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Preference Ranking Organization Method Of Enrichment Evaluation (Promethee)

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ABSTRACT : *This paper gives an overview of the PROMETHEE methodology for MCDM. It starts with general comments on Multicriterion problems, stressing that a Multicriterion problem cannot be treated without additional information related to the preferences and the priorities of the decision-makers. The information requested by PROMETHEE is particularly clear and easy to define for both decision-makers and analysts. It consists in a preference function associated to each criterion as well as weights describing their relative importance. The PROMETHEE I. the PROMETHEE II complete ranking, as well as the visual interactive module arc then described and commented. The two next sections are devoted to the PROMETHEE VI sensitivity analysis procedure (human brain) and to the PROMETHEE V procedure for multiple selections of alternatives under constrains. An overview of the PROMETHEE procedure for group decision making is then given. Finally the DECISION LAB software implementation of the PROMETEE methodology is described using the case study of begampur branch canal a numerical example.*

KEYWORDS*: MCDM, outranking methods, PROMETHEE, DECISION LAB.*

1. INTRODUCTION TO PROMETHEE

PROMETHEE was created by Professor Jean-Pierre Brans in 1982. At that time it included only the basic PROMETHEE I and II rankings. Soon thereafter Bertrand Mareschal started to work with Jean-Pierre Brans on the development of the method. PROMETHEE III (interval order) and IV (continuous) extensions were proposed in 1983. A first (mainframe) computer program was implemented at that time. Between 1984 and 1989, two important milestones took place: the GAIA method was created as a descriptive extension of PROMETHEE and the (MS-DOS) PROMCALC software was made available to the users of PROMETHEE. GAIA is still today one of a very few effective descriptive MCDA methods. PROMCALC (later PROMCALC-GAIA) was one of the first truly interactive MCDA software with a strong emphasis on user interface, graphical representations and sensitivity analysis. In the 90's additional PROMETHEE-based instruments were created: PROMETHEE V provided a solution for constrained Multicriterion selection of a subset of actions while PROMETHEE VI introduced the notion of the "decision maker brain" in GAIA. Meanwhile group decision extensions of PROMETHEE and GAIA were also introduced. At the end of the century, Decision Lab 2000 was launched as a joint project between our ULB team and the Canadian company Visual Decision. It replaced PROMCALC and set up new standards for MCDA software.

How to choose the right preference function?

Currently the D-SIGHT software is in its late beta stage. It will include some newer developments (especially visual representations for PROMETHEE and extensions of GAIA).There are six different shapes of preference function in the original PROMETHEE methods and in the PROMETHEE software. Here are some guidelines in choosing the right preference function for your criterion. The V-shape (type III) and linear (type V) preference functions are best suited for quantitative criteria (e.g. prices, costs, power,). The choice will depend on whether you want to introduce an indifference threshold or not. Actually, V-shape is a special case of the linear one. The Gaussian (type VI) preference function is less often used as it is more difficult to parameter (the s threshold value is somewhere between the q indifference threshold and the p preference threshold).The Usual (type I) and Level (type IV) preference functions are best suited for qualitative criteria. In case of a small number of levels on the criteria scale (e.g. yes/no criteria or up to 5-point scale) and if the different levels are considered quite different from each other, the Usual preference function is the good choice. If you want to differentiate smaller deviations from larger ones, the Level preference function is more adequate.

The PROMETHEE method is a multi-criteria decision aid system that permits the building of an outranking between different alternatives.

This article contains a short introduction to the multi-criteria decision aid system PROMETHEE.
Let A be a set of solutions, each $a \in A$, $fj(a)$ represents the evaluation of a solution, a , to a given criterion, fj .

Table 1 represents a generic evaluation table.

	$f1(.)$	$f2(.)$	⋯	$fj(.)$	⋯	$fk(.)$
$a1$	$f1(a1)$	$f2(a1)$	⋯	$fj(a1)$	⋯	$fk(a1)$
$a2$	$f1(a2)$	$f2(a2)$	⋯	$fj(a2)$	⋯	$fk(a2)$
Ai	$f1(ai)$	$f2(ai)$	⋯	$fj(ai)$	⋯	$fk(ai)$
An	$f1(an)$	$f2(an)$	⋯	$fj(an)$	⋯	$fk(an)$

Enrichment of the Preference Structure

The notion of generalized criteria is introduced in order to take into account the extent of the deviations between the evaluations.For this purpose we define preference function $Pj(a,b)$ as giving the degree of preference of solution a over solution b for a given criteria, fj . In most cases, we can assume that $Pj(a,b)$ is a function of the deviation $d=f(a)-f(b)$. We consider that the function $Pj(a,b)$ is normalized, so that:

- $0 \le Pj(a,b) \le 1$;
- $P(a,b)=0$, if $d \le 0$, no preference or indifference;
- $P(a,b) \approx 0$, if $d>0$, weak preference;
- $P(a,b) \approx 1$, if $d>>0$, strong preference;
- $P(a,b)=1$, if $d>>>0$, strict preference.

It is clear that P has to be a non-decreasing function of d, Parameters q and p are known respectively as the indifference and the preference threshold.

The generalized criterion associated with $f(.)$ is then defined by the pair $(f(.),P(.,.))$. The PROMETHEE method requires a generalized criterion to be associated with each criterion, fj .

Enrichment of the Dominance Relation

A valued outranking relation is built up that takes all the criteria into account. Let us now suppose that a generalized criterion $(fj(.),Pj(.,.))$ is associated with each criterion $fj(.)$ .The p and q values are the indifference and preference thresholds respectively. When the difference between the evaluations of a and b is lower than q it is not significant, and the preference of a over b is thus equal to zero. When the difference between the evaluations of a and b is greater than p it is considered to be very significant, and the corresponding preference is thus equal to one.A multi-criteria preference index $\pi(a,b)$ of a over b can then be defined, that takes all the criteria into account with the expression (↓).

$$\pi(a,b)=\sum j=1k wjPj(a,b)$$

Where $wj>0$ are weights associated with each criterion. These weights are positive real numbers that do not depend on the scales of the criteria. It is interesting to note that if all the weights are equal, $\pi(a,b)$ will simply be the arithmetical average of all the $Pj(a,b)$ degrees. $\pi(a,b)$ expresses how, and to what extent, a is preferred to b , while $\pi(b,a)$ expresses how b is preferred to a over all the criteria. The values $\pi(a,b)$ and $\pi(b,a)$ are computed for each pair of alternatives $a,b \in A$. In this way, a complete and valued outranking relation is constructed on A .

Exploitation for Decision Aid

Let us considered how each alternative, $a \in A$, faces the $n-1$ others and therefore defines the two following outranking flows:

- the positive outranking flow is given by:
  $\Phi+ (a) = 1n-1 \sum b \in A, b \neq a \pi (a, b)$
- the negative outranking flow is given by:
  $\Phi- (a) = 1n-1 \sum b \in A, b \neq a \pi (b, a)$

The positive outranking flow expresses to what extent each alternative outranks all the others. The higher $\Phi+ (a)$ is, the better the alternative will be. $\Phi+ (a)$ represents the power of a, i.e. its outranking character.

The negative outranking flow expresses to what extend each alternative is outranked by all the others. The smaller $\Phi- (a)$ is, the better the alternative will be. $\Phi- (a)$ represents the power of a, i.e. its outranked character.

II. PROMETHEE II RANKING

Principles

As all outranking methods, PROMETHEE method, which is the method that is developed and used through the project, proceeds to a pairwise comparison of alternatives in each single criterion in order to determine partial binary relations denoting the strength of preference of an alternative *a* over alternative *b*. The evaluation table is the starting point of the PROMETHEE method. In this table, the alternatives are evaluated on the different criteria. These evaluations involve essentially quantitative data.

The implementation of PROMETHEE requires two additional types of information, namely:

- Information on the relative importance (i.e. the weights) of the criteria considered
- Information on the decision-makers preference function, which he/she uses when comparing the contribution of the alternatives in terms of each separate criterion.

The weights of criteria can be determined according to various methods. In the present work, weight factors reflecting the DMs previous experience and their insights are adopted.

The preference function

The preference function (P_j) translates the difference between the evaluations (i.e., scores) obtained by two alternatives (a and b) in terms of a particular criterion, into a preference degree ranging from 0 to 1.

$$P_{j\,(a,b)} = G_j[f_j(a) - f_j(b)], \quad (1)$$

$$0 \leq P_{j\,(a,b)} \leq 1, \quad (2)$$

Let be the preference function associated to the criterion, $f_j(i)$ where G_j is a non decreasing function of the observed deviation (d) between $f_j(a)$ and $f_j(b)$.

In order to facilitate the selection of a specific preference function, six basic types have been proposed, usual function, U-shape function, V-shape function, level function, linear function and Gaussian function (Table 1).

Function	Shape	Threshold
Usual		No threshold
U-shape		Q threshold
V-shape		P threshold
Level		Q and P thresholds
Linear		Q and P thresholds
Gaussian		S threshold

Figure: Preference functions of Promethee

PROMETHEE allows the computation of the following quantities for each alternative a and b

$$\Pi r\ (a, b) = \sum_{j=1}^{k} P_j\ (a, b)\ wr, j,$$

$$\Phi^{+}\ (\alpha) = \Sigma_{x \epsilon A} \pi_r (x, a), \quad (3)$$

$$\Phi\text{-}(\alpha) = \Sigma_{x \epsilon A} \pi_r\ (a, x),$$

$$\Phi\ (\alpha) = \varphi^{+}\ (\alpha) - \varphi^{-}(\alpha)$$

For each alternative *a*, belonging to the set A of alternatives, $\pi(a,b)$ is an overall preference index of *a* over *b*, taking into account all the criteria, $\varphi^{+}(\alpha)$ and $\varphi^{-}(\alpha)$. $\varphi(\alpha)$ represents a value function, whereby a higher value reflects a higher attractiveness of alternative *a* and is called net flow.

The two main PROMETHEE tools can be used to analyse the evaluation problem:

- The PROMETHEE I partial ranking,
- The PROMETHEE II complete ranking.

The PROMETHEE I partial ranking provides a ranking of alternatives. In some cases, this ranking may be incomplete. This means that some alternatives cannot be compared and, therefore, cannot be included in a complete ranking. This occurs when the first alternative obtains high scores on particular criteria for which the second alternative obtains low scores and the opposite occurs for other criteria. The use of PROMETHEE I then suggests that the decision-maker should engage in additional evaluation efforts. PROMETHEE II provides a complete ranking of the alternatives from the best to the worst one. Here, the net flow is used to rank the alternatives. Additional tools such as the 'walking weights' can be used to further analyse the sensitivity of the results in function of weight changes.

III. METHODOLOGY

The work is divided into the following parts:-

[1] Selection of the site.
[2] Data collection from the site (map and layout of the canal.)
[3] Selection of distributaries on the basis of I.C.A in hectares covered by each distributaries.
[4] Selection of Criteria.
[5] Collection of data in the form of questionnaire's farmers point of view (Appendix)
[6] Collection of data from the official's point of view on the basis of chosen criteria.
[7] Analysis of data collected from farmer's point of view on the basis of chosen criteria.
[8] Formulation of pay of matrix.
[9] Use of (MCDM) Multi Criterion Decision Making weighted average method.
[10] Arrangements of distributaries' according to ascending order of ranking from the final pay of matrix by using.

a) Unit weight
b) Using different weight for different criteria's

IV. CASE STUDY

Details of Selected site

Begumpur branch is 35 Km from Ujjani dam and is comes under Ujjani left bank canal, the length of canal is spread 7Km-9Km.The irrigation area under this branch is 10140 hector, head required is 7.14 cumecs against the carrying capacity of 13.09 cumecs. The carrying capacity at Km 10 (head) is 5.50 cumecs and that at the 34 Km (tail) it is 4.85 cumecs. Bhīma project contemplates irrigation in two stages. In the first stage it was proposed construct storage on the river Pawana (a tributary of Mula/ mutha/Bhīma) and in the second stage a dam near Ujjani on the river Bhīma above the confluence of Nira. The entire proposal to be served by the project has no other suitable source except for providing water for the irrigation, industrial and drinking water supply. The project report was submitted to central water commission in January-1964 and cleared by the planning commission in march-1965.

Distribution of systems

Water from the main canals and branches will have to be distributed over the entire command through a net work of distributions, minor and water courses. Distributaries will take off at suitable points on ridges between 2 bigger nallas for irrigation of local patches between these 2 nallas. All the distributaries except water courses will be constructed at government cost up to one cusecs discharge as per government. Circular No C.D.A/1080/338/2786 CAD dt.13-04-1981.From the government channels water courses will take off from outlets. Generally no outlets will be allowed on the main canals/branches but they will be provided on the distributaries or minors. Water courses for the irrigation of the fields will be constructed by the C.A.D. Authorities. The canal sections completed on different canals and created up to 6/2001 thereon is as under.
Depending upon the questionnaires and interviewers of farmers, executive engineer and social workers following criteria's are selected.

1. **On farm development works (OFD):** Farm development works include mainly land leveling and shaping.
2. **Social impact (SCI):** Social impact includes generating labour employment, which is measured in terms of man days employed per hectare for each crop grown
3. **Conjunctive use of water resources (CUW):** conjunctive use of surface and ground water is essential to provide more reliable supply of water to crops when needed as well as to reduce water logging effect.
4. **Use of fertilizers and seeds (UFS):** Timely supply of inputs such as seeds, fertilizers are essential for effective irrigation management.
5. **Economic impact (ECI):** Economic impact includes farmer's income and revenue collect due to supply of irrigation water

- Collection of data in the form of questionnaire's farmers point of view (Appendix)

With the opinion of our guide the questionnaire was formed as per written appendix which was used to collect farmers point of view of the various distributaries'. Each distributaries' was divided into three main parts head, middle and tail and equal number of farmers were selected from each parts and answers to the questions were collected for the required pay of matrix.

[1] Collection of data from the official's point of view on the basis of chosen criteria.
Officers of the irrigation department of Ujjani canal sections were asked to give their opinions about all the distributaries' based on the criteria selected as above (4). To form the pay of matrices of the officers

[2] Analysis of data collected from farmer's point of view on the basis of chosen criteria.
The data collected from the questionnaire were analyzed on the basis of the criteria selected and pay of matrix of the average of the farmer's opinion was prepared. As per the Table 2. And table 2A showing excellent, very good, good and average status according to the number of relative yes/no answers given by the farmers.

[3] Formulation of pay of matrix.
After the formation of average matrices of farmers and officials the final pay of matrices is formed by their average, showing the distributaries' with their final values which forms the pay of matrix with unit weight.

[4] Use of (M.C.D.M) Multi Criterion Decision Making weighted average method.
With the opinion of our guides and site conditions the criteria's were given weights and weighted average method the final matrix with weighted values of criteria were formed.

[5] Arrangements of distributaries according to descending order of ranking from the final pay of matrix by using.

- Unit weight.
- Using different weight for different criteria's.

As per the final values of the matrices (unit and weighted) the distributaries were ranked and grouped according

V. RESULTS AND DISCUSSION

Average pay of matrix average

TABLE 2

	C1	C2	C3	C4	C5
D_1	65	75	80	85	65
D_2	80	65	85	60	80
D_3	45	50	65	70	45
D_4	35	45	50	45	40
D_5	30	35	55	40	30

RANKING TABLE

TABLE 3

	Ø Horizontal	Ø vertical	Ø	Rank
1	0.066	0.472	0.406	2
2	0.06	0.5782	0.5182	1
3	0.252	0.213	-0.039	3
4	0.439	0.299	-0.14	4
5	0.5118	0.0332	-0.4786	5

It is observed that ranking pattern in order of alternatives is 2,1,3,4,5 and alternative D2 with highest net Ø value is considered as the best. Based on the analysis of the results of a real world problem involving the application of Multi-Criterion Decision Making(MCDM) methods in performance evaluation studies are applied to 5 distributaries of Begumpur branch canal of Ujjani project, Maharashtra following conclusions are drawn on from development social impact and conjunctive use of water are the 3 criteria that are given the top priorities by experts. Group decision making concept can be effectively incorporated in the decision making process using the presently developed methodology, it is found that the observations from experts help us to drawn the correct values.

VI. CONCLUSION

Irrigation water management in irrigation schemes is complex due to their heterogeneity. Three phases of irrigation water management namely planning, operation and evaluation were identified. Previous studies on the performance assessment of irrigation scheme have provided the conceptual framework for performance measurement. This has been extended in this paper for the qualitative and quantitative evaluation of performance during every phase of irrigation water management. Two types of performance measures were proposed in this paper: the allocative type comprising productivity and equity; and the scheduling type comprising adequacy (excess), reliability, flexibility, sustainability and efficiency. These performance measures are described with different attributes in this paper. The methodologies to estimate these measures explained in this paper provide the irrigation authorities with the information on the performance of irrigation water management in the scheme, their management capability, the response of the irrigation water management to variations in climatological, physical and management aspects and insight to improve the performance during different phases of irrigation water management.

Although the primary focus is on the management of canal systems for agricultural production, we have also discussed indicators that can be used for assessing longer term performance, including physical, economic and social sustainability. Finally, the paper has highlighted the crucial importance of strategic as well as operational management performance. It is unlikely that in any single evaluation there will be sufficient time or resources to assess all aspects of performance simultaneously.Water is greater source of humanity and is not only help for making life comfortable and luxurious besides other uses of water is it can largely used for irrigation of land irrigation is nothing but continuous and reliable for different crops in accordance with their needs. The Ujjani dam is constructed for development of the nearby district of the Solapur and Solapur city.

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