. The selection of farmers was according to the following:

1. Whether the farmers were recruited or included in the project or not.
2. All watershed management units should be represented by 1% of the total farmers in that unit. Unit number four was excluded because there was no recruitment.
3. Farmers were divided into three groups in each watershed management unit:
   a) Small farmers - who own less than half the average farm size.
   b) Middle farmers - who own more than half the average and less than double the average.
   c) Big farmers - who own more than double the average.

Table 5.1 shows the number of farmers interviewed in each watershed management unit. The questionnaire outputs were used as inputs for the utility worth analysis and compromise programming. Table 5.2 shows the average criteria weights given by each group, and Table 5.3a is a summary of the results. From Table 5.3a, we find that criteria number four which is soil erosion hazard was ranked number one 23 times out of 39 times,

Table 5.1. Distribution of farmers interviewed.

WPM Unit	Agro-climatic Zone	# of Farm Families	Sample Size: Farm Size	Included	Not Included	Total
I	A	1,470	Small	5	3	8
			Middle	3	2	5
			Big	1	1	2
			Total	9	6	15
II	B	955	Small	3	2	5
			Middle	2	1	3
			Big	1	1	2
			Total	6	4	10
III	C	693	Small	3	1	4
			Middle	1	1	2
			Big	1	1	2
			Total	5	3	8
V	B	542	Small	3	1	4
			Middle	1	1	2
			Big	1	1	2
			Total	5	3	8
VI	A & B	1,738	Small	7	4	11
			Middle	3	2	5
			Big	2	2	4
			Total	12	8	20
Total LZC		5,398	Small	21	11	32
			Middle	10	2	12
			Big	6	6	12
			Total	37	24	61

Table 5.2. Average criteria weights by the different groups of interviewee.

	C_1	C_2	C_3	C_4	C_5
DM	40	23	17	6	14
PLNR	34	26	13	18	12
Tech	25	30	15	20	10
ISI	21	15	16	35	13
ISN	23	15	17	35	10
IMI	12	12	12	52	7
IMN	18	12	12	43	10
IBI	30	15	20	30	5
IBN	20	15	15	40	10
IISI	12	12	13	43	10
IISN	20	15	15	40	10
IIMI	22	13	15	40	10
IIMN	25	15	10	35	15
IIBI	25	15	25	25	10
IIBN	15	10	25	30	20
IIISI	13	23	20	24	20
IIISN	15	20	15	20	30
IIIMI	25	20	20	15	20
IIIMN	15	25	15	25	20
IIIBI	25	15	30	25	5
IIIBN	20	25	25	20	10
VSI	12	10	17	36	20
VSN	10	5	10	15	60
VMS	15	20	25	20	20
VMN	10	20	20	35	15
VBI	15	10	30	25	20
VBN	20	10	25	30	15
VISI	12	13	23	27	30
VISN	12	16	21	23	23
VIMI	15	13	13	32	22
VIMN	13	15	12	35	20
VIBI	15	15	10	40	20
VIBN	20	15	15	35	20

DM: Decision makers
PLNR: Planners
Tech: Technicians
I-VI: Watershed management unit numbers 1-6
S,M,B: Small, Middle, Big farmer
N: Not included in this project
I: Included in the project

Table 5.3a. Summary of criteria ranks.

Criteria	Ranks				
	R_1	R_2	R_3	R_4	R_5
C_1	5	11	6	6	5
C_2	3	8	6	9	7
C_3	5	5	14	7	2
C_4	23	5	2	-	3
C_5	3	7	6	4	13

Table 5.3b. Weighted criteria ranks.

Criteria	Ranks							
	R_1	R_2	R_3	R_4	R_5		Total	Rank
C_1	25	44	18	12	5	=	104	2
C_2	15	32	18	18	7	=	90	4
C_3	15	20	42	14	2	=	91	3
C_4	115	20	6	0	3	=	144	1
C_5	15	28	18	12	13	=	86	5

which is about 60%. Criteria number one was ranked number two, 11 out of 36 times, which is about 36%. Criteria number three was ranked number 3, 14 out of 35 times, which is 40%. Criteria number two was ranked number four, 9 out of 26 times, which is about 34%. Finally, criteria number five was ranked number five 13 out of 29 times, which is about 45%.

The ranks wre given different weights as following:

Rank	Weight (points)
1	5
2	4
3	3
4	2
5	1

Table 5.3b shows the total weights for each criterion and their ranks. It is very clear that C_4, which is the soil erosion hazard, received the highest points and ranked the most important criteria. $C_{1,3}$ ranked the second important criteria, C_3 was ranked the third important, C_2 ranked as the fourth important, and C_5, which is the creation of job opportunities, ranked the lowest.

Appendix D and E include the results of the utility worth analysis and compromise programming for each group of respondents. Tables 5.4, 5.5 and 5.6 summarize the ranks assigned by the different interviewee groups to each alternative as a result of using utility worth analysis, compromise programming, and the summation of both results. Alternative number six was ranked one, 33 times out of 33 times, 32 times out of 33 times, and 65 times out of 66 times.

Alternative number one was ranked number two, 29 times out of 33 times, 25 times out of 33 times, and 54 times out of 66 times as total.

Table 5.4. Summary of ranking the alternatives, results of utility worth analysis.

Alternative \ Rank	R_1	R_2	R_3	R_4	R_5	R_6
A_1	--	29	3	1	--	--
A_2	--	4	28	--	1	--
A_3	--	--	--	--	5	28
A_4	--	--	--	1	28	4
A5	--	--	3	30	--	--
A_6	33	--	--	--	--	--

Table 5.5. Summary of ranking the alternatives, results of compromise programming.

Alternative \ Rank	R_1	R_2	R_3	R_4	R_5	R_6
A_1	1	25	6	1	--	--
A_2	--	7	26	--	--	--
A_3	--	--	--	--	5	28
A_4	--	--	--	2	26	5
A5	--	--	1	30	2	--
A_6	32	1	--	--	--	--

Table 5.6. Summation of utility worth analysis and compromise programming.

Alternative \ Rank	R_1	R_2	R_3	R_4	R_5	R_6
A_1	1	54	9	2	--	--
A_2	--	11	54	--	1	--
A_3	--	--	--	--	10	56
A_4	--	--	--	3	54	9
A5	--	--	4	60	2	--
A_6	65	1	--	--	--	--

Alternative number two was ranked number three 28 times out of 34 times, 26 times out of 33 times, and the total is 54 out of 67 times. Alternative number five was ranked number four 30 times out of 32 times, 30 times out of 33 times, and a total of 60 times out of 65 times. Alternative number four was ranked number five 28 times out of 34 times, 26 times out of 33 times, and a total of 54 out of 67 times. Alternative number three was ranked number six 28 times out of 32 times, 28 times out of 33 times, and a total of 56 times out of 65 times.

The above results show that there is high consistency between the two techniques, that is 0.969, for the selection of rank number one, 0.862 for the selection of rank number two, 0.928 for the selection of rank number three, 1.0 for the selection of rank number four, 0.928 for the selection of rank number five, and 1.0 for the selection of rank number six. The sensitivity of the results of compromise programming was examined, as shown in Appendix E the change in ranking was clearly insignificant.

When the alternatives were ranked according to their economic efficiency by using the economic internal rates of return and the benefit/cost ratio, the ranking was identical as Table 5.7 shows, but when the alternatives were ranked according to multiobjective methods the only agreement between the economic efficiency ranking and multibojective ranking was on ranking alternative number 6 as number one.

Table 5.7. Economic efficiency and multiobjective ranking of the six alternatives.

Alternative	EIRR	Rank	B/C	Rank	M.O.Rank
I	8.99	6	1.06	6	2
II	12.39	5	1.30	5	3
III	15.19	3	1.63	3	6
IV	13.22	4	1.59	4	5
V	15.50	2	1.65	2	4
VI	16.45	1	1.29	1	1

CHAPTER 6

CONCLUSIONS

The planning of watershed management projects is a complex procedure, it involves different kinds of resources impacted by numerous natural and human processes. In developing watershed resources, decision makers are seeking to achieve different objectives which can not be reduced to a single objective such as economic efficiency this covers only part of the problem. Tradeoffs between multiple objective of unequal importance and about which knowledge is uncertain is unavoidable in the process of selection or ranking of alternative developmental projects or plans.

The multiobjective approach toward project evaluation and assessment is as much an art as it is a science. The effectiveness of any multiobjective approach in practice will depend, in part, on how easy it is to understand, how well it addresses the appropriate issues or problems, and how adaptive it is to various dynamic institutional setting. The key to successful multiobjective assessments is to make such assessments practical for a particular agency within the limits of information availability, technical personnel and development schedule (Loucks et al., 1986). This is especially true in developing countries where the resources and capabilities are limited.

More than 70 multiobjective techniques are available to be used by decision analysts. Different researchers might give different and sometimes contradictory results by using the same techniques to solve a

certain problem (Cohon et al., 1975; Krysztofowics et al., 1977; Gershon et al., 1982). In selection of a MODM technique, one must be aware of their limitations, assumptions and theoretical validity before choosing a model which best suits the nature of the problem. Tecle (1988) used twenty-four selection criteria for evaluating the appropriateness of fifteen MODM techniques to solve a forest watershed resources management problem. The results showed compromise programming to be the most preferred technique.

Compromise programming and utility worth analysis were applied on the Zarqa River Basin Project (ZRBP) as a case study. Utility worth analysis aims at getting a rank order of alternatives based on total utility. This order can then be used for evaluation and decision making. This technique was applied in many diverse areas e.g., developing water quality indices (O'Connor, 1973), land management (Gardiner and Edward, 1975), airport location (Keeney and Raiffa, 1976), hospital location (Kaiserlautern City, 1978), and public traffic (Mid-upper Rhein Region, 1980).

What is interesting in this study is the criteria weights given by the different groups of farmers, technicians, planners, and decision makers 23 out of 30 farmer groups gave erosion hazard the highest rank, the decision makers gave it the last rank, and the planners and technicians gave it the third rank at the same time soil erosion hazard received the highest points when the ranks were weighted. Those results reflect the awareness among the farmers on the problems of soil erosion

and that is mainly due to the intensive extension work by the project among the farmers.

Criteria one - improves the standard of living - was given the first rank by the decision makers and planners and the second rank by the technicians, while only three farmer groups gave it the highest rank.

High consistency was obtained among the results of ranking the six alternatives, when utility worth analysis and compromise programming were used. UWA results were obtained manually and without using any computers, where in CP, a computer was used. Therefore, it depends on the situation and the analyst decision to choose which method to use. UWA is a good learning procedure for decision makers, where they can see more clearly the different stages of the procedure and achieve a better understanding and appreciation of the results, while in CP the results and ranks are presented in a table and need considerable work from the analyst to illustrate, if the decision makers wants to go and search behind the figures. At the same time, if the capabilities and resources are available in the organization and the decision maker has knowledge about the concept behind CP, it is then practical to use it and it saves time and money.

Finally, this study was an attempt to inprove the decision making process in watershed management by applying two multiobjective techniques on the case study, but it should be stressed again, that the results of the multiobjective techniques are used to aid and improve the choice of decision maker(s). Table 5.7 shows that there is a big difference in ranking the alternatives when economic efficiency and multiobjective

techniques were applied on the same project. When such a table is presented to decision maker, then it is up to him to decide on which ranking to take. The possibilities for him are, either he takes the economic efficiency approach, or the multiobjective approach, or compromise between both. However, a multiobjective technique is able to deal with qualitative information and also mix qualitative-quantitative objectives, also, it enhances the planning process by involving broader segments of the target groups, planners and decision makers in the process and includes their assessments and feedback in the evaluation.

APPENDIX A:

LIST OF MULTIOBJECTIVE METHODS

LIST OF MULTIOBJECTIVE METHODS

1. Adaptive Search Method (Beeson and Meisel, 1971; Haimes et al., 1974).
2. Analytical Hierarchy Process (AHP) (Saaty, 1977, 1980, 1982, 1986, 1987; Saaty and Vargas, 1982, 1987).
3. Combined Goal Programming and Step Methods (GPSTEM) (Fichefet, 1976).
4. Composite Programming (CTP) (Bogardi and Bardossy, 1983; Bardossy et al., 1984).
5. Compromise Programming (CP) (Yu, 1973b; Zeleny, 1973, 1973b, 1977, 1982).
6. Concordance Method (Nijkamp and Vos, 1977; Massam, 1984).
7. Conjunctive Ranking (Goicoechea et al., 1982).
8. Cooperative Game Theory (CGT) (Nash, 1953; Williams, 1954; Luce and Raiffa, 1957; Harsanyi, 1959, 1977; Rapoport, 1970; Rapoport et al., 1975; Young, 1975; Aoki, 1984; Szidarovszky et al., 1978, 1984, 1986; Thomas, 1984; Tecle and Fogel, 1986; Tecle et al., 1978).
9. Copeland's Reasonable Social Welfare Function (Goicoechea at al., 1982).
10. Delphi Goal Programming (DGP) (Dalkey, 1969; Linestone and Turoff, 1975; Khorramshahgol and Gousty, 1986).
11. Displaced Ideal method (DIM) (Zeleny, 1974b, 1976c, 1977; Nijkamp, 1979; Nijkamp and Spronk, 1981).

12. Dynamic Compromise Programming (DCP) (Szidarovszky, 1979; Opricovic, 1979; Gershon, 1981a,b).
13. Dynamic Compromise Programming (DCP) (Taux et al., 1979; Opricovic, 1979b; Seo and Sakawa, 1979; Szidarovszky et al., 1981; Duckstein and Szidarovszky, 1982g; Szidarovszky and Duckstein, 1986; Kornbluth, 1986).
14. Constraint Method (Marglin, 1967; Haimes et al., 1971; Olangundoye, 1971; Olangundoye and Haimes, 1973; Goicoechea et al., 1982).
15. ELECTRE I, II, III and IV (Benayoun et al., 1966; Bertier and De Montgolfier, 19783; Roy, 1968, 1971, 1973, 1974, 1975, 1976; Roy and Bertier, 1971; Karimi, 1981; Grama and Hansen, 1983; Heidel and Duckstein, 1983; Skalka et al., 1983; Siskos et al., 1986).
16. Ellipsoid Algorithm (EA) for Linear Programming (Shor, 1977; Murray and Yakowitz, 1979; Goldfarb and Todd, 1980; Gacs and Lovasz, 1979; Wolfe, 1980; Zeleny, 1980, 1982; Slowinski and Warczynski, 1984).
17. Evaluation and Sensitivity Analysis Program (ESAP) (West and Husain, 1981; Mumpower and Bollacker, 1981).
18. Exclusionary Screening (Hobbs, 1979; Goicoechea et al., 1982).
19. Geoffrion's Bicriterion Method (GBM) (Geoffrion, 1966, 1967a,b; Chankong and Haimes, 1983b).
20. Global Multiattribute Utility Theory (GMAUT) (Fishburn, 1970; Keelin, 1976; Keeney and Raiffa, 1976; Farquhar, 1977, 1984).
21. Goal Attainment Method (Gembicki, 1973; Gembicki and Haimes, 1975).
22. Goal Programming (GP) (Charnes and Cooper, 1957, 1961, 1975; Ijiri, 1965; Lee, 1972, 1975; Hasenauer, 1976; Ignizio, 1976b).

23. Holistic Preference Evaluation Method (HOPE) (Ho, 1979, 1981, 1985).

24. Hypergame (Takahaski et al., 1984; Fraser and Hipel, 1984).

25. Interactive Goal Programming (IGP) (Dyer, 1972; Franz, 1980).

26. Interaction Multiobjective Stochastic Linear Programming (STRANGE) (Teghem et al., 1986).

27. Interactive Weighted-Sams/Filtering Approach (Steuer, 1976c,d, 1977, 1980; Steuer and Choo, 1983; Steuer, 1986).

28. Interactive Weighted Tchevycheff (TCHA) (Steuer and Choo, 1983; Steuer, 1986; Kaliszewski, 1978).

29. Interval Criterion Weights/Vector Maximum Approach (Steuer, 1976a, 1977, 1980, 1985).

30. Lagrangian Technique (Neuman and Krzysztofowicz, 1977; Shapiro, 1970; Seo and Sakawa, 1979).

31. Lexicographic Method (Georgescu-Roegen, 1954; Fishburn, 1970, 1974).

32. Linear Integer Goal Programming (LIGP) (Lee and Morris, 1977; Lee, 1978; Schniederjans, 1984).

33. Linear Programming Techniques for Multidimensional Analysis Preferences (LINMAP) (Srinivasan and Shocker, 1973).

34. Local Multiattribute Utility Theory (LMAUT) (Geoffrion, Dyer and Feinberg, 1972; Keeney and Raiffa, 1976; Oppenheimer, 1978; MacCrimmon, 1973; Nijkamp and Val Delft, 1977).

35. Maximum Programming (Dyson, 1980; Behringer, 1986).

36. Metagame (Hipel, Ragede and Unny, 1976; Fraser and Hipel, 1980, 1984; Howard, 1987).

37. Method of Geoffrion, Dyer and Feinberg (MGDF) (Geoffrion et al., 1972).

38. Method of Nelder and Mead (Nelder and Mead, 1965; Hemming, 1976).

39. Method of Satisfactory Goals (Benayoun et al., 1966; Monarchi, 1974; Benson, 1975).

40. MO Linear Fractional Programming (MOLEP) (Kornbluth and Steuer, 1979, 1980; Kornbluth, 1981; Steuer, 1986).

41. MO Simplex Method of Philip (Philip, 1972, 1976; Goicoechea et al., 1982).

42. MO Simplex Method of Zeleny (Zeleny, 1974a, 1976d, 1982; Goicoechea et al., 1982).

43. Multicriterion Q-Analysis (MCQA) I and II (Atkin, 1974a,b, 1978, 1981; Duckstein and Kempf, 1979; Casti, 1979; Casti et al., 1979; Pfaff and Duckstein, 1981; Johnson, 1981; Duckstein, 1983; Hiessl et al., 1985; Featherkile and Duckstein, 1986; Tecle et al., 1987a,b).

44. Multiobjective Statistical Method (MOSM) (Haimes, 1980; Haimes et al., 1980; Chankong and Haimes, 1983b).

45. Multiutility Analysis G_1 and G_2 (Zangemeister, 1970; Bechmann, 1978).

46. Noninferior Set Estimation (NISE) method (Cohn, 1978).

47. Noncooperative Game Theory (NCGT) (Nash, 1952; Venttsel, 1959; Singleton and Tyndall, 1974; Rapoport et al., 1976; Vorob'ev, 1977; Owens, 1982; Zagare, 1984).

48. Nonlinear Goal Programming (NLGP) (Ignizio, 1976b; Dauer and Krueger, 1977; Hwang and Masud, 1979).

49. Nonlinear Integer Goal Programming (NLIGP) (Taylor, III et al., 1985).

50. PRAETO RACE (Korhonen and Wallenius, 1987; Duckstein et al., 1988).

51. PASEB (Edwards, 1979; Thanassoulis, 1983, 1985).

52. Probabilistic Tradeoff Development Method (PROTRADE) (Goicoechea, 1977; Goivoechea et al., 1979, 1982).

53. PROMETHEE Methods I, II and III (Brans and Vincke, 1985; Mareschal, 1986; Brans et al., 1985, 1986).

54. Reference Objective (Wierzbicki, 1975, 1979, 1980; Lewandowski and Grauer, 1982).

55. Sequential Information Generator for MO Problems (SIGMOP) (Monarchi, Weber and Duckstein, 1976).

56. Sequential SEMOPS Method (Monarchi, 1972; Monarchi et al., 1973).

57. STEP Method (STEM) (Benayoun et al., 1971, 1972).

58. Stochastic Multiobjective Programming (SMOP) (Goicoechea, 1977, Teghem and Kunsch, 1984; Teghem et al., 1986).

59. Surrogate Worth Tradeoff (SWT) (Haimes and Hall, 1974; Haimes et al., 1975; Sakawa, 1978; Haimes, 1979; Chankong and Haimes, 1982, 1983b).

60. The Method of Gabbani and Magazine (MGM) (Gabbani and Magazine, 1980, 1986).

61. The Method of Marcotte and Soland (MMS) (Marcotte and Soland, 1980, 1981, 1986).

62. The Method of Morris and Oren (MM)) (Morris and Oren, 1980)

63. The Method of Stewart (Stewart, 1981b, 1984, 1986).

64. The Method of White (White, 1980; French et al., 1983).

65. The Method of Yu (Yu, 1973a, 1974, 1985; Yu and Zeleny, 1975).

66. Tradeoff Development Method (TRADE) (Goicoechea, Duckstein and Bulfin, 1976; Goicoechea, Duckstein and Fogel, 1976).

67. Vector Optimization Decision Convergence Algorithm (VODCA) (Morgan and Thurgood, 1984).

68. Visual Interactive Method (Korhonen and Laakso, 1985; Korhonen, 1986, 1987a, 1987b; Korhonen and Wallenius, 1986, 1987; Duckstein et al., 1987).

69. Weighted average Method (Einhorn and McCoach, 1977; Otway and Edwards, 1977).

70. Weighting Method (Zadeh, 1963; Geoffrion, 1968; Goicoechea et al., 1982).

71. Zoints' Discrete Alternative Method (ZDA) (Zoints, 1979a, 1981).

72. Zoints' Interactive Algorithm (ZIA) (Zoints, 1976).

73. Zoints-Wallenius Method (Z-W) (Wallenius, 1975a,b; Zoints, 1976, Wallenius and Zoints, 1976).

APPENDIX B:

ZRBP COST BENEFIT ANALYSIS

Table B.1. Sub-project 1: Financial costs per WMU and Category.

WMU	Government costs	Consultancy services	Contracted works	Supply contracts	Agricultural development	Private forests	Total
	in '000 JD						
I	312.5	199.4	402.6	128.2	188.7	9.9	1,241.5
II	283.9	567.3	990.5	162.3	702.9	8.1	2,715.2
III	288.2	753.4	579.4	163.8	522.3	-	2,307.157
IV	212.6	463.2	332.6	124.5	429.1	2.2	1,554.157
V	221.7	324.4	664.8	128.1	885.1	41.7	2,235.867
VI	358.401	801.3	1,144.7	169.2	1,797.3	11.9	4,282.854
Total	1,677.3	3,109.2	4,104.7	876.2	4,495.5	73.9	14,334.8
+ 15 % physical contingencies	251.6	466.4	615.7	131.4	674.3	11.1	2,150.5
+ costs in 1986 constant prices	1,928.9	3,575.5	4,720.4	1,007.7	5,169.8	85.0	16,487.3
+ 6 % financial contingencies	505.4	824.2	1,291.6	138.5	1,923.9	25.8	4,759.2
+ costs in current prices	2,434.2	4,449.7	6,012.0	1,146.1	7,093.7	110.8	21,246.5

Table B.2. Sub-project 1: Internal rates of return.

Watershed Management Unit	EIRR %
I	8.99
II	12.39
III	15.19
IV	13.22
V	15.50
VI	16.45
Sub-Project 1	14.46

Table B.3. Benefit/cost ratio and net present value for sub-project 1.

Watershed Management Unit	Benefit/Cost ratio
I	1.06
II	1.30
III	1.63
IV	1.59
V	1.65
VI	1.79
Sub-Project 1	1.54

APPENDIX C:

THE QUESTIONNAIRE

Farmers name Age

Village WMU#

Area of the holding planted

not planted

Total

# of animals Sheep

goats

cows

% of farm contribution in the total income ---------%
formal or informal position

Main occupation

How much of your time is given for farming ---------%

I would like to thank you in advance for your contribution in this study which I'm preparing in partial fulfillment of the requirements for the Ph.D. degree in Watershed Management at the University of Arizona in the U.S.A.

It is well known that rural development and watershed management projects are in reality very complex. Because the resources are inter-linked in use over space and time, these resources are evaluated differently by different people according to their attitudes and backgrounds.

Traditionally, the economic profitability is the major decision making objective when ever the political or other considerations do not prevail. In the last 25 years, various multi-objective decision making techniques have been developed and used in the U.S.A., West Germany and some other countries. The main purpose of these new techniques is to consider all the objectives and benefits of the projects once they are evaluated, whether these benefits are tangible or intangible, direct or indirect.

In this study, a decision making methodology will be developed to help and aid decision makers and planners in evaluating and identifying efficient alternative management plans and to aid them in selecting the best compromise for different developmental alternatives. In doing so, the Zarqa River Basin Project (ZRBP) in Jordan will be taken as a case study.

Different criteria have been developed to evaluate this Project, assume you have (100) points, how much would you give to each of the following criteria according to their importance to you. Please notice that the total of the points should be (100).

CRITERIA	Points
- Improve the standard of living of the people in the project area, especially rural poor and the small farmers.	
- Acceptability by target groups "adoption rate."	
- Increase production of annual crops, orchards and meat.	
- Erosion hazard.	
- Creation of job opportunities.	
Total	100

The Alternatives

The (ZRBP) is divided into six watershed management units (WMU) as shown in the map attached, each WMU f developed according to the project plans will have different impact on the criteria mentioned before, following is a summary of the expected impact of each alternative on the different criteria.

Income increase of people in (000 JD)

Alternative	I	II	III	IV	V	VI
	1,226	472	139	75	196	1,241

Acceptability by target groups "adoption rate."

Alternative	I	II	III	IV	V	VI
	64%	63%	38%	42%	40%	70%

Production increase in (kg/du.)

Alternative	I	II	III	IV	V	VI
Crops	5.7	10.9	6.3	1.5	4.2	2.1
Orchards	85.3	41.4	8.2	18.8	113.8	73.6
Meat	1.1	2.3	1.2	0.8	2.8	1.8

Erosion hazard

Alternative	I	II	III	IV	V	VI
	V.H-H	M-L	L-M	H-M	M-L	V.H-M

Creation of job opportunities (000 Man day)

Alternative	I	II	III	IV	V	VI
	125	310	181	104	208	358

According to the above data, please give a value (0-10) to indicate the impact of each alternative on the criterion, for example if you think that alternative #VI if implemented, the increase in the income of the population is high, then you may want to give a high value of (9). In the same way if you think that alternative #VI will have little impact on the creation of Jobs then you may want to give it low value as (2) or (3).

Criteria	Alternatives					
	I	II	III	IV	V	VI
Income increase of People						
Adoption rate "acceptability"						
Production increase						
Erosion hazard						
Creation of Jobs						

APPENDIX D:

RESULTS OF UTILITY WORTH ANALYSIS

Table D.1a. Tradeoff matrix of DM.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
40	6.00	5.00	3.00	2.00	4.00	7.00
23	7.00	7.00	2.00	5.00	5.00	9.00
17	7.00	8.00	4.00	4.00	9.00	7.00
6	8.00	4.00	2.00	5.00	4.00	7.00
14	4.00	9.00	5.00	2.00	8.00	9.00

Table D.1b. Accumulated score and ranking matrix of DMM.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	240	200	120	80	160	280
	161	161	46	115	115	202
	119	136	68	68	153	119
	48	24	12	30	24	42
	56	126	20	28	112	126
Total Alternative Points	624	647	316	321	564	274
Rank	3	2	6	5	4	1

Table D.2a. Tradeoff matrix for PLANRS.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
34	8.00	5.00	3.00	3.00	4.00	8.00
26	8.00	8.00	2.00	6.00	6.00	10.00
13	7.00	7.00	5.00	5.00	8.00	7.00
10	10.00	7.00	2.00	8.00	7.00	9.00
17	4.00	8.00	5.00	2.00	6.00	9.00

Table D.2b. Accumulated score and ranking matrix of PLANRS.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	272	170	102	102	0136	272
	208	208	52	156	156	260
	91	91	65	65	104	91
	100	70	20	80	70	90
	68	136	85	34	102	153
Total Alternative Points	739	675	324	437	568	866
Rank	2	3	6	5	4	1

Table D.3a. Tradeoff matrix for TECH.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
25	8.00	4.00	3.00	1.00	3.00	9.00
30	9.00	9.00	5.00	8.00	8.00	10.00
15	7.00	9.00	5.00	5.00	9.00	8.00
20	9.00	6.00	3.00	7.00	6.00	9.00
10	3.00	8.00	4.00	3.00	6.00	8.00

Table D.3b. Accumulated score and ranking matrix of TECH.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	200	100	75	25	75	225
	270	270	150	240	240	300
	105	135	75	75	135	120
	180	120	60	140	120	180
	30	80	40	30	60	80
Total Alternative Points	785	705	400	510	630	905
Rank	2	3	6	5	4	1

Table D.4a. Tradeoff matrix for ISI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
21	9.00	5.00	2.00	1.00	3.00	9.00
15	8.00	8.00	4.00	6.00	6.00	10.00
16	6.00	7.00	4.00	2.00	8.00	7.00
35	10.00	5.00	3.00	8.00	5.00	9.00
13	5.00	9.00	5.00	4.00	7.00	10.00

Table D.4b. Accumulated score and ranking matrix of ISI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	189	105	42	21	63	189
	120	120	60	90	90	150
	96	112	64	32	128	112
	350	175	105	280	175	315
	65	117	65	52	91	130
Total Alternative Points	820	629	336	475	547	896
Rank	2	3	6	5	4	1

Table D.5a. Tradeoff matrix for ISN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
23	9.00	7.00	3.00	2.00	4.00	10.00
15	9.00	9.00	6.00	8.00	7.00	10.00
17	5.00	8.00	4.00	4.00	10.00	7.00
35	8.00	6.00	3.00	8.00	6.00	8.00
10	5.00	8.00	5.00	4.00	6.00	9.00

Table D.5b. Accumulated score and ranking matrix of ISN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	207	161	69	46	42	230
	135	135	90	120	105	150
	85	136	68	68	170	119
	280	210	105	280	210	280
	50	80	50	40	60	40
Total Alternative Points	757	722	382	554	637	869
Rank	2	3	6	5	4	1

Table D.6a. Tradeoff matrix for IMI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
17	8.00	5.00	3.00	.00	4.00	9.00
12	9.00	9.00	3.00	7.00	7.00	10.00
12	7.00	9.00	4.00	3.00	10.00	9.00
52	9.00	6.00	5.00	8.00	6.00	8.00
7	4.00	6.00	4.00	3.00	5.00	8.00

Table D.6b. Accumulated score and ranking matrix of IMI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	136	85	51	00	68	153
	108	108	36	84	84	120
	84	108	84	36	120	108
	468	312	260	416	312	416
	28	42	28	21	35	56
Total Alternative Points	824	655	459	557	619	853
Rank	2	3	6	5	4	1

Table D.7a. Tradeoff matrix for IMN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
18	7.00	5.00	2.00	.00	3.00	8.00
12	8.00	8.00	3.00	5.00	5.00	10.00
12	5.00	8.00	3.00	1.00	9.00	7.00
48	8.00	4.00	2.00	6.00	4.00	7.00
10	5.00	8.00	6.00	5.00	6.00	9.00

Table D.7b. Accumulated score and ranking matrix of IIIBN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	126	90	36	00	54	144
	96	96	36	60	60	120
	60	96	36	12	108	84
	384	192	96	288	192	336
	50	80	60	50	60	90
Total Alternative Points	716	554	264	410	474	774
Rank	2	3	6	5	4	1

Table D.8a. Tradeoff matrix for IBI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
30	10.00	5.00	2.00	1.00	3.00	10.00
15	8.00	7.00	2.00	5.00	5.00	9.00
20	7.00	8.00	4.00	2.00	9.00	7.00
30	8.00	5.00	2.00	7.00	5.00	8.00
5	4.00	7.00	4.00	3.00	6.00	7.00

Table D.8b. Accumulated score and ranking matrix of IBI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	300	150	60	30	90	300
	120	105	30	75	75	135
	140	160	80	40	180	140
	240	150	60	210	150	240
	20	35	20	15	30	35
Total Alternative Points	820	600	250	370	525	850
Rank	2	3	6	5	4	1

Table D.9a. Tradeoff matrix for IBN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
20	8.00	6.00	2.00	1.00	4.00	8.00
15	6.00	6.00	4.00	4.00	4.00	7.00
15	3.00	8.00	7.00	2.00	7.00	9.00
40	7.00	4.00	1.00	5.00	4.00	7.00
10	4.00	7.00	5.00	3.00	5.00	7.00

Table D.9b. Accumulated score and ranking matrix of IBN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	160	120	40	20	80	160
	90	90	60	60	60	105
	45	120	150	30	105	135
	280	160	40	200	160	280
	40	70	50	30	50	70
Total Alternative Points	615	560	295	340	455	750
Rank	2	3	6	5	4	1

Table D.10a. Tradeoff matrix for IISI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
17	9.00	8.00	2.00	.00	4.00	9.00
17	8.00	8.00	6.00	7.00	6.00	10.00
13	6.00	7.00	4.00	2.00	8.00	7.00
43	7.00	5.00	3.00	6.00	5.00	7.00
10	4.00	6.00	3.00	2.00	4.00	8.00

Table D.10b. Accumulated score and ranking matrix of IISI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	153	136	34	00	68	153
	136	136	102	119	102	120
	78	91	52	26	104	91
	301	215	129	258	215	301
	40	60	30	20	40	80
Total Alternative Points	708	638	347	423	529	795
Rank	2	3	6	5	4	1

Table D.11a. Tradeoff matrix for IISN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
20	9.00	7.00	4.00	2.00	5.00	9.00
15	8.00	8.00	6.00	8.00	6.00	10.00
15	6.00	9.00	5.00	2.00	9.00	7.00
40	8.00	5.00	4.00	8.00	5.00	8.00
10	5.00	8.00	5.00	3.00	7.00	9.00

Table D.11b. Accumulated score and ranking matrix of IISN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	180	140	80	40	100	180
	120	120	90	120	90	150
	90	135	75	30	135	105
	320	200	160	320	200	320
	50	80	50	30	70	90
Total Alternative Points	760	675	455	540	595	845
Rank	2	3	6	5	4	1

Table D.12a. Tradeoff matrix for IIMI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
22	8.00	6.00	4.00	1.00	4.00	8.00
13	8.00	7.00	3.00	3.00	3.00	9.00
15	7.00	7.00	4.00	6.00	8.00	10.00
40	9.00	7.00	4.00	8.00	7.00	8.00
10	8.00	4.00	3.00	5.00	7.00	9.00

Table D.12b. Accumulated score and ranking matrix of IIMI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	176	132	88	22	88	176
	104	91	39	39	39	117
	105	105	60	90	120	150
	360	280	160	320	280	320
	80	40	30	50	70	90
Total Alternative Points	825	648	377	521	597	853
Rank	2	3	6	5	4	1

Table D.13a. Tradeoff matrix for IIMN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
25	8.00	5.00	4.00	2.00	4.00	8.00
15	7.00	7.00	3.00	6.00	6.00	10.00
10	5.00	8.00	5.00	4.00	8.00	6.00
35	9.00	6.00	5.00	7.00	6.00	8.00
15	5.00	8.00	7.00	4.00	8.00	10.00

Table D.13b. Accumulated score and ranking matrix of IIMN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	200	125	100	50	100	200
	105	105	45	90	90	150
	50	80	50	40	80	60
	315	210	175	245	210	280
	75	120	105	60	120	150
Total Alternative Points	745	640	475	485	600	840
Rank	2	3	6	5	4	1

Table D.14a. Tradeoff matric for IIBI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
25	9.00	5.00	2.00	2.00	4.00	9.00
15	7.00	7.00	4.00	5.00	5.00	8.00
25	6.00	7.00	5.00	4.00	8.00	6.00
25	9.00	5.00	3.00	6.00	5.00	7.00
10	3.00	8.00	4.00	2.00	6.00	8.00

Table D.14b. Accumulated score and ranking matrix of IIBI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	225	125	50	50	100	225
	105	105	60	75	35	120
	150	175	125	100	200	150
	275	125.	75	150	125	175
	30	80	40	20	60	80
Total Alternative Points	735	610	350	395	560	750
Rank	2	3	6	5	4	1

Table D.15a. Tradeoff matrix for IIBN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	7.00	6.00	4.00	2.00	5.00	7.00
10	7.00	7.00	4.00	5.00	5.00	8.00
25	4.00	8.00	7.00	2.00	6.00	7.00
30	8.00	4.00	2.00	5.00	4.00	7.00
20	5.00	8.00	6.00	3.00	7.00	8.00

Table D.15b. Accumulated score and ranking matrix of IIBM.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	105	90	60	30	75	105
	70	70	40	50	50	100
	100	200	175	50	150	175
	240	120	60	150	120	210
	100	160	120	60	140	160
Total Alternative Points	615	640	455	340	535	730
Rank	3	2	5	6	4	1

Table D.16a. Tradeoff matrix for IIISI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
13	8.00	6.00	2.00	1.00	4.00	9.00
23	8.00	7.00	4.00	6.00	5.00	8.00
20	5.00	7.00	5.00	3.00	8.00	6.00
24	7.00	5.00	2.00	6.00	5.00	6.00
20	2.00	8.00	3.00	1.00	4.00	9.00

Table D.16b. Accumulated score and ranking matrix of IIISI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	104	78	26	13	52	117
	184	161	92	138	115	184
	100	140	100	60	160	120
	168	120	48	144	120	144
	40	160	60	20	80	180
Total Alternative Points	596	659	326	275	527	745
Rank	3	2	6	5	4	1

Table D.17a. Tradeoff matrix for IIISN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	9.00	6.00	2.00	1.00	4.00	10.00
20	8.00	8.00	5.00	7.00	6.00	9.00
15	5.00	7.00	3.00	2.00	7.00	5.00
20	9.00	5.00	2.00	6.00	5.00	8.00
30	4.00	6.00	5.00	2.00	5.00	7.00

Table D.17b. Accumulated score and ranking matrix of IIISN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	135	90	30	15	60	150
	160	160	100	140	120	180
	75	105	45	30	105	75
	180	100	40	120	100	160
	120	180	150	60	150	210
Total Alternative Points	670	635	365	365	535	775
Rank	2	3	5	5	4	1

Table D.18a. Tradeoff matrix for IIIMI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
25	7.00	4.00	3.00	1.00	3.00	9.00
20	7.00	7.00	2.00	5.00	5.00	9.00
20	5.00	7.00	4.00	4.00	8.00	7.00
15	8.00	5.00	1.00	6.00	5.00	8.00
20	5.00	7.00	5.00	3.00	6.00	9.00

Table D.18b. Accumulated score and ranking matrix of IIIMI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	175	100	75	25	75	225
	140	140	40	100	100	180
	100	140	80	80	160	140
	120	75	15	90	75	120
	100	140	100	60	120	180
Total Alternative Points	635	595	310	355	530	845
Rank	2	3	6	5	4	1

Table D.19a. Tradeoff matrix for IIIMN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	8.00	6.00	2.00	1.00	4.00	9.00
25	6.00	6.00	3.00	4.00	4.00	7.00
15	6.00	9.00	4.00	3.00	9.00	5.00
25	10.00	5.00	4.00	7.00	5.00	9.00
20	4.00	8.00	6.00	3.00	7.00	9.00

Table D.19b. Accumulated score and ranking matrix of IIIMN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	120	90	30	15	60	135
	150	150	75	100	100	175
	90	135	60	45	135	75
	250	125	100	175	125	225
	80	160	120	60	140	180
Total Alternative Points	690	660	385	395	560	180
Rank	2	3	6	5	4	1

Table D.20a. Tradeoff for IIIBI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
25	8.00	6.00	3.00	1.00	5.00	8.00
15	7.00	7.00	3.00	5.00	5.00	9.00
30	6.00	8.00	4.00	1.00	10.00	7.00
25	8.00	5.00	3.00	7.00	5.00	7.00
5	5.00	8.00	6.00	4.00	7.00	8.00

Table D.20b. Accumulated score and ranking matrix of IIIBI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	200	150	75	75	125	200
	105	105	45	75	75	135
	180	240	120	30	300	210
	200	125	75	175	125	175
	25	40	30	20	35	40
Total Alternative Points	710	660	345	275	660	760
Rank	2	3	5	6	3	1

Table D.21a. Tradeoff matrix for IIIBN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
20	9.00	7.00	3.00	1.00	5.00	9.00
25	7.00	7.00	3.00	5.00	5.00	9.00
25	7.00	8.00	5.00	4.00	10.00	7.00
20	8.00	4.00	2.00	6.00	4.00	7.00
10	4.00	8.00	5.00	3.00	6.00	8.00

Table D.21b. Accumulated score and ranking matrix of IIIBN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	180	140	60	20	100	180
	175	175	75	125	125	225
	175	200	125	100	250	175
	160	80	40	120	80	140
	40	80	50	30	60	80
Total Alternative Points	730	675	350	395	615	800
Rank	2	3	6	5	4	1

Table D.22a. Tradeoff matrix for VSI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
17	6.00	4.00	3.00	2.00	3.00	8.00
10	6.00	5.00	3.00	4.00	4.00	7.00
17	7.00	9.00	4.00	3.00	10.00	8.00
36	8.00	4.00	3.00	5.00	4.00	6.00
20	3.00	5.00	4.00	3.00	5.00	6.00

Table D.22b. Accumulated score and ranking matrix of VSI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	102	68	51	34	51	136
	60	50	30	40	40	70
	119	153	68	51	170	135
	288	144	108	180	144	216
	60	100	80	60	100	120
Total Alternative Points	629	515	337	365	505	678
Rank	2	3	6	5	4	1

Table D.23a. Tradeoff matrix for VSN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
10	7.00	6.00	2.00	2.00	4.00	9.00
5	6.00	6.00	3.00	5.00	5.00	7.00
10	7.00	9.00	4.00	3.00	9.00	5.00
15	8.00	4.00	3.00	5.00	4.00	6.00
60	4.00	8.00	6.00	2.00	7.00	9.00

Table D.23b. Accumulated score and ranking matrix of VSN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	70	60	20	20	40	90
	30	30	15	25	25	35
	70	90	40	30	90	50
	120	60	45	75	60	90
	240	480	360	120	420	540
Total Alternative Points	530	720	480	270	635	805
Rank	4	2	5	6	3	1

Table D.24a. Tradeoff matrix for VMI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	9.00	7.00	3.00	2.00	4.00	10.00
20	7.00	6.00	3.00	5.00	5.00	8.00
25	8.00	8.00	4.00	3.00	9.00	7.00
20	9.00	5.00	3.00	7.00	5.00	8.00
20	5.00	8.00	5.00	3.00	6.00	8.00

Table D.24b. Accumulated score and ranking matrix of VMI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	135	105	45	30	60	150
	140	120	60	100	100	160
	200	200	100	75	225	175
	180	100	60	140	100	160
	100	160	100	60	120	160
Total Alternative Points	755	685	365	405	605	805
Rank	2	3	6	5	4	1

Table D.25a. Tradeoff matrix for VMN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
10	8.00	6.00	3.00	3.00	4.00	8.00
20	7.00	7.00	3.00	6.00	6.00	8.00
20	6.00	6.00	5.00	4.00	8.00	7.00
35	9.00	5.00	3.00	6.00	5.00	9.00
15	4.00	8.00	5.00	3.00	6.00	8.00

Table D.25b. Accumulated score and ranking matrix of VMN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	80	60	30	30	40	80
	140	140	60	120	120	160
	120	120	100	80	160	140
	315	175	105	210	175	315
	60	120	75	45	90	120
Total Alternative Points	715	615	370	485	585	815
Rank	2	3	6	5	4	1

Table D.26a. Tradeoff matrix for VBI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	9.00	7.00	4.00	2.00	5.00	10.00
10	6.00	6.00	4.00	5.00	5.00	8.00
30	6.00	8.00	5.00	4.00	9.00	7.00
25	8.00	6.00	5.00	8.00	6.00	8.00
20	5.00	7.00	5.00	4.00	6.00	8.00

Table D.26b. Accumulated score and ranking matrix of VBI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	135	105	60	30	25	150
	60	60	46	50	50	80
	180	24	150	120	220	210
	200	150	125	200	150	200
	100	140	100	80	120	160
Total Alternative Points	675	429	475	480	655	800
Rank	2	5	6	4	3	1

Table D.27a. Payoff matrix for VBN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
20	7.00	5.00	4.00	2.00	4.00	8.00
10	8.00	7.00	3.00	5.00	5.00	9.00
25	7.00	9.00	4.00	3.00	9.00	8.00
30	9.00	5.00	3.00	7.00	5.00	8.00
15	4.00	6.00	5.00	4.00	6.00	7.00

Table D.27b. Accumulated score and ranking matrix of VBN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	105	75	60	30	60	120
	80	70	30	50	50	90
	175	225	100	75	225	200
	270	150	90	210	150	240
	60	90	75	60	90	105
Total Alternative Points	690	610	355	425	575	755
Rank	2	3	6	5	4	1

Table D.28a. Tradeoff matrix for VISI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
17	8.00	6.00	2.00	1.00	4.00	9.00
13	8.00	8.00	3.00	6.00	6.00	9.00
23	7.00	7.00	6.00	4.00	9.00	7.00
27	9.00	5.00	3.00	7.00	5.00	8.00
20	4.00	8.00	5.00	3.00	7.00	9.00

Table D.28b. Accumulated score and ranking matrix of VISI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	136	102	34	17	68	153
	104	104	39	78	78	117
	161	161	138	92	207	161
	248	135	81	189	135	216
	80	160	100	60	140	180
Total Alternative Points	724	160	392	436	628	827
Rank	2	3	6	5	4	1

Table D.29a. Tradeoff matrix for VISN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
17	8.00	7.00	5.00	3.00	6.00	9.00
16	9.00	8.00	6.00	7.00	7.00	9.00
21	6.00	8.00	4.00	3.00	9.00	7.00
23	10.00	5.00	3.00	8.00	5.00	8.00
23	3.00	8.00	6.00	2.00	7.00	9.00

Table D.29b. Accumulated score and ranking matrix of VISN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	136	119	85	51	102	153
	144	128	96	112	112	144
	126	168	84	63	189	147
	230	115	69	184	115	184
	69	184	138	46	161	207
Total Alternative Points	705	714	472	456	679	835
Rank	2	3	5	6	4	1

Table D.30a. Tradeoff matrix for VIMI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	7.00	5.00	4.00	3.00	4.00	8.00
13	7.00	6.00	4.00	5.00	5.00	8.00
13	8.00	9.00	5.00	3.00	10.00	9.00
32	7.00	4.00	2.00	6.00	4.00	7.00
22	5.00	7.00	6.00	4.00	6.00	9.00

Table D.30b. Accumulated score and ranking matrix of VIMI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	105	75	60	65	60	120
	91	78	52	65	65	104
	104	117	65	39	130	112
	224	128	64	192	128	224
	135	189	162	108	162	243
Total Alternative Points	659	587	403	449	545	688
Rank	2	3	6	5	4	1

Table D.31a. Tradeoff matrix for VIMN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
13	8.00	6.00	4.00	3.00	5.00	9.00
15	6.00	6.00	4.00	5.00	5.00	7.00
17	6.00	8.00	6.00	4.00	9.00	7.00
35	10.00	7.00	5.00	7.00	7.00	8.00
20	6.00	9.00	6.00	5.00	8.00	10.00

Table D.31b. Accumulated score and ranking matrix of VIMN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	104	78	52	39	65	117
	90	90	60	75	75	105
	102	136	102	68	153	119
	350	245	175	245	245	280
	120	180	120	100	160	200
Total Alternative Points	766	729	509	527	698	821
Rank	2	3	6	5	4	1

Table D.32a. Tradeoff matrix for VIBI.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
15	8.00	7.00	2.00	1.00	5.00	9.00
15	7.00	7.00	5.00	6.00	6.00	9.00
10	6.00	7.00	5.00	3.00	8.00	7.00
40	8.00	5.00	3.00	6.00	5.00	7.00
20	5.00	9.00	5.00	4.00	7.00	9.00

Table D.32b. Accumulated score and ranking matrix of VIBI.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	120	105	30	15	75	135
	105	105	75	90	90	135
	60	70	50	30	80	20
	320	200	120	240	200	280
	100	180	100	80	140	180
Total Alternative Points	705	660	375	455	585	800
Rank	2	3	6	5	4	1

Table D.33a. Tradeoff matrix for VIBN.

CRITERIA	ALTERNATIVES A1	A2	A3	A4	A5	A6
2o	9.00	6.00	4.00	3.00	5.00	9.00
15	6.00	6.00	4.00	5.00	5.00	8.00
15	6.00	8.00	5.00	4.00	9.00	6.00
30	8.00	6.00	5.00	7.00	6.00	8.00
20	5.00	8.00	6.00	5.00	7.00	9.00

Table D.33b. Accumulated score and ranking matrix of VIBN.

	ALTERNATIVES (Points) A1	A2	A3	A4	A5	A6
	180	120	80	60	100	180
	90	90	60	75	75	120
	90	120	75	60	135	90
	240	180	150	210	180	240
	100	160	120	100	140	180
Total Alternative Points	700	670	485	505	630	810
Rank	2	3	6	5	4	1

APPENDIX E:

RESULTS OF COMPROMISE PROGRAMMING

Table E.1a. Scaled payoff matrix for DM.

ALTERNATIVES	CRITERIA C1	C2	C3	C4	C5
1	.600	.700	.700	.800	.400
2	.500	.700	.800	.400	.900
3	.300	.200	.400	.200	.500
4	.200	.500	.400	.500	.200
5	.400	.500	.900	.400	.800
6	.700	.900	.700	.700	.900

Table E.1b. Values of Lp-Matrix for DM.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.31371	3	.15919	2	.10000	2
2	.29971	2	.18076	3	.16000	3
3	.86000	5	.44068	5	.32000	5
4	.87143	6	.47610	6	.40000	6
5	.43143	4	.27726	4	.24000	4
6	.07800	1	.06873	1	.06800	1

Table E.2a. Scaled payoff matrix for PLANRS.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.800	.700	1.000	.400
2	.500	.800	.700	.700	.800
3	.300	.200	.500	.200	.500
4	.300	.600	.500	.800	.200
5	.400	.600	.800	.700	.600
6	.800	1.000	.700	.900	.900

Table E.2b. Values of Lp-Matrix of PLANRS.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.22976	2	.14439	2	.12143	2
2	.37412	3	.22297	3	.20400	3
3	.92714	6	.46855	6	.34000	5
4	.79500	5	.42300	5	.34000	6
5	.51236	4	.31241	4	.27200	4
6	.05583	1	.04510	1	.04333	1

Table E.3a. Scaled payoff matrix for TECH.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.900	.700	.900	.300
2	.400	.900	.900	.600	.800
3	.300	.500	.500	.300	.400
4	.100	.800	.500	.700	.300
5	.300	.800	.900	.600	.600
6	.900	1.000	.800	.900	.800

Table E.3b. Values of Lp-Matrix for TECH.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.26625	2	.14213	2	.10000	2
2	.31625	3	.19497	3	.15625	3
3	.91750	6	.44052	6	.30000	6
4	.68667	5	.33741	5	.25000	5
5	.44750	4	.24730	4	.18750	4
6	.03750	1	.03750	1	.03750	1

Table E.4a. Scaled payoff matrix for ISI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.800	.600	1.000	.500
2	.500	.800	.700	.500	.900
3	.200	.400	.400	.300	.500
4	.100	.600	.200	.800	.400
5	.300	.600	.800	.500	.700
6	.900	1.000	.700	.900	1.000

Table E.4b. Values of Lp-Matrix for ISI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.21167	2	.13069	2	.10833	2
2	.45333	3	.27786	3	.25000	4
3	.89875	6	.44931	6	.35000	6
4	.70000	5	.32650	5	.21000	3
5	.57250	4	.31864	4	.25000	5
6	.07667	1	.05667	1	.05000	1

Table E.5a. Scaled payoff matrix for ISN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.900	.500	.800	.500
2	.700	.900	.800	.600	.800
3	.300	.600	.400	.300	.500
4	.200	.800	.400	.800	.400
5	.400	.700	1.000	.600	.600
6	1.000	1.000	.700	.800	.900

Table E.5b. Values of Lp-Matrix for ISN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.28792	2	.16942	2	.14167	3
2	.34042	3	.17904	3	.14000	2
3	.95125	6	.46990	6	.35000	6
4	.57500	5	.31213	5	.23000	5
5	.48500	4	.25615	4	.17250	4
6	.08500	1	.08500	1	.08500	1

Table E.6a. Scaled payoff matrix for IMI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.900	.700	.900	.400
2	.500	.900	.900	.600	.600
3	.300	.300	.400	.500	.400
4	.000	.700	.300	.800	.300
5	.400	.700	1.000	.600	.500
6	.900	1.000	.900	.800	.800

Table E.6b. Values of Lp-Matrix for IMI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.14346	1	.08020	1	.05600	1
2	.52784	3	.39897	4	.39000	4
3	.91219	6	.55800	6	.52000	6
4	.54143	4	.26028	3	.17000	3
5	.57787	5	.40673	5	.39000	5
6	.14714	2	.13113	2	.13000	2

Table E.7a. Scaled payoff matrix for IMN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.800	.500	.800	.500
2	.500	.800	.800	.400	.800
3	.200	.300	.300	.200	.600
4	.000	.500	.100	.600	.500
5	.300	.500	.900	.400	.600
6	.800	1.000	.700	.700	.900

Table E.7b. Values of Lp-Matrix for IMN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.21679	2	.12362	2	.10000	2
2	.46179	3	.33012	4	.32000	4
3	.90000	6	.52607	6	.48000	6
4	.64571	5	.29958	3	.18000	3
5	.59321	4	.35781	5	.32000	5
6	.11000	1	.08544	1	.08000	1

Table E.8a. Scaled payoff matrix for IBI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	1.000	.800	.700	.800	.400
2	.500	.700	.800	.500	.700
3	.200	.200	.400	.200	.400
4	.100	.500	.200	.700	.300
5	.300	.500	.900	.500	.600
6	1.000	.900	.700	.800	.700

Table E.8b. Values of Lp-Matrix for IBI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.11607	2	.07163	2	.05714	1
2	.38810	3	.23007	3	.16667	3
3	.89702	6	.45324	6	.30000	5
4	.68571	5	.37729	5	.30000	6
5	.48155	4	.29060	4	.23333	4
6	.05714	1	.05714	1	.05714	2

Table E.9a. Scaled payoff matrix for IBN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.600	.300	.700	.400
2	.600	.600	.800	.400	.700
3	.200	.400	.700	.100	.500
4	.100	.400	.200	.500	.300
5	.400	.400	.700	.400	.500
6	.800	.700	.900	.700	.700

Table E.9b. Values of Lp-Matrx for IBN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.25357	2	.15702	2	.12857	2
2	.32857	3	.21500	3	.20000	3
3	.81429	6	.46500	6	.40000	6
4	.73333	5	.33582	5	.20000	4
5	.55714	4	.28266	4	.20000	5
6	.00000	1	.00000	1	.00000	1

Table E.10a. Scaled payoff matrix for IISI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.800	.600	.700	.400
2	.800	.800	.700	.500	.600
3	.200	.600	.400	.300	.300
4	.000	.700	.200	.600	.200
5	.400	.600	.800	.500	.400
6	.900	1.000	.700	.700	.800

Table E.10b. Values of Lp-Matrix for IISI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.19500	2	.11639	2	.08500	2
2	.37389	3	.23535	3	.21500	4
3	.90222	6	.49572	6	.43000	6
4	.63500	5	.28916	4	.17000	3
5	.54611	4	.29747	5	.21500	5
6	.02167	1	.02167	1	.02167	1

Table E.11a. Scaled payoff matrix for IISN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.800	.600	.800	.500
2	.700	.800	.900	.500	.800
3	.400	.600	.500	.400	.500
4	.200	.800	.200	.800	.300
5	.500	.600	.900	.500	.700
6	.900	1.000	.700	.800	.900

Table E.11b. Values of Lp-Matrix for IISN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.20595	2	.11917	2	.07500	2
2	.44881	3	.31491	4	.30000	4
3	.84524	6	.46336	6	.40000	6
4	.52500	4	.27951	3	.20000	3
5	.59762	5	.35591	5	.30000	5
6	.04286	1	.04286	1	.04286	1

Table E.12a. Scaled payoff matrix for IIMI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.800	.700	.900	.800
2	.600	.700	.700	.700	.400
3	.400	.300	.400	.400	.300
4	.100	.300	.600	.800	.500
5	.400	.300	.800	.700	.700
6	.800	.900	1.000	.800	.900

Table E.12b. Values of Lp-Matrix for IIMI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.11333	2	.07983	1	.07500	1
2	.42452	3	.20976	3	.16000	3
3	.90571	6	.47456	6	.40000	6
4	.59667	5	.29350	5	.22000	5
5	.49905	4	.24883	4	.16000	4
6	.08000	1	.08000	2	.08000	2

Table E.13a. Scaled payoff matrix for IIMN.

ALTERNATIVES	CRITERIA C1	C2	C3	C4	C5
1	.800	.700	.500	.900	.500
2	.500	.700	.800	.600	.800
3	.400	.300	.500	.500	.700
4	.200	.600	.400	.700	.400
5	.400	.600	.800	.600	.800
6	.800	1.000	.600	.800	1.000

Table E.13b. Values of Lp-Matrix for IIMN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.26429	2	.15932	2	.12500	2
2	.50179	3	.30193	3	.26250	4
3	.81667	6	.42898	6	.35000	6
4	.76071	5	.36465	5	.25000	3
5	.56488	4	.32639	4	.26250	5
6	.13750	1	.10078	1	.08750	1

Table E.14a. Scaled payoff matrix for IIBI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.700	.600	.900	.300
2	.500	.700	.700	.500	.800
3	.200	.400	.500	.300	.400
4	.200	.500	.400	.600	.200
5	.400	.500	.800	.500	.600
6	.900	.800	.600	.700	.800

Table E.14b. Values of Lp-Matrix for IIBI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.24583	2	.15484	2	.12500	1
2	.40952	3	.23130	3	.16667	3
3	.90417	6	.43255	6	.25000	5
4	.83750	5	.40408	5	.25000	6
5	.49107	4	.27099	4	.17857	4
6	.20833	1	.15023	1	.12500	2

Table E.15a. Scaled payoff matrix for IIBN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.700	.400	.800	.500
2	.600	.700	.800	.400	.800
3	.400	.400	.700	.200	.600
4	.200	.500	.200	.500	.300
5	.500	.500	.600	.400	.700
6	.700	.800	.700	.700	.800

Table E.15b. Values of Lp-Matrix for IIBN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.31167	3	.20689	3	.16667	2
2	.25500	2	.20378	2	.20000	3
3	.61167	5	.34093	5	.30000	6
4	.82500	6	.39131	6	.25000	5
5	.45833	4	.24035	4	.20000	4
6	.09167	1	.06509	1	.05000	1

Table E.16a. Scaled payoff matrix for IIISI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.800	.500	.700	.200
2	.600	.700	.700	.500	.800
3	.200	.400	.500	.200	.300
4	.100	.600	.300	.600	.100
5	.400	.500	.800	.500	.400
6	.900	.800	.600	.600	.900

Table E.16b. Values of Lp-Matrix for IIISI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.31125	3	.21281	3	.17500	4
2	.26725	2	.13086	2	.09600	2
3	.85375	6	.40042	6	.24000	6
4	.69300	5	.33530	5	.20000	5
5	.47475	4	.24738	4	.17250	3
6	.12800	1	.09330	1	.08000	1

Table E.17a. Scaled payoff matrix for IIISN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.800	.500	.900	.400
2	.600	.800	.700	.500	.600
3	.200	.500	.300	.200	.500
4	.100	.700	.200	.600	.200
5	.400	.600	.700	.500	.500
6	1.000	.900	.500	.800	.700

Table E.17b. Valuce of Lp-Matrix for IIISN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.30667	3	.19692	3	.18000	4
2	.29095	2	.15364	2	.11429	2
3	.77333	5	.35578	5	.20000	5
4	.78571	6	.39032	6	.30000	6
5	.48429	4	.24487	4	.15000	3
6	.08857	1	.06646	1	.06000	1

Table E.18a. Scaled payoff matrix for IIIMI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.700	.500	.800	.500
2	.400	.700	.700	.500	.700
3	.300	.200	.400	.100	.500
4	.100	.500	.400	.600	.300
5	.300	.500	.800	.500	.600
6	.900	.900	.700	.800	.900

Table E.18b. Values of Lp-Matrix for IIIMI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.40298	3	.21783	3	.15000	2
2	.39435	2	.19687	2	.15625	3
3	.87083	6	.39425	5	.20000	5
4	.80714	5	.39673	6	.25000	6
5	.46607	4	.24970	4	.18750	4
6	.05000	1	.05000	1	.05000	1

Table E.19a. Scaled payoff matrix for IIIMN.

ALTERNATIVES	CRITRIA 1	2	3	4	5
1	.800	.600	.600	1.000	.400
2	.600	.600	.900	.500	.800
3	.200	.300	.400	.400	.600
4	.100	.400	.300	.700	.300
5	.400	.400	.900	.500	.700
6	.900	.700	.500	.900	.900

Table E.19b. Values of Lp-Matrix for IIIMN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.32292	2	.19406	2	.16667	2
2	.36042	3	.22712	3	.20833	4
3	.85625	6	.40970	6	.25000	6
4	.81250	5	.36849	5	.20000	3
5	.55625	4	.30297	4	.20833	5
6	.14167	1	.10833	1	.10000	1

Table E.20a. Payoff matric for IIIBI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.700	.600	.800	.500
2	.600	.700	.800	.500	.800
3	.300	.300	.400	.300	.600
4	.100	.500	.100	.700	.400
5	.500	.500	1.000	.500	.700
6	.800	.900	.700	.700	.800

Table E.20b. Values of Lp-Matrix for IIIBI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.22083	2	.14725	2	.13333	2
2	.33810	3	.18587	3	.15000	3
3	.80357	6	.39688	5	.25000	5
4	.75000	5	.40927	6	.30000	6
5	.36964	4	.21009	4	.15000	4
6	.15000	1	.11180	1	.10000	1

Table E.21a. Scaled payoff matrix for IIIBN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.700	.700	.800	.400
2	.700	.700	.800	.400	.800
3	.300	.300	.500	.200	.500
4	.100	.500	.400	.600	.300
5	.500	.500	1.000	.400	.600
6	.900	.900	.700	.700	.800

Table E.21b. Values of Lp-Matrix for IIIBN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.28833	2	.17020	2	.12500	1
2	.35000	3	.18484	3	.13333	3
3	.86833	6	.41473	6	.25000	5
4	.78333	5	.38042	5	.25000	6
5	.44000	4	.23907	4	.16667	4
6	.15833	1	.12937	1	.12500	2

Table E.22a. Scaled payoff matrix for VSI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.600	.600	.700	.800	.300
2	.400	.500	.900	.400	.500
3	.300	.300	.400	.300	.400
4	.200	.400	.300	.500	.300
5	.300	.400	1.000	.400	.500
6	.800	.700	.800	.600	.600

Table E.22b. Values of Lp-Matrix for VSI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.35452	2	.22169	2	.20000	2
2	.54229	3	.32144	3	.28800	4
3	.88071	6	.44574	6	.36000	6
4	.83100	5	.38740	5	.21600	3
5	.57133	4	.33628	4	.28800	5
6	.19257	1	.15197	1	.14400	1

Table E.23a. Scaled payoff matrix for VSN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.600	.700	.800	.400
2	.600	.600	.900	.400	.800
3	.200	.300	.400	.300	.600
4	.200	.500	.300	.500	.200
5	.400	.500	.900	.400	.700
6	.900	.700	.500	.600	.900

Table E.23b. Values of Lp-Matrix for VSN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.50298	4	.43100	5	.42857	5
2	.26107	2	.15408	2	.12000	2
3	.64048	5	.32874	4	.25714	4
4	.91500	6	.62348	6	.60000	6
5	.38786	3	.22252	3	.17143	3
6	.12667	1	.08969	1	.06667	1

Table E.24a. Scaled payoff matrix for VMI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.700	.800	.900	.500
2	.700	.600	.800	.500	.800
3	.300	.300	.400	.300	.500
4	.200	.500	.300	.700	.300
5	.400	.500	.900	.500	.600
6	1.000	.800	.700	.800	.800

Table E.24b. Values of Lp-Matrix for VMI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.22042	2	.13449	2	.12000	2
2	.31125	3	.17052	3	.13333	3
3	.85958	6	.39374	6	.20833	5
4	.78667	5	.37927	5	.25000	6
5	.44583	4	.22635	4	.13333	4
6	.11667	1	.08975	1	.08333	1

Table E.25a. Scaled payoff matrix for VMN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.700	.600	.900	.400
2	.600	.700	.600	.500	.800
3	.300	.300	.500	.300	.500
4	.300	.600	.400	.600	.300
5	.400	.600	.800	.500	.600
6	.800	.800	.700	.900	.800

Table E.25b. Values of Lp-Matrix for VMN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.26000	2	.16125	2	.12000	2
2	.41333	3	.26009	3	.23333	4
3	.89000	6	.45067	6	.35000	6
4	.70500	5	.33095	5	.20000	3
5	.45333	4	.26617	4	.23333	5
6	.05000	1	.05000	1	.05000	1

Table E.26a. Scaled payoff matrix for VBI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.600	.600	.800	.500
2	.700	.600	.800	.600	.700
3	.400	.400	.500	.500	.500
4	.200	.500	.400	.800	.400
5	.500	.500	.900	.600	.600
6	1.000	.800	.700	.800	.800

Table E.26b. Values of Lp-Matrix for VBI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.39875	3	.24032	4	.18000	4
2	.38292	2	.19885	2	.16667	2
3	.85250	6	.40652	6	.25000	5
4	.72500	5	.39765	5	.30000	6
5	.43542	4	.22846	3	.16667	3
6	.12000	1	.12000	1	.12000	1

Table E.27a. Scaled payoff matrix for VBN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.800	.700	.900	.400
2	.500	.700	.900	.500	.600
3	.400	.300	.400	.300	.500
4	.200	.500	.300	.700	.400
5	.400	.500	.900	.500	.600
6	.800	.900	.800	.800	.700

Table E.27b. Values of Lp-Matrix for VBN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.28333	2	.17559	2	.15000	2
2	.38333	3	.23154	3	.20000	3
3	.84167	6	.41374	6	.30000	6
4	.76667	5	.37342	5	.25000	5
5	.45000	4	.25441	4	.20000	4
6	.09167	1	.06509	1	.05000	1

Table E.28a. Scaled payoff matrix for VISI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.800	.700	.900	.400
2	.600	.800	.700	.500	.800
3	.200	.300	.600	.300	.500
4	.100	.600	.400	.700	.300
5	.400	.600	.900	.500	.700
6	.900	.900	.700	.800	.900

Table E.28b. Values of Lp-Matrix for VISI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.30158	2	.19278	2	.16667	2
2	.39075	3	.21566	3	.18000	3
3	.82008	6	.38568	6	.27000	6
4	.75500	5	.36623	5	.23000	5
5	.41792	4	.22882	4	.18000	4
6	.13700	1	.10242	1	.09200	1

Table E.29a. Scaled payoff matrix for VISN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.900	.600	1.000	.300
2	.700	.800	.800	.500	.800
3	.500	.600	.400	.300	.600
4	.300	.700	.300	.800	.200
5	.600	.700	.900	.500	.700
6	.900	.900	.700	.800	.900

Table E.29b. Values of Lp-Matrix for VISN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.33048	2	.22515	4	.19714	4
2	.34214	3	.18802	2	.16429	2
3	.77690	5	.36289	5	.23000	5
4	.78238	6	.37629	6	.23000	6
5	.42167	4	.22341	3	.16429	3
6	.13571	1	.09601	1	.07000	1

Table E.30a. Scaled payoff matrix for VIMI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.700	.700	.800	.700	.500
2	.500	.600	.900	.400	.700
3	.400	.400	.500	.200	.600
4	.300	.500	.300	.600	.400
5	.400	.500	1.000	.400	.600
6	.800	.800	.900	.700	.900

Table E.30b. Values of Lp-Matrix for VIMI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.31564	2	.22359	2	.21600	4
2	.47357	3	.24738	3	.19200	2
3	.82486	6	.41057	6	.32000	6
4	.71150	5	.35483	5	.27000	5
5	.57150	4	.29498	4	.19200	3
6	.01857	1	.01857	1	.01857	1

Table E.31a. Scaled payoff matrix for VIMN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.600	.600	1.000	.600
2	.600	.600	.800	.700	.900
3	.400	.400	.600	.500	.600
4	.300	.500	.400	.700	.500
5	.500	.500	.900	.700	.800
6	.900	.700	.700	.800	1.000

Table E.31b. Values of Lp-Matrix for VIMN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.33367	2	.19742	2	.16000	2
2	.39900	3	.23148	3	.21000	3
3	.87033	6	.43902	6	.35000	6
4	.81000	5	.37403	5	.21000	4
5	.47667	4	.26079	4	.21000	5
6	.20800	1	.15564	1	.14000	1

Table E.32a. Scaled payoff matrix for VIBI.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.800	.700	.600	.800	.500
2	.700	.700	.700	.500	.900
3	.200	.500	.500	.300	.500
4	.100	.600	.300	.600	.400
5	.500	.600	.800	.500	.700
6	.900	.900	.700	.700	.900

Table E.32b. Values of Lp-Matrix for VIBI.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.29375	2	.18214	2	.16000	2
2	.37250	3	.25501	3	.24000	4
3	.90125	6	.47846	6	.40000	6
4	.72250	5	.33280	5	.20000	3
5	.50750	4	.28685	4	.24000	5
6	.10000	1	.08246	1	.08000	1

Table E.33a. Scaled payoff matrix for VIBN.

ALTERNATIVES	CRITERIA 1	2	3	4	5
1	.900	.600	.600	.800	.500
2	.600	.600	.800	.600	.800
3	.400	.400	.500	.500	.600
4	.300	.500	.400	.700	.500
5	.500	.500	.900	.600	.700
6	.900	.800	.600	.800	.900

Table E.33b. Values of Lp-Matrix for VIBN.

ALTERNATIVE	P = 1		P = 2		P = 3	
	VALUE	RANK	VALUE	RANK	VALUE	RANK
1	.36500	2	.23179	2	.20000	4
2	.45500	3	.24295	3	.20000	2
3	.88667	6	.42092	6	.30000	6
4	.76250	5	.35377	5	.20000	5
5	.54583	4	.28361	4	.20000	3
6	.09000	1	.09000	1	.09000	1

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