MCDMGDSS: A GROUP DECISION SUPPORT SYSTEM FOR MULTICRITERION ANALYSIS

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Abstract: An integrated interactive menu driven software MCDMGDSS was developed to consider multicriterion analysis in group decision making environment. The capability of MCDMGDSS is demonstrated with the case study of Chaliyar river basin planning problem, Kerala, India to find the most suitable configuration of the reservoirs. Eight alternatives are analysed with respect to six non-commensurable discrete criteria. Three MCDM methods PROMETHEE-2, EXPROM-2 and Compromise Programming (CP) are employed. Group decision making concept is incorporated by considering the views of two experts. Analysis of the results indicated that same alternative is found to be the potential one by all the methods and by all the experts.

INTRODUCTION

Multicriterion Decision Making (MCDM) methods have demonstrated their immense versatility in solving many problems in physical plane marked by extensive nature of conflicts. The decision makers are often confronted not only with the task of classifying, analysing and arranging suitably the vast information concerning the system but also the choice and ranking of the optimal possibilities. These choice possibilities could be, among many, a number of alternative plans. Multicriterion decision support systems (MCDSS) are computer based systems that employ multiple criteria decision methods as part of the decision support system. Jelassi et al.(1984) explained the requirements of MCDSS as 1)an extensive data base 2) a portfolio of multiple criteria methods 3) user friendly interface. A number of multicriterion decision support techniques have emerged in recent years which use varying computational approaches to arrive at the most desirable solution and thereby 'recommend' a course of action.

Design of water resources systems is becoming more and more complex due to a large number of factors which are tangible or intangible as well as qualitative and quantitative. In this scenario, planning the development of a river basin is not an easy task. This complexity necessitates the utilisation of Multicriterion Decision Making (MCDM) methods. The chosen one could be further analysed in depth for its final implementation. Several MCDM methods have been developed and applied to various case studies in river basin planning (Gershon and Duckstein, 1983). The present paper deals with the development of integrated interactive menu driven software MCDMGDSS (Multi Criterion Decision Making in Group Decision Support System) to consider multicriterion analysis in group decision making environment. The capability of MCDMGDSS is demonstrated with the case study of Chaliyar river basin planning problem, Kerala, India to find the most suitable configuration of the reservoirs. Eight alternative reservoir configurations are analysed to select the most suitable one with respect to six non-commensurable discrete criteria namely, Irrigation, Power production, Drinking water supply, Environmental quality, Flood protection and Benefits from the project. The three different Multicriterion Decision Making (MCDM) methods adopted in the present study are PROMETHEE-2, EXPROM-2 and Compromise Programming (CP). These MCDM methods are discussed in brief here but more details are available in Srinivasa Raju (1995).

PROMETHEE-2

PROMETHEE-2 (Preference Ranking Organisation METHod of Enrichment Evaluation) is of out ranking nature. The method uses preference function $P_j(a,b)$ which is a function of the difference d_j

between two alternatives for any criterion j. Six types of functions based on notions of criteria, namely, Usual criterion, Quasi criterion, Criterion with linear preference, Level criterion, indifference area and Gaussian criterion are proposed (Brans et al.,1986). The indifference and preference thresholds q and p are also defined depending on the type of criterion function. Multicriterion preference index, $\text{Đ}(a,b)$, weighted average of the preference functions $P_j(a,b)$ for all the criteria is defined as

$$\text{Đ}(a,b) = \frac{\sum_{j=1}^{J} w_j \, P_j(a,b)}{\sum_{j=1}^{J} w_j} \qquad (1)$$

$$\text{Ö}^+(a) = \sum_A \text{Đ}(a,b); \; \text{Ö}^-(a) = \sum_A \text{Đ}(b,a); \; \text{Ö}(a) = \text{Ö}^+(a) - \text{Ö}^-(a) \qquad (2)$$

where w_j = Weight assigned to the criterion j; $\text{Ö}^+(a)$=Outranking character of a in the alternative set A; $\text{Ö}^-(a)$=Outranked character of a in the alternative set A; $\text{Ö}(a)$=Net ranking of a in the alternative set A.

a outranks *b* iff $\text{Ö}(a) > \text{Ö}(b)$; *a* is indifferent to *b* iff $\text{Ö}(a) = \text{Ö}(b)$

EXTENSION OF PROMETHEE-2 (EXPROM-2)

EXPROM-2 is the modified and extended version of PROMETHEE-2 method which is based on the notion of ideal and anti-ideal solutions. The relative performance of one alternative over the other is defined by two preference indices, one by weak preference index (based on outranking i.e.,Multicriterion preference index in PROMETHEE-2), and the other by strict preference index (based on the notion of ideal and anti-ideal). The total preference index i.e., summation of strict and weak preference indices in the fuzzy environment gives an accurate measure of the intensity of preference of one alternative over the other for all criteria (Diakoulaki & Koumoutsos, 1991).

COMPROMISE PROGRAMMING (CP)

Compromise Programming defines the 'best' solution as the one, whose point is at the least distance from an ideal point in the set of efficient solutions (Gershon and Duckstein, 1983). The aim is to obtain a solution that is as 'close' as possible to some ideal. The distance measure used in Compromise Programming is the family of L_p - metrics and is given as

$$L_p(a) = \left[\sum_{i=1}^{J} w_j^p \left| \frac{f_j^* - f(a)}{M_j - m_j} \right|^p \right]^{1/p} \qquad (3)$$

$L_p(a)$ = L_p - metric for alternative a, f(a) = Value of alternative a for criterion j, M_j = Maximum value of criterion j in set A, m_j = Minimum value of criterion j in set A, f_j^* = Ideal value of criterion j, w_j=Weight of the criterion j, p = Parameter reflecting the attitude of the decision maker. For p=1, all deviations from f_j^* are taken into account in direct proportion to their magnitudes. For $2 < p < \infty$ the largest deviation has the greatest influence. For $p=\infty$, the largest deviation is the only one taken into account (min-max criterion).

CASE STUDY

The Chaliyar is one of the major rivers in the State of Kerala, India. The river has a length of about 170 km. It has nine important tributaries. The river basin has 93,276 ha of cultivable land. The only irrigation facilities in the basin are those provided by minor lift irrigation schemes, which serve only a limited area of the Paddy lands that too for a part of the crop period. More cultivation of Paddy and other crops is possible if adequate irrigation facilities are provided. The objective of the present study is to find the most suitable configuration of the reservoirs for the development of the basin. The criteria are Irrigation (IR), Power production (PO), Drinking water supply (DW), Environmental quality (EQ), Flood protection (FL) and Benefits from the project (BE). Detailed information on the above six criterion values for each alternative configuration is available from Mohan and Raipure (1991). A total of eight alternative configurations are proposed, each alternative being either a system of reservoirs or varied combination of individual reservoirs. Table 1 shows the reservoir combinations as well as payoff matrix for the eight alternatives. The reservoirs are shown as R1 to R9 in Fig 1.

Table 1: Payoff matrix

Alternatives: combination of reservoirs	Criteria					
	IR	PO	DW	EQ	FL	BE
1. R1,R3,R4,R5,R7,R8	60	15	G	A	40	20
2. R2,R4,R7,R8,R9	60	10	G	A	50	20
3. R2,R3,R4,R5,R9	60	15	G	A	40	30
4. R3,R5,R7,R9	20	5	A	G	30	60
5. R2,R4,R5,R8	70	20	A	A	30	20
6. R2,R4,R7,R8	60	10	A	A	40	30
7. R4,R5,R8,R9	70	15	A	A	30	20
8. R2,R6,R9	20	5	A	G	30	50

A : Average G : Good

MCDMGDSS: INTEGRATED DECISION SUPPORT SYSTEM

An integrated interactive menu driven software MCDMGDSS was developed to consider multicriterion analysis in group decision making environment. MCDMGDSS consists of software modules Multicrit, Correl, Group and Help. Multicrit covers seven Multicriterion Decision Making methods, namely, ELECTRE-1, ELECTRE-2, PROMETHEE-2, EXPROM-2 (Extension of PROMETHEE-2 in distance based environment), Analytic Hierarchy Process (AHP), Compromise Programming (CP) and STOPROM-2 (Stochastic extension of PROMETHEE-2). Multicrit has the capability to graphically display the ranking pattern. Correl includes Spearman and Kendall rank correlation methods which are useful to compute the correlation coefficient values. Group includes group decision making methods i.e., Pairwise comparison majority rule, Sum-of-the-ranks rule, Additive ranking and Geometric mean (multiplicative ranking). Help contains three segments, about MCDM methods, MCDM algorithm & inputs and Exit to DOS. Details of the software and instructions for users are given in Srinivasa Raju (1998). Fig 2 presents the schematic diagram of MCDMGDSS.

RESULTS AND DISCUSSION

The responses from two water resources management experts are employed to provide inputs to the three MCDM methods PROMETHEE-2, EXPROM-2 and Compromise Programming (CP). Weights are based on a scale of 1 to 10. Normalised weights of six criteria i.e., IR, PO, DW, EQ, FL, BE of the first expert are 0.2273, 0.1818, 0.1136, 0.1818, 0.1364, 0.1591 and for the second expert these are 0.1666, 0.1666, 0.1666, 0.1666, 0.1666, 0.1666 respectively.

Parameters employed in various MCDM methods are as follows: In PROMETHEE-2, usual criterion function is adopted. In Compromise Programming maximum, minimum and ideal values for each criterion are obtained from Table 1. For EXPROM-2, parameters are fixed based on the parameters of PROMETHEE-2 and CP. Remaining sets of values are tackled through sensitivity analysis studies. It is observed from Table 2 (for expert 1) that alternative 3 (R2,R3,R4,R5,R9) is found to be the best choice by all the methods and found to be the potential alternative for further analysis. From the next group of suitable alternatives, alternative 1 is found to be the next best if decision maker wants to analyse more than one reservoir configuration. There is a slight change in the ranking pattern between PROMETHEE-2 and EXPROM-2 due to the contribution of strict preference index values in the later while formulating the total preference index. For CP(p=1) alternative 3 is the best, followed by alternatives 1 and 2. Similar observations are reported for CP(p=2). But for CP (p=∞) alternatives 1,2,5 and 7 occupied second position due to their equal L_{p-} metric value. Similarly ties are observed for alternatives 3 and 6 (rank 1) and alternatives 4,8 (rank 3). Table 2 also presents the ranking pattern of expert 2.

Table 2 Final ranks obtained by different MCDM methods

Method	Ranking of alternatives Expert 1	Ranking of alternatives Expert 2
Alternative	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
PROMETHEE-2	2 4 1 6 3 5 3 7	2 3 1 6 5 4 5 7
EXPROM-2	2 3 1 6 4 5 4 7	**2 3 1 5 6 4 6 7** *
CP(p=1)	2 3 1 6 4 5 4 7	2 2 1 4 4 3 4 5
CP(p=2)	**2 3 1 6 5 4 5 7** *	2 2 1 4 4 3 4 5
CP(p=∞)	2 2 1 3 2 1 2 3	2 2 1 3 3 2 3 3

* Submitted for group decision making

^ Consensus ranking : 2, 3, 1, 5, 5, 4, 5, 6

Table 3: Summary Sheet of MCDMGDSS
Consensus Ranking for River Basin Planning Problem

1. If more than one individual decision technique is used, which individual outcome you would like to submit for group decision making ?

a) Ranking pattern obtained by PROMETHEE-2	Yes	No
b) Ranking pattern obtained by EXPROM-2	Yes	No
c) Ranking pattern obtained by CP	Yes	No
d) Ranking pattern of your choice (Please specify the ranking in order of alternatives i.e., A1,A2,A3,A4,A5,A*n*)	Yes	No

2. Group Decision Making
Which aggregation of preference techniques are you preferring ?

a) Pairwise comparison majority rule	Yes	No
b) Sum-of-the-Ranks rule	Yes	No
c) Additive ranking rule	Yes	No
d) Multiplicative ranking rule	Yes	No

3. Can you accept consensus ranking (if not suggest your ideas)	Yes	No

Signature
Designation:

GROUP DECISION MAKING

In the MCDMGDSS, decision maker has the option to work with any of the MCDM methods of his choice or all to rank different alternatives. Decision maker has the choice to submit any of the ranking patterns of his choice for group decision making analysis. He can prefer any one or all of the four group decision making techniques for aggregation since combination of group decision making techniques can increase the chances of reaching a consensus or can at least constitute a richer basis for bargaining and negotiation.

In the present study, group consensus is achieved through Additive ranking module of MCDMGDSS. In the first expert's case, preference is given to the ranking pattern obtained by CP(p=2), where as in second expert's case it is of EXPROM-2. The above ranking pattern is submitted to Additive ranking module. Consensus ranking in order of alternatives is 2, 3, 1, 5, 5, 4, 5, 6. In this case alternatives 4,5,7 are having ties (fifth rank). However, the first three positions remain unchanged. Extensive sensitivity analysis indicated that alternative 3 (R2, R3, R4, R5, R9) is found to have greatest potential for further study. Table 3 shows summary sheet of MCDMGDSS for the river basin planning problem.

CONCLUSIONS

Group decision support system MCDMGDSS was developed and applied to Chaliyar river basin planning problem, Kerala, India, and the following conclusions are drawn:

1. Alternative 3 (R2,R3,R4,R5,R9) is found to be the best choice having greatest potential for further investigations as supported by extensive sensitivity analysis.
2. There is slight change in the ranking pattern between PROMETHEE-2 and EXPROM-2 due to the contribution of strict preference index values in the later one, while formulating the total preference index.
3. Sensitivity analysis studies indicates that the ranking pattern is quite robust to the parameter changes upto the first and second positions.
4. Comparison of the results indicate that the methodologies are quite versatile and can be used in other similar situations with suitable modifications.

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