POLITÉCNICA

UNIVERSIDAD POLITÉCNICA DE MADRID

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Sobre uso de PROMETHEEs y otros métodos MCDM para Agro Decisiones en Argentina

Métodos Discretos. Casos en Salta, Argentina, de Elección de Usos de Tierras, y de Entidad de Gestión de Recursos Hidráulicos.

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Métodos MCDM discretos

Los autores, siendo Profs. ETS Ing. Agrónomos, con Asignatura MMTD, con otros del GI GASC de **UPM**, en TMD (Teoría Matemática de la Decisión), MMTD, en varios estudios **MCDM** (Multi-criteria Decision Making).

En esa ETSIA tradición MMTD (Métodos Matemáticos Toma Decisiones), tal como el C.U. Enrique Ballestero, su discípulo Carlos Romero ahora C.U. en la E.T.S. de Montes.

Usaron Métodos Continuos, y aquí con **Métodos Discretos**, en casos para los que el estudio bien considerado conduce a un número *m* de *i*-alternativas, cuya valoración depende de *n j*-criterios.

En todo caso para aplicar MMTD hay que considerar el caso con experticia sobre los temas involucrados.

AHP, ELECTRE-I, PROMETHEEs

- Los autores entraron con métodos, aparte del AHP, "outranking" tales como el tradicional **ELECTRE-I**, que usa datos para valoraciones **t(*j*,*i*) = Im(*i*,*j*)**, **matriz decisional**, para la **alternativa *i*** en el **criterio *j***, que tiene un **peso** (**weight**) normalizado, suman 1, ***w*(*j*)** y un índice **I(*j*)** que es **1** si es "**más es mejor**" y un **-1** si es "**más es peor**". Siguieron la introducción posterior de métodos "**original PROMETHEE**", que usan matriz decisional **Im(*j*,*i*)** e índice **I(*j*)**, valorando criterios de otros modos. Posteriormente siguieron la introducción de los más recientes con "**weighted PROMETHEE**" que requieren pesos normalizados ***w*(*j*)**, para cada ***j*-criterio**.
- Al final compaginaban con los mismos datos ELECTRE-I y weighted PROMETHEE, que aparece más claro.

Métodos PROMETHEE, (1)

- Para comparar las *i*-alternativas en cada *j*-criterio se debe utilizar una llamaremos "*j*-función al (0,1)" ***p(j,x)***. Su lista con 6 se encuentra en **PROMETHEE** (Preference Ranking Organization Method for Enrichment Evaluations) by J.P. Brans, Ph. Vincke 1986(2). Deben dar resultado en (0,1) según aumente la diferencia de **Im**(*i*,*j*)-**Im**(*k*,*j*). Con ellas se obtiene la "*j*-**initial preference functions**" *P*(*i*, *k*, *j*) como

$$P(i,k,j) = \text{if}\left[I_j \cdot \left(\mathbf{Im}_{ij} - \mathbf{Im}_{kj}\right) \leq 0 \right] \text{ then } \ 0 \text{ else } \ p\left(j, \left|\mathbf{Im}_{ij} - \mathbf{Im}_{kj}\right|\right)$$

- de ellas "preferences indexes" para "weighted PROMETHEE"

$$q(i,k) = \sum_{j=1}^{n} P(i,k,j) \cdot w_j$$

- que eran para "original PROMETHEE"

$$q(i,k) = \sum_{j=1}^{n} P(i,k,j) \cdot 1/(n \quad)$$

Métodos PROMETHEE, (2)

- Con ello para valorar la alternativa *i* se le obtienen
- "out-going flow"
- "incoming flow"
- "net flow"

$$\mathrm{Of}(i) = \sum_{k=1}^{n} q(i,k)$$

$$\mathrm{Of}(i) = \sum_{k=1}^{n} q(i,k)$$

$$P_i = \mathrm{Tpf}(i) = \mathrm{Of}(i) - \mathrm{If}(i)$$

• PROMETHEE-II technique, "Ranking the Actions by a Total Pre-order": estas "net flows" son valoraciones de las *i*-alternativas y las clasifican según su valor.

• PROMETHEE-I technique, "Ranking the Actions by a Partial Pre-order" : se considera que *i* "outranks" *k*, i.e. "es preferible a", si sus outcoming flows son todos mejores o iguales, siendo sus incoming flows peores o iguales, no siendo todos iguales, y se pone en una matriz CP(*i,k*) = 1.

•Si todos son iguales *i* "es indiferente" a k, y CP(*i,k*) = 0.

•Y en caso contrario "son incomparables" y CP(*i,k*) = -1.

Esto según Brans, (3)

$$Of(i) = \sum_{k=1}^{n} q(i,k)$$

$$Of(i) = \sum_{k=1}^{n} q(i,k)$$

- CP(i,k) = 1
- CP(i,k) = 0
- CP(i,k) = -1

a. *PROMETHEE* I: *Ranking the Actions by a Partial Preorder*

Let us therefore consider the valued outranking graph and let us define, for each node a, the outgoing flow

$$\phi^+(a) = \sum_{x \in K} \pi(a,x), \tag{5.1}$$

and the incoming flow

$$\phi^-(a) = \sum_{x \in K} \pi(x,a). \tag{5.2}$$

The larger $\phi^+(a)$, the more a dominates the other actions of K. The smaller $\phi^-(a)$, the less a is dominated. Let us first define the two total preorders (P^+, I^+) and (P^-, I^-) such that:

$$\begin{aligned} a\ P^+\ b \quad &\text{iff} \quad \phi^+(a) > \phi^+(b), \\ a\ P^-\ b \quad &\text{iff} \quad \phi^-(a) < \phi^-(b); \end{aligned} \tag{5.3}$$

$$\begin{aligned} a\ I^+\ b \quad &\text{iff} \quad \phi^+(a) = \phi^+(b), \\ a\ I^-\ b \quad &\text{iff} \quad \phi^-(a) = \phi^-(b). \end{aligned} \tag{5.4}$$

We then obtain the following partial preorder $(P^{(1)}, I^{(1)}, R)$ by considering their intersection:

$$\begin{cases} a \text{ outranks } b\ (a\ P^{(1)}\ b): & \text{if } \begin{cases} a\ P^+\ b \text{ and } a\ P^-\ b, \\ a\ P^+\ b \text{ and } a\ I^-\ b, \\ a\ I^+\ b \text{ and } a\ P^-\ b, \end{cases} \\ a \text{ is indifferent to } b\ (a\ I^{(1)}\ b); & \text{if } a\ I^+\ b \text{ and } a\ I^-\ b, \\ a \text{ and } b \text{ are incomparable } (a\ R\ b) & \text{otherwise.} \end{cases} \tag{5.5}$$

This is the PROMETHEE I partial relation. It offers the decision-maker a graph in which some actions are comparable, while some others are not. This information can be used fruitfully in concrete applications for making decisions. See for instance the example below.

Métodos PROMETHEE, (4)

- Así se tiene la Partial pre-order matrix **CP** , en esquema como

For PROMETHEE-I technique "Ranking the Actions by a Partial Pre-order", the elements $CP_{i,k}$ of a Partial pre-order matrix CP are defined as follows:

1. $\mathbf{CP}_{i,k} = 1$ if {[Of(i) > Of(k) and If(i) < If(k)] or [Of(i) > Of(k) and If(i) = If(k)] or [Of(i) = Of(k) and If(i) < If(k)]}, indicating that "the alternative i outranks the alternative k",
2. $\mathbf{CP}_{i,k} = 0$ if [Of(i) = Of(k) and If(i) = If(k)] indicating that "the alternative i is indifferent to the alternative k",
3. $\mathbf{CP}_{i,k} = -1$ otherwise, indicating that "they are incomparable".

Métodos PROMETHEE, (5)

Para la "*j*-función al (0,1)" ***p(j,x)***, para *j*-columna de **Im**(*i*,*j*)
Brans ….indica:

Ello normaliza y lleva a tener $0<=P(i, k, j)<=1$.

Indican 4 otras "*j*-funciones"…

Son usados en:

Type III: *Criterion with Linear Preference*

Let $p(x)$ be:

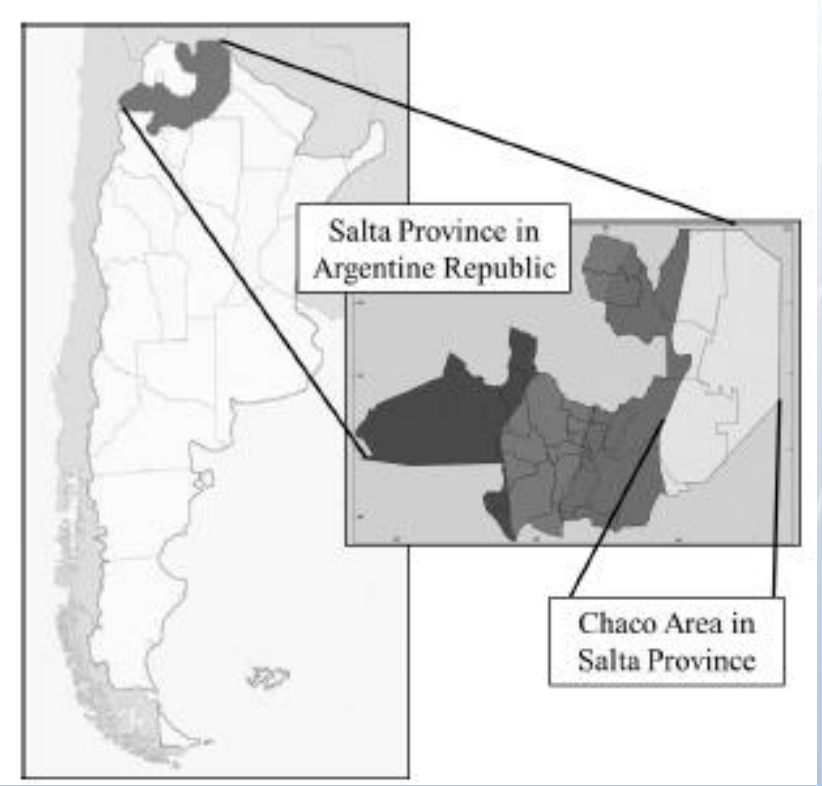
$$p(x) = \begin{cases} x/m, & x \leqslant m, \\ 1, & x \geqslant m. \end{cases}$$

type I : p4(x) := if(x=0,0,1)

$$P(i,k,j) = \text{if}\left[I_j \cdot \left(\mathbf{Im}_{ij} - \mathbf{Im}_{kj}\right) \leq 0 \right] \text{ then } 0 \text{ else } p\left(j, \left|\mathbf{Im}_{ij} - \mathbf{Im}_{kj}\right|\right)$$

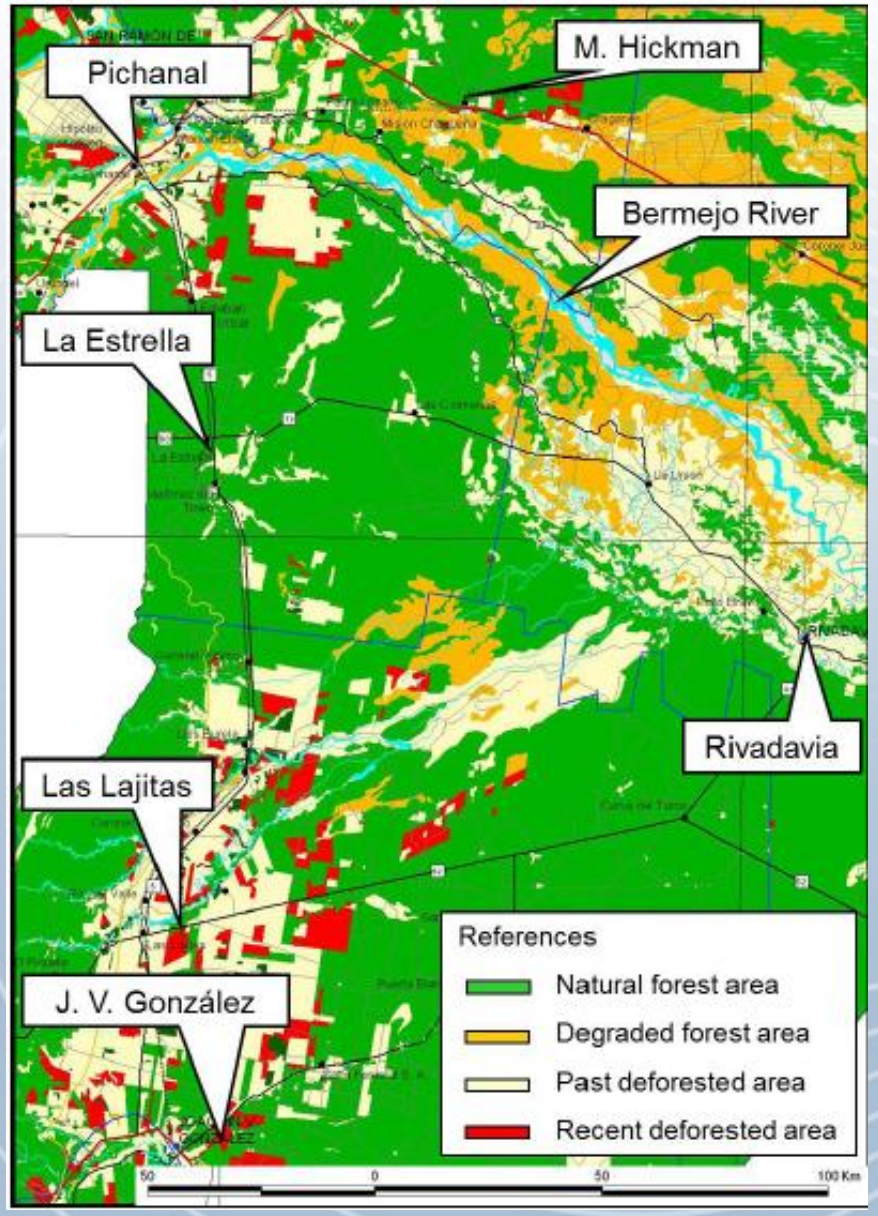
Los autores han pasado a menudo … la *j*-columna de **Im**(*i*,*j*) al intervalo (0,10), usándole luego un *m* igual a 10.

Caso 1: Elección Usos de Tierras mejorados en el Chaco Salteño.



Prov. Salta de Arg., (2015)
155.488km2, 1.333.365 hab..

Se adopta aquí la zona La Estrella



La Estrella, alternativas

- A) **Bosque Autóctono** : dominando las especies forestales “Quebracho Blanco” y “Quebracho Colorado”.
- (de A) Autochtonous Forest, mainly “” and “” forest species.)
- B) **High value forest**: mainly teak, ebony, walnut tree, cherry tree, lignum vitae, eucalyptus, etc ….
- C) **Traditional farms** with extensive agriculture and livestock mixed with autochthonous forest modified and several foraging plants.
- D) **Erosion control Crop with agriculture use**.
- E) **Erosion control Crop with industrial use (biomass**).

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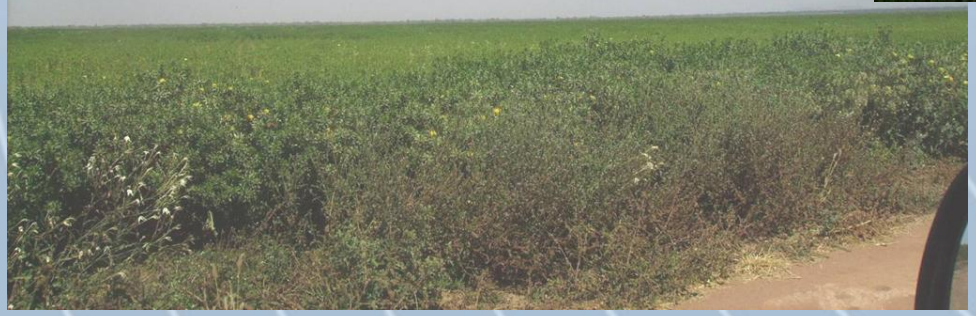
Ej.Alternativas La Estrella

Autochthonous forest

High value forest

Traditional farm

Winter crop



Cartamo crop

La Estrella Criterios

1) **Water erosion (WE)**: The water erosion is important. The relative water erosion indexes figures in the decisional matrix.

2) **Eolian erosion (EE)**: Winds erode, transport and deposit materials and are effective agents in several areas of this region.

3) **Implementation Facility (IF)**: They have been established taking into account actors' opinions.

4) **Water Resources (WR)**: By each alternative have been considered and the relative results have been taken into this criterion.

5) **Economical benefits (EB)**: The relative economical benefits using each alternative in a period of 25 years have been obtained as shown in the matrix with figures from 1 to 10.

6) **Hand power (HP)**: We have considered that would be satisfactory to give employment to the majority of it population. For that, we have considered this criterion as of "more is better" kind.

7) **Environmental Impacts (EI)**: They have been considered in each sub zone the environmental impacts according with the alternative adopted.

8) **Social Acceptance (SA)**: The figures included in this criterion have been obtained from the results of different forums and meeting with institutions, organizations and native people.

PROMETHEE, MATHCAD

$$t := \begin{array}{c} \begin{matrix} 1 & 2 & 3 & 4 & 5 \end{matrix} \\ \begin{bmatrix} 7 & 7 & 3 & 2 & 3 \\ 6 & 6 & 3 & 2 & 2 \\ 5 & 5 & 6 & 6 & 8 \\ 8 & 4 & 4 & 4 & 5 \\ 5 & 5 & 8 & 5 & 8 \\ 2 & 9 & 9 & 6 & 6 \\ 8 & 6 & 3 & 5 & 4 \\ 6 & 5 & 9 & 6 & 8 \end{bmatrix} \end{array} \qquad W := \begin{bmatrix} 0.20 \\ 0.15 \\ 0.15 \\ 0.10 \\ 0.10 \\ 0.10 \\ 0.10 \\ 0.10 \end{bmatrix} \qquad \text{Weights :}$$

$$I := \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \qquad \text{Indexes :}$$

Criterion-parameter functions, following Brans @ Vincke :

type III :

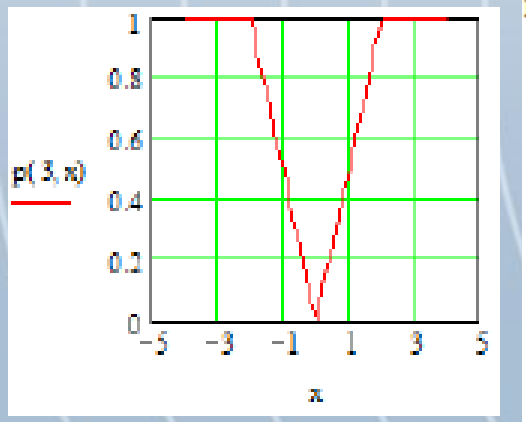
$$p1(x) := \text{if}\left(x \le 2, \frac{x}{2}, 1\right)$$

$$p2(x) := \text{if}\left(x \le 3, \frac{x}{3}, 1\right)$$

$$p3(x) := \text{if}\left(x \le 6, \frac{x}{6}, 1\right)$$

type I :

$$p4(x) := \text{if}(x = 0, 0, 1)$$



$$p(j, x) := \begin{vmatrix} y \leftarrow |x| \\ z \leftarrow p1(y) \text{ if } j = 1 \\ z \leftarrow p2(y) \text{ if } j = 2 \\ z \leftarrow p1(y) \text{ if } j = 3 \\ z \leftarrow p4(y) \text{ if } j = 4 \\ z \leftarrow p4(y) \text{ if } j = 5 \\ z \leftarrow p3(y) \text{ if } j = 6 \\ z \leftarrow p1(y) \text{ if } j = 7 \\ z \leftarrow p1(y) \text{ if } j = 8 \\ z \end{vmatrix}$$

$$P(i, ii, j) := \text{if}\left[I_j \cdot \left(t_{j,i} - t_{j,ii}\right) \le 0, 0, p\left[j, \left|t_{j,i} - t_{j,ii}\right|\right]\right]$$

Mide la diferencia para cada criterio *j* , dando un valor P(*i,ii,j*) pasado a entre 0 y 1, positivo si en ello la alternativa i tiene mejor valor T(*i,j*) = Im(*i,j*) que la *ii* = *k* ; y es 0 cero en caso contrario.

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PROMETHEE, Mathcad

A.- Results following initial PROMETHEE methods of Brans&Vinkle

$$q(i,ii) := \left(\sum_{j=1}^{8} P(i,ii,j) \right) \cdot 8^{-1}$$

Incoming flow: $fm(i) := \sum_{ii=1}^{5} q(ii,i)$ $\quad fmm_i := fm(i)$

Outgoing flow: $fp(i) := \sum_{ii=1}^{5} q(i,ii)$ $\quad fpp_i := fp(i)$

$fd(i) := fp(i) - fm(i)$ $\quad fdd_i := fd(i)$

Total flow

PROMETHEE II (clasification of alternatives by Total Preorder, Each alternative obtain one value fdd(i) (more is better):

$$fmm = \begin{bmatrix} 1.167 \\ 1.25 \\ 1.313 \\ 1.854 \\ 1.167 \end{bmatrix} \quad fpp = \begin{bmatrix} 1.813 \\ 1.313 \\ 1.333 \\ 0.458 \\ 1.833 \end{bmatrix} \quad fdd = \begin{bmatrix} 0.646 \\ 0.063 \\ 0.021 \\ -1.396 \\ 0.667 \end{bmatrix}$$

PROMETHEE I (clasification of alternatives by Partial Preorder):

$pr(i,ii) :=$ $z \leftarrow -1$

$z \leftarrow 0$ if $(fp(i) = fp(ii)) \cdot (fm(i) = fm(ii))$

$z \leftarrow 1$ if $(fp(i) > fp(ii)) \cdot (fm(i) < fm(ii))$

$z \leftarrow 1$ if $((fp(i) > fp(ii)) \cdot (fm(i) = fm(ii)))$

$z \leftarrow 1$ if $((fp(i) = fp(ii)) \cdot (fm(i) < fm(ii)))$

z

$prr_{i,ii} := pr(i,ii)$

Alternative E is preferred

$$prr = \begin{bmatrix} 0 & 1 & 1 & 1 & -1 \\ -1 & 0 & -1 & 1 & -1 \\ -1 & -1 & 0 & 1 & -1 \\ -1 & -1 & -1 & 0 & -1 \\ 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

pr(i,ii) = 1 tell us that alternative i is preferenced (outranks) to alternative j, pr(i,ii) = 0 is indifference and pr(i,ii) = -1 are incomparable, they may be compared by pr(ii,i).

PROMETHEE, Mathcad

B Results following the Weighted PROMETHEE method

$$q(i, ii) := \sum_{j=1}^{8} P(i, ii, j) \cdot W_j$$

Incoming flow: $fm(i) := \sum_{ii=1}^{5} q(ii, i)$ $\quad fmm_i := fm(i)$

Outgoing flow: $fp(i) := \sum_{ii=1}^{5} q(i, ii)$ $\quad fpp_i := fp(i)$

$fd(i) := fp(i) - fm(i)$ $\quad fdd_i := fd(i)$

Total flow

PROMETHEE II (clasification of alternatives by Total Preorder fdd ::

PROMETHEE I (clasification of alternatives by Partial Preorden) :

$pr(i, ii) :=$
- $z \leftarrow -1$
- $z \leftarrow 0$ if $(fp(i) = fp(ii)) \cdot (fm(i) = fm(ii))$
- $z \leftarrow 1$ if $(fp(i) > fp(ii)) \cdot (fm(i) < fm(ii))$
- $z \leftarrow 1$ if $((fp(i) > fp(ii)) \cdot (fm(i) = fm(ii)))$
- $z \leftarrow 1$ if $((fp(i) = fp(ii)) \cdot (fm(i) < fm(ii)))$
- z

$$fmm = \begin{bmatrix} 1.033 \\ 1.1 \\ 1.4 \\ 1.95 \\ 1.25 \end{bmatrix} \quad fpp = \begin{bmatrix} 1.9 \\ 1.5 \\ 1.2 \\ 0.417 \\ 1.717 \end{bmatrix} \quad fdd = \begin{bmatrix} 0.867 \\ 0.4 \\ -0.2 \\ -1.533 \\ 0.467 \end{bmatrix}$$

Alternative A is preferred

$prr_{i, ii} := pr(i, ii)$

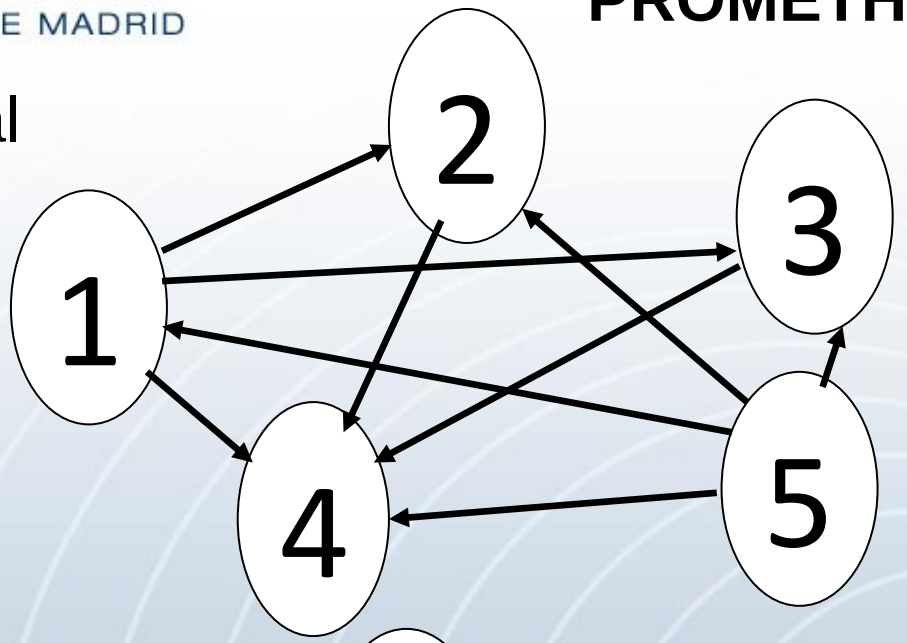
$$prr = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 \\ -1 & 0 & 1 & 1 & -1 \\ -1 & -1 & 0 & 1 & -1 \\ -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & 1 & 1 & 0 \end{bmatrix}$$

pr(i,ii) = 1 tell us that alternative i is preferenced (outranks) to alternative j, pr(i,ii) = 0 is indifference and pr(i,ii) = -1 are incomparable, they may be compared by pr(ii,i).

PROMETHEE II

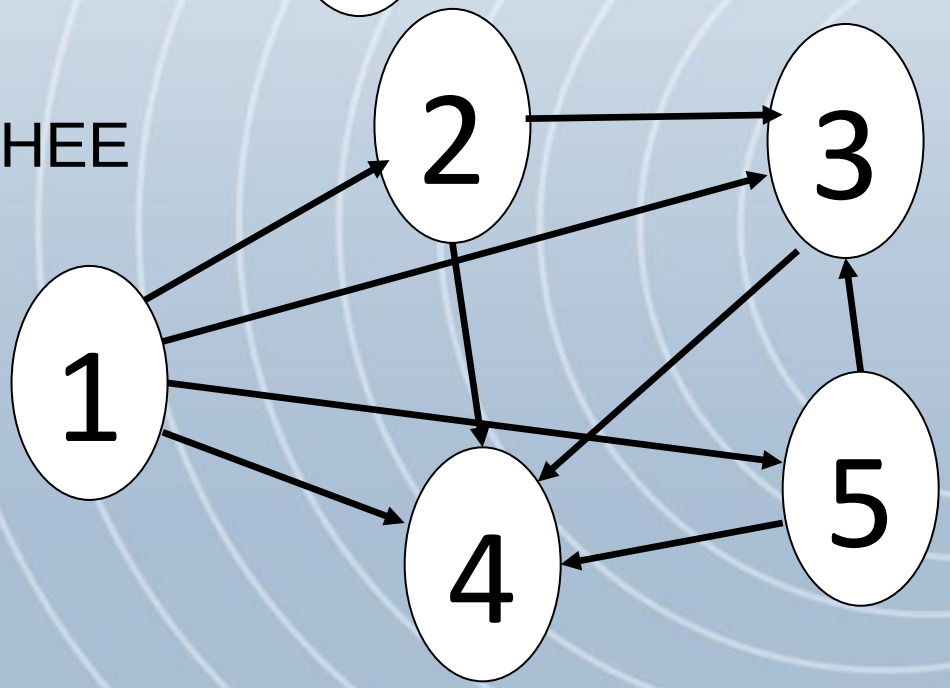
- PROMETHEE original

$$\pi = \begin{bmatrix} 0 & 1 & 1 & 1 & -1 \\ -1 & 0 & -1 & 1 & -1 \\ -1 & -1 & 0 & 1 & -1 \\ -1 & -1 & -1 & 0 & -1 \\ 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$



- Weighted PROMETHEE

$$\pi = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 \\ -1 & 0 & 1 & 1 & -1 \\ -1 & -1 & 0 & 1 & -1 \\ -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & 1 & 1 & 0 \end{bmatrix}$$



- Se viene usando en **La Estrella** la alternativa **A Bosque Autóctono**, bastante degradado por usarlo para ferrocarril antes; hay indios wichis, cabras y chanchos … Pero en la buena **Finca La Moraleja**, unas 33000ha **regando** con aguas del río San Francisco (viene del Oeste), hay algo como alternativa **E, Erosion control Crop with industrial use (biomass)**, (y un poco **D, Erosion control Crop with agriculture use,** y **algo B) High value forest**).
- A continuación se extiende el método para considerar otras áreas del Chaco Salteño.
- Se mantiene para ello una redacción anterior con diapositivas.

METHODOLOGY

- We have used Multiple Criteria Decision-Making Method **PROMETHEE** ((Preference Ranking Organization METHod for Enrichment Evaluations)) by J.P. Brans, Ph. Vincke 1986(2).
- Following Brands two possibilities are offered:

  - PROMETHEE I that provide a partial preorder

  -PROMETHEE II a total preorder on the set of possible alternative.
- We have also use weighted PROMETHEE Method in pararel with ELECTRE Method, taking, some times, the same Initial Matrix and weights and …
- We compare the results

STUDY AREA

- Chaco area is situated in the Province of Salta at North West of Argentine. The desertification is a big problem. In order to mitigate the problem it is necessary to take into account not only pedologic criteria but the economical, environmental, cultural and sociological criteria. Six sub zones have been established following previous studies. Eight criteria and six alternatives have been introduced in the model

EROSION FACTORS

- 1) Water is the most critical factor
- 2) Historically, the human exploitation of natural forest to use in the railway and other activities
- 3) Later on, the autochthonous population following the irrational wood extraction and over pasture as "modus vivendi"

DESERTIZATION BY EROSION

CRITERIA

- **Water erosion, WE**
- **Eolian erosion, EE**
- **Implementation Facility, IF**
- **Water Resources, WR**
- **Economical benefits, EB**
- **Hand power, HP**
- **Environmental Impacts, EI**
- **Social Acceptance, SA**

ALTERNATIVES

- A) **Autochthonous forest**
- B) **High value forest**
- C) **Traditional farms**
- D) **Erosion control Crop with agriculture use**
- E) **Erosion control crop with industrial use (biomass)**

SUB-ZONES

- Las Lajitas.
- La Estrella.
- Pichanal.
- Martin Hickmann.
- Rivadavia banda sur.
- Joaquín V. Gonzalez.

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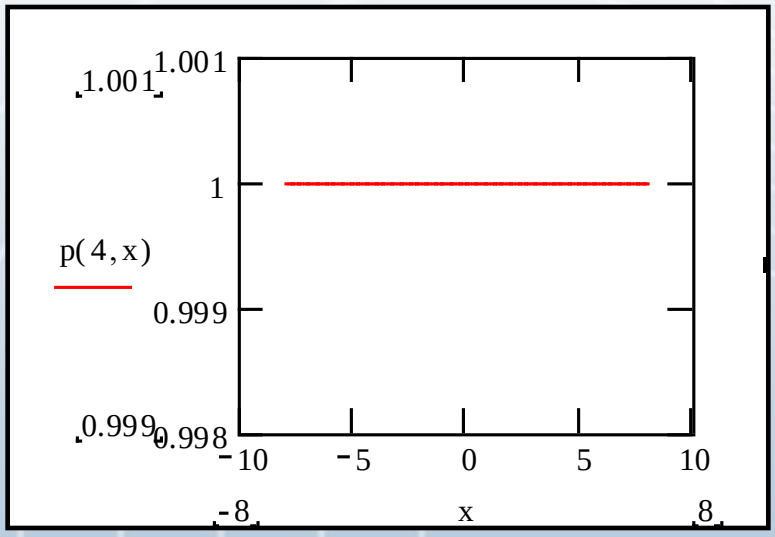
DECISIONAL MATRIX

For the Example: La Estrella subzone)

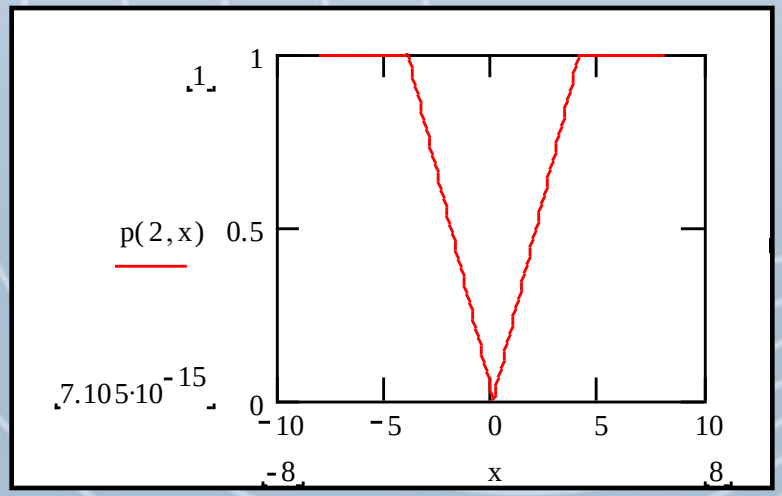
Alternative	W.E.I	E.E.I.	I.F.	W.R.	E.B.	H.P.	E.I.	S.A.
A	7	6	1	8	5	2	8	6
B	7	6	5	4	5	9	6	5
C	3	3	6	4	8	9	3	9
D	2	2	6	4	5	6	5	6
E	3	2	8	5	8	6	4	8
Weight	0,15	0,15	0,15	0,1	0,15	0,1	0,1	0,1
Pseudo criterion	III	III	III	I	I	III	III	III
Thresholds	2	4	4			6	6	2

TYPES OF PSEUDO-CRITERIA

- **Type I:** The usual pseudo-criterion

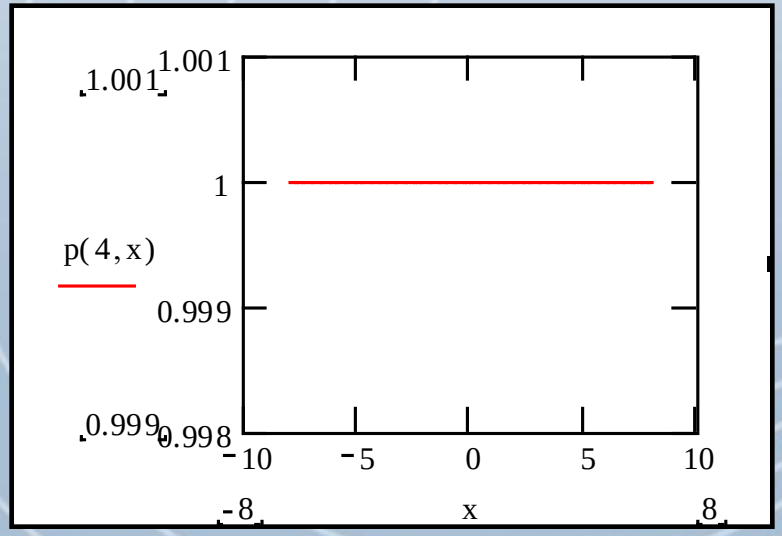


- **Type III:** pseudo-criterion with Linear Preference.



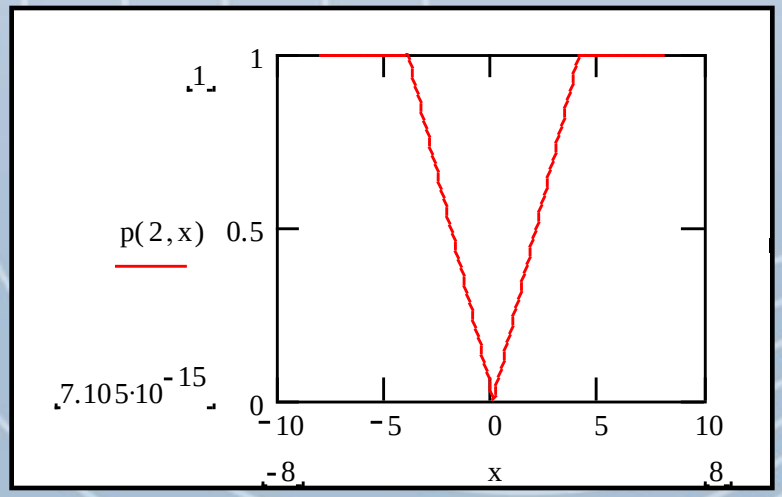
CRITERION TYPE I

- With this criterion if f(a)=f(b) this is indifference between a and b. If this is not the case the decision-maker has a strict preference for the action having greatest value.



CRITERION TYPE III

- Such an extension of the notion of criterion allows the decision-maker to prefer progressively a to b for progressively larger deviations between f(a) and f(b). The preference increases linearly until deviation equals m, after this value the preference is strict. For m the values 2, 4 and 6 have been taken.



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PROMETHEE MATHEMATICAL PROGRAMMATION – Mathcad®

EROSION AND DESERTIFICATION INTEGRAL CONTROL PLAN USING PROMETHEE

SUB ZONE LA ESTRELLA (1)

ORIGIN := 1

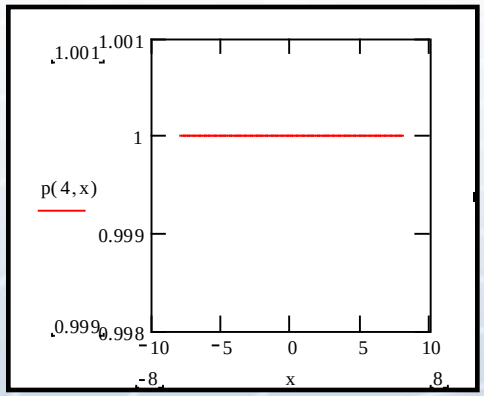
.

CRITERION: 1.-water erosion index 2.- eolian erosion index, 3.- Implementation facility 4.-Water Resources, 5.- Economical Benefits, 6.- Hand power, 7.-Environmental Impacts, 8.- Social Acceptance

Index Isubj:
more is better Isubj = 1
more is worse Isubj = -1

alternatives i
1 2 3 4 5

$$t := \begin{bmatrix} 7 & 7 & 3 & 2 & 3 \\ 6 & 6 & 3 & 2 & 2 \\ 1 & 5 & 6 & 6 & 8 \\ 8 & 4 & 4 & 4 & 5 \\ 5 & 5 & 8 & 5 & 8 \\ 2 & 9 & 9 & 6 & 6 \\ 8 & 6 & 3 & 5 & 4 \\ 6 & 5 & 9 & 6 & 8 \end{bmatrix} \quad I := \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad W := \begin{bmatrix} 0.20 \\ 0.15 \\ 0.15 \\ 0.10 \\ 0.10 \\ 0.10 \\ 0.10 \\ 0.10 \end{bmatrix}$$



Alternatives:
i = 1 ....5 .

with x >= 0, if not with |x|

Functions of pseudo-criterion-parameter and type elected for each criterion j:
following Brans @ Vincke

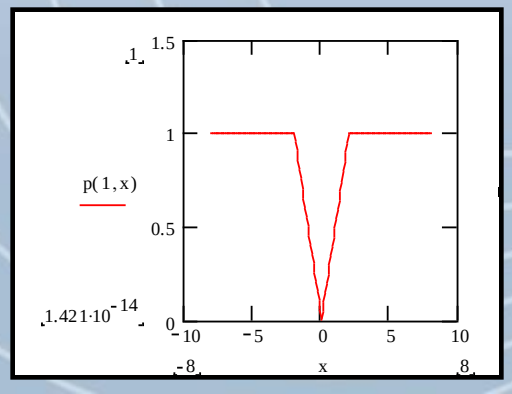
j = 1 type III, m=2, j = 2 type III, m=4, j=3 type III, m=4, j=4 type I
j = 5 type I ,
j = 6 type III, m=6, j=7 type III, m=6 j=8 type III, m=2

$$p1(x) := if\left(x \le 2, \frac{x}{2}, 1\right)$$

$$p2(x) := if\left(x \le 4, \frac{x}{4}, 1\right)$$

$$p4(x) := if(x = 0, 0, 1)$$

$$p3(x) := if\left(x \le 6, \frac{x}{6}, 1\right)$$



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PROMETHEE MATHEMATICAL PROGRAMMATION – Mathcad®

A.- Results following initial methods of Brans&Vincke: :

Índixes q(i,ii) of preferences((,ii) Brans&Vincke), giving outranking graphs according with values:

$$q(i,ii) := \frac{\sum_{j=1}^{8} P(i,ii,j)}{8}$$

$i := 1..5 \quad ii := 1..5 \qquad qq_{i,ii} := q(i,ii)$

$$qq = \begin{bmatrix} 0 & 0.229 & 0.448 & 0.438 & 0.458 \\ 0.25 & 0 & 0.281 & 0.333 & 0.354 \\ 0.5 & 0.281 & 0 & 0.406 & 0.156 \\ 0.208 & 0.094 & 0.042 & 0 & 0.021 \\ 0.458 & 0.469 & 0.208 & 0.5 & 0 \end{bmatrix}$$

Outgoing flows: $fp(i) := \sum_{ii=1}^{5} q(i,ii) \qquad fpp_i := fp(i)$

$$fpp = \begin{bmatrix} 1.573 \\ 1.219 \\ 1.344 \\ 0.365 \\ 1.635 \end{bmatrix}$$

Incoming flows: $fm(i) := \sum_{ii=1}^{5} q(ii,i) \qquad fmm_i := fm(i)$

$$fmm = \begin{bmatrix} 1.417 \\ 1.073 \\ 0.979 \\ 1.677 \\ 0.99 \end{bmatrix}$$

PROMETHEE II (clasification of alternatives by Total Preorder)

$fd(i) := fp(i) - fm(i) \qquad fdd_i := fd(i)$

$$fdd = \begin{bmatrix} 0.156 \\ 0.146 \\ 0.365 \\ -1.313 \\ 0.646 \end{bmatrix}$$

Alternative E: Erosion control Crop with agriculture use.

$$fdd = \begin{bmatrix} 0.156 \\ 0.146 \\ 0.365 \\ -1.313 \\ 0.646 \end{bmatrix}$$

Alternative E is preferred

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PROMETHEE MATHEMATICAL PROGRAMMATION – Mathcad®

B Results following the method modified by Ref [6] in order to we comparativment the criteria with similar weights to ELECTRE-I:

q Preference Index (π in Ref [4]), gives outranking graph by values

Including the weights W(j) and are multiplied by 5 .

$$q(i,ii) := \frac{\sum_{j=1}^{8} P(i,ii,j)\cdot W_j}{5}$$

$i := 1..5 \quad ii := 1..5$

$qq_{i,ii} := q(i,ii)\cdot 5$

$$qq = \begin{bmatrix} 0 & 0.45 & 1.533 & 1.8 & 1.567 \\ 1.3 & 0 & 1.1 & 1.667 & 1.533 \\ 1.95 & 0.667 & 0 & 1.1 & 0.467 \\ 1.15 & 0.167 & 0.033 & 0 & 0.017 \\ 1.933 & 1.05 & 0.417 & 1.033 & 0 \end{bmatrix}$$

Outgoing flows: $fp(i) := \sum_{ii=1}^{5} q(i,ii)$ $\quad fpp_i := fp(i)$

$$fpp = \begin{bmatrix} 1.07 \\ 1.12 \\ 0.837 \\ 0.273 \\ 0.887 \end{bmatrix}$$

Incoming flows: $fm(i) := \sum_{ii=1}^{5} q(ii,i)$ $\quad fmm_i := fm(i)$

$$fmm = \begin{bmatrix} 1.267 \\ 0.467 \\ 0.617 \\ 1.12 \\ 0.717 \end{bmatrix}$$

PROMETHEE II (clasification of alternatives by Total Preorder

$fd(i) := fp(i) - fm(i)$ $\quad fdd_i := fd(i)$

$$fdd = \begin{bmatrix} -0.197 \\ 0.653 \\ 0.22 \\ -0.847 \\ 0.17 \end{bmatrix}$$

PROMETHEE I (clasificación de acciones (alternativas) por Preorder Parcial:

Alternative B: High value forest

$$fdd = \begin{bmatrix} -0.197 \\ 0.653 \\ 0.22 \\ -0.847 \\ 0.17 \end{bmatrix}$$

Alternative B is preferred

Se usaron TESTs

- Some modifications were introduced and tried in order to test the robustesness:

1) Other value of criteria, same weight, pseudo-criteria and thresholds

2) Changing the weights.

For La Estrella the weights gave more importance to the 4 first criteria; {Water erosion, Eolian erosion, Implementation Facility, Water Resources, Economical benefits, Hand power, Environmental Impacts, Social Acceptance}.

Resultados Generales

Subzone / Matrix-weights	Martin Hickman	La Estrella	Rivadavia Banda Sur	Pichanal	J. V. González	Las Lajitas
PROMETHEE ORIGINAL						
1	**A**	**E**	**E**	**E**	**C**	**C**
2	**C**	**A**	**A**	**C**	**C**	**C**
3	**A**	**E**	**E**	**E**	**C**	**C**
4	**C**	**A**	**A**	**C**	**C**	**C**
Weighted PROMETHEE						
1	**A**	**E**	**A**	**E**	**C**	**C**
2	**A**	**A**	**A**	**C**	**C**	**C**
3	**A**	**B**	**A**	**E**	**C**	**C**
4	**A**	**A**	**A**	**A**	**C**	**C**

Criteria Types, Brans

Type I: *Usual Criterion*

In this case:

$$p(x) = \begin{cases} 0 & \forall x \leqslant 0, \\ 1 & \forall x > 0; \end{cases}$$

Type II :

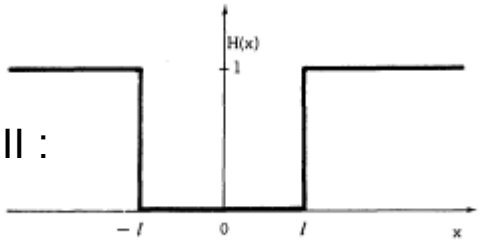

FIGURE 2. Criterion of Type II.

Type II: *Quasi-Criterion*

Let $p(x)$ be:

$$p(x) = \begin{cases} 0, & x \leqslant l, \\ 1, & x > l. \end{cases}$$

Type IV: *Level-Criterion*

Let $p(x)$ be:

$$p(x) = \begin{cases} 0, & x \leqslant q, \\ 1/2, & q < x \leqslant q + p, \\ 1, & x > q + p. \end{cases}$$

Type III: *Criterion with Linear Preference*

Let $p(x)$ be:

$$p(x) = \begin{cases} x/m, & x \leqslant m, \\ 1, & x \geqslant m. \end{cases}$$

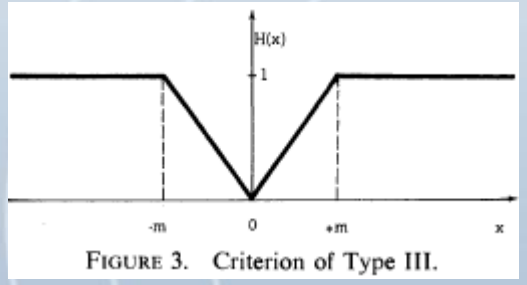

FIGURE 3. Criterion of Type III.

Type V: *Criterion with Linear Preference and Indifference Area*

This time we consider for $p(x)$:

$$p(x) = \begin{cases} 0, & x \leqslant s, \\ (x - s)/r, & s \leqslant x \leqslant s + r, \\ 1, & x \geqslant s + r. \end{cases}$$

Type VI: *Gaussian Criteria*

Let $p(x)$ be:

$$p(x) \begin{cases} 0, & x \leqslant 0, \\ 1 - e^{-x^2/2\sigma^2}, & x > 0. \end{cases}$$

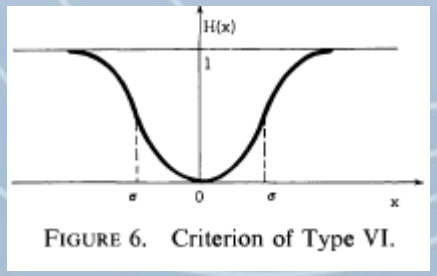

FIGURE 6. Criterion of Type VI.

Se ha expuesto un caso I de Elección de modos de uso de tierras en las áreas del Chaco Salteño.

Ahora luego se va a exponer más brevemente sobre la Elección del modo de Ente Gestor de Recursos Hídricos para una región en la Provincia de Salta.
En inglés: Election of water resources management entity.

CASE II ELECCIÓN DEL MODO DE ENTE GESTOR DE RECURSOS HÍDRICOS

Estas entidades hacen falta y existen en muchas áreas hidrológicas. De antiguo “Tribunal de aguas de Valencia”. A España la cubren “Confederaciones Hidrográficas”, consorcios al MOP(U) o MAGRAMA, que abarcan partición en grandes cuencas o zonas. Existen comunidades de regantes.

Én este caso aquí se hizo con Pr.J.B.Grau con UCASAL para áreas pensando en la Prov. De Salta Argentina. Se pensaba en cuencas menores y sale más bien el punto de vista de propietarios que las explotan. Allí hay “zonas fiscales” públicas. Provincia de Salta {155488 km2, 1333365 habtes}, tiene zonas andinas (Puna), Chaco, y centro muy variado, ríos relieve …

INTRODUCCIÓN

- In the XXI Century, Water Resources (WR) have got one of the top priorities worldwide. This is not only due to the need of this element for each one of the society sectors (agriculture, industry, residential use, etc) but also or its great irregularity, as much as in time as in space.
- The consequences of the lack, as well as the excess can be dangerous, since the lost of productions till catastrophic floods and therefore can be a landslide.
- Besides, the water pollution due to uncontrolled drainages carries out strong consequences for the people's health, also for the extinction of the natural habitat and for the environmental risks.

INTRODUCCIÓN (II)

- In the majority of the countries, except maybe in the Valencian Community (Spain) … , a worry for the knowledge of the existent Water Ressource and its integral dealing have recently started within 4 fields:
- 1) The transformation into irrigable land of huge extensions of dry land, due to a bigger demand of agriculture products.
- 2) The usage of water for leisure and tourism purposes, since in large areas where water was not used, the population has increased strongly by a factor of 10, having installed golf courses, tourist and residential areas.
- 3) Bigger worry for environmental issues.
- 4) The mass-media pressure that derives from that conduces or is partly known by “the **Climate Change”.**

NUEVAS NECESIDADES, NEW NEEDS

- The transformation into irrigable land, of huge extensions of dry land, due to a bigger demand of agriculture products.
- The usage of water for leisure and tourism purposes
- Bigger worry for environmental issues.
- The massmedia pressure

OBJECTIVO

The creation of an organism to watch, to standardize and to manage the water resource use.

Elección del modo de Ente Gestor de Recursos Hídricos.

THE PROBLEM

The competences are spread and in many cases are confronted, being more important political and competence subjects than the rational, technical and economic.

INITIAL MATRIX, Im(*i*,*j*)

Criteria / Alternatives	Implementation Facility	Implementation delay	Legislation in Force	Social Acceptance	Flexibility
Public Entity	8	12	10	5	5
Institute	7	18	8	6	6
Foundation	6	18	7	7	7
Cooperative	7	20	7	8	8
Private Company	6	15	5	4	9
Weights	0.30	0.10	0.15	0.20	0.25
Index	+1	-1	+1	+1	+1

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Election of water resources management entity USING PROMETHEE

CRITERION (j): 1.- Implementation facility 2.-Implementation delay, 3.- Legislation in Force, 4.- Social Acceptance , 5.-Flexibility

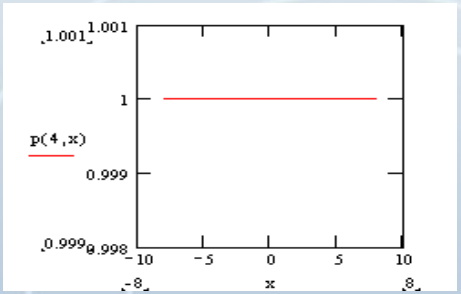
Alternatives: 1.-Public Entity, 2.- Institute, 3.- Foundation, 4.- Cooperative, 5.- Private company i = 1 ....5 .

Index Isubj:
more is better Isubj = 1
more is worse Isubj = -1

alternatives i
1 2 3 4 5

$$t := \begin{bmatrix} 8 & 7 & 6 & 7 & 6 \\ 12 & 18 & 18 & 20 & 15 \\ 10 & 8 & 7 & 7 & 5 \\ 5 & 6 & 7 & 8 & 4 \\ 5 & 6 & 7 & 8 & 9 \end{bmatrix} \quad I := \begin{bmatrix} 1 \\ -1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad W := \begin{bmatrix} 0.30 \\ 0.10 \\ 0.15 \\ 0.20 \\ 0.25 \end{bmatrix} \quad t^T = \begin{bmatrix} 8 & 12 & 10 & 5 & 5 \\ 7 & 18 & 8 & 6 & 6 \\ 6 & 18 & 7 & 7 & 7 \\ 7 & 20 & 7 & 8 & 8 \\ 6 & 15 & 5 & 4 & 9 \end{bmatrix}$$

$p4(x) := if(x=0, 0, 1)$



A.- Results following initial methods of Brans&Vinkle:

Outgoing flow: $fp(i) := \sum_{ii=1}^{5} q(i, ii)$ $fpp_i := fp(i)$ $fpp = \begin{bmatrix} 2.6 \\ 1.8 \\ 1.4 \\ 2 \\ 1.4 \end{bmatrix}$

PROMETHEE II (clasification of alternatives by Total Preorder, Each alternative obtain one value(more is better):

$fd(i) := fp(i) - fm(i)$ $fdd_i := fd(i)$ $fdd = \begin{bmatrix} 1.2 \\ 0 \\ -0.6 \\ 0.4 \\ -1 \end{bmatrix}$

PROMETHEE I (clasification of alternatives by Partial Preorden):

Incoming flow: $fm(i) := \sum_{ii=1}^{5} q(ii, i)$ $fmm_i := fm(i)$ $fmm = \begin{bmatrix} 1.4 \\ 1.8 \\ 2 \\ 1.6 \\ 2.4 \end{bmatrix}$

$prr = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 \\ -1 & 0 & 1 & -1 & 1 \\ -1 & -1 & 0 & -1 & 1 \\ -1 & 1 & 1 & 0 & 1 \\ -1 & -1 & -1 & -1 & 0 \end{bmatrix}$

Alternative 1 is preferred: Public Entity

Resultados a partir del PROMETHEE con pesos

$$q(i,ii) := \frac{\sum_{j=1}^{5} P(i,ii,j)\cdot W_j}{1}$$

$$qq = \begin{bmatrix} 0 & 0.55 & 0.55 & 0.55 & 0.75 \\ 0.45 & 0 & 0.45 & 0.25 & 0.65 \\ 0.45 & 0.45 & 0 & 0.1 & 0.35 \\ 0.45 & 0.45 & 0.75 & 0 & 0.65 \\ 0.25 & 0.35 & 0.35 & 0.35 & 0 \end{bmatrix}$$

Alternatives: 1.-Public Entity, 2.-Institute, 3.- Foundation, 4.- Cooperative, 5.- Private company

outgoing flows: $fp(i) := \sum_{ii=1}^{5} q(i,ii)$ $fpp_i := fp(i)$

$$fpp = \begin{bmatrix} 2.4 \\ 1.8 \\ 1.35 \\ 2.3 \\ 1.3 \end{bmatrix}$$

Incoming flows: $fm(i) := \sum_{ii=1}^{5} q(ii,i)$ $fmm_i := fm(i)$

$$fmm = \begin{bmatrix} 1.6 \\ 1.8 \\ 2.1 \\ 1.25 \\ 2.4 \end{bmatrix}$$

$$I := \begin{bmatrix} 1 \\ -1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \qquad W := \begin{bmatrix} 0.30 \\ 0.10 \\ 0.15 \\ 0.20 \\ 0.25 \end{bmatrix}$$

PROMETHEE I modified

$$prr = \begin{bmatrix} 0 & 1 & 1 & -1 & 1 \\ -1 & 0 & 1 & -1 & 1 \\ -1 & -1 & 0 & -1 & 1 \\ -1 & 1 & 1 & 0 & 1 \\ -1 & -1 & -1 & -1 & 0 \end{bmatrix}$$

Alternative 4 is preferred COOPERATIVE, but nearly after it is Alternative 1 Public Entity

PROMETHEE II modified

$$fdd = \begin{bmatrix} 0.8 \\ 0 \\ -0.75 \\ 1.05 \\ -1.1 \end{bmatrix}$$

T(*j*,*i*)=Im(*i*,*j*)

$$t^T = \begin{bmatrix} 8 & 12 & 10 & 5 & 5 \\ 7 & 18 & 8 & 6 & 6 \\ 6 & 18 & 7 & 7 & 7 \\ 7 & 20 & 7 & 8 & 8 \\ 6 & 15 & 5 & 4 & 9 \end{bmatrix}$$

CRITERION (j): 1.- Implementation facility 2.-Implementation delay, 3.- Legislation in Force, 4.- Social Acceptance , 5.-Flexibility

The 12th World Multi-Conference on
Systemics, Cybernetics and Informatics

Session's Best Paper Award

Session: Neural Networks and Soft Computing in Signal, Communications and Industry

presented to

Juan B. Grau, José M. Anton, Ana M. Tarquis and Diego Andina

for the paper entitled

Election of Water Resources Management Entity Using a Multi-Criteria Decision (MCD) Method in Salta Province (Argentine)

William Lesso
Honorary Chair

July 2nd, 2008

Nagib Callaos
General Chair

CONCLUSIONES

- En general el método PROMETHEE ha sido muy útil en todos los casos que hemos estudiado.

- Hemos obtenido que el PROMETHEE II modificado usando pesos como en el ELECTRE I es más robusto.

- Para estos fines les recomendaríamos a ustedes su uso con varios tipos de seudocriterios.

- Estos procesos para decisión dependen mucho de la pericia y experiencia sobre la situación real de los agentes involucrados en ello.

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Para nuestros dos casos dos referencias nuestras en revistas.

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- ***Y luego presentamos una lista de referencias sobre estos temas :***
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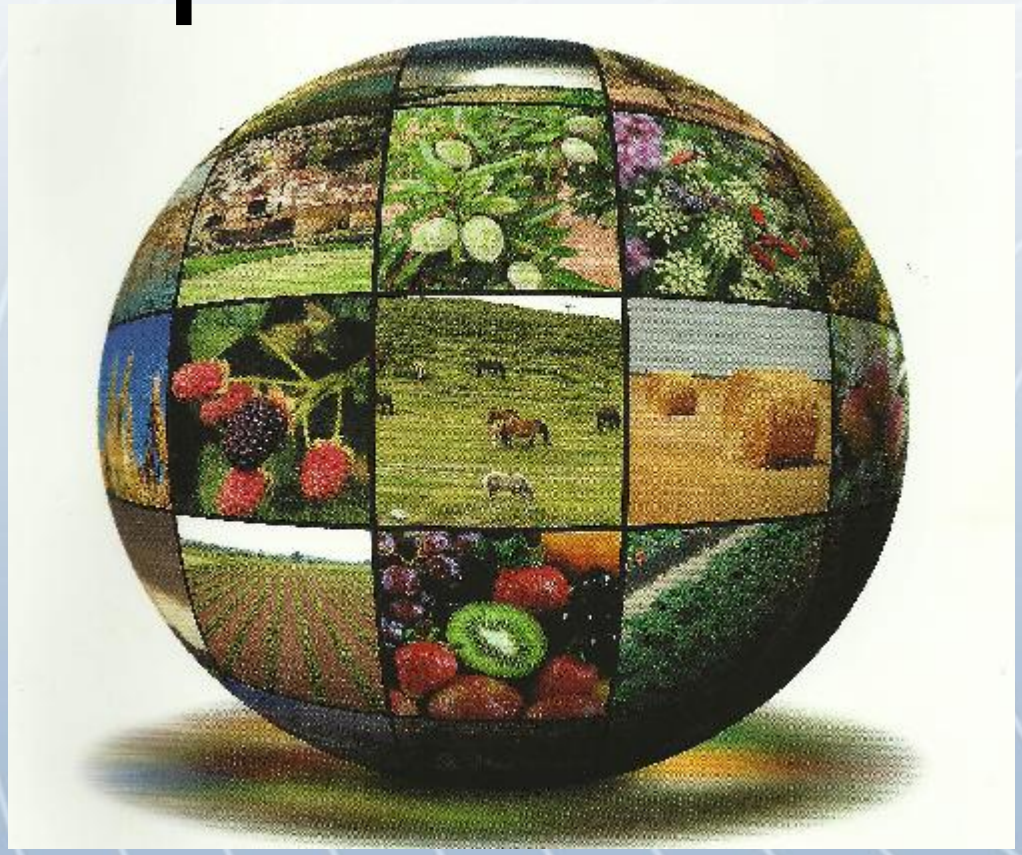
Muchas Gracias …

por su



Atención