ELECTION OF WATER RESOURCES MANAGEMENT ENTITY IN SALTA PROVINCE (ARGENTINE) TAKING INTO ACCOUNT THE PROBABILITY OF FUTURE SITUATION

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ABSTRACT
In the decision-making, in many cases, we need to know the situation in a next step, if another alternative was adopted or which would be the best alternative, in that moment, with the situation that is envisaged. Decision making for election of regional water resources management entities shows a high complexity, due to much interrelation between aspects, decision makers and planning procedures. We make the decision following the Multi-criteria Discrete Decision Methods and we combine this procedure with the Bayesian methods and dynamic programming. The new decisional matrix, weights and the utility functions are obtained under uncertainty. We combine uncertainty and decision-making. An objective function, relating effects of decisions to actions, often cannot be specified in advance. This is an approach of MCDM to decide in conflict situations

KEYWORDS: Multi-criteria Decision Methods, Water Resources, Environment, Discrete Decision-Methods, Optimization.

1. INTRODUCTION
   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 for 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 the environmental risks.
    Decision-Making for the election of regional water resources management entities shows a high complexity, due to many interrelations between aspects, decision makers and planning procedures. The aspects that must be taken into consideration are of technical, psychological, sociological, ergonomical and organisational nature. Decision makers are policy makers, planners, designers, associations of users and lawyers. The entity must create a complex structure, at regional level relating with national and international entities. This structure should have bodies for drinking and industrial water resources management and for land use at several levels. It will establish short, medium and long range planning of water resources. [4]
For all that, new laws, and rules for surface water and groundwater are coming up, as well as the creation of an organism to watch, to standardize and to manage the water resource use. In the past for the creation of entity and planning structure no mathematical methods and models were used. Heuristics and experience of decision makers sufficed. Today we have Multi-criteria Decision Methods to aid the decision makers in so an important decision. [1], [22]

2. GEO-HYDROLOGIC CHARACTERISTICS AND CURRENT LEGAL SITUATION OF SALTA PROVINCE (ARGENTINE)

The Salta Province has 155 000 km2 and 1 million population, is at NW of Argentina (NOA) having latitudes around 25°S, it has rain from 400 to 800 mm/year (with peaks of 1200 in high altitude places in SO) and great ranges of altitude (at NE are areas at 200m and at NW a PUNA region with summits higher than 6000m). It has a low density of population in small cities located in important long mountain valleys, has low standards for roads and it has an environment that is "deteriorating progressively".

Bermejo river is the most important fluvial artery in the area. It presents a zone known as a meander digression since due to low slopes its course changes constantly forming meanders. That area in rainy period is transformed into a immense sheet of rain that completely isolates the communities living by the river between 5 to 10 km from the riverside. It produces a constant erosion that makes a great lot of sediments setting down at the Paraná river generating an important cost in the continuous drainage. The majority and more important flowing of the Paraná drain through this region, such us Pilcomayo, San Francisco flowing into Bermejo, Juramento or Salado. The Horcones and the rest like Itiyuro, Rio Seco, Dorado, Del Valle etc., less in water but very important for the Province, end in marshlands, generating wet areas.

In the climate aspect the lack of water is the characteristic in the whole region. Rainfall is concentrated in the summer time. The rainfall presents a strong decline, from 1200 mm per year in the east to 300 mm in the Southwest. In the Northeast it goes up to 1200 mm. The groundwater resources are poor in volume and in quality (salty and with arsenic). It is possible to find good quality groundwater but in deep levels (100m) with high operating costs.

Water is the most critical factor, as much for human and animal consumption, as for the production system in general. For that reason, it is so important to define an official entity for the WR, in order to contemplate all the aspects related with data control and water management from its capture till it is used, as well as those in relation to the social, cultural and economic substratum, where they must be applied. The management of water must include both the surface water and groundwater due to the critical resource in that region. For that, an effort should be made in seeking the best way of extraction and usage in low cost and to implement good management and the best practices.

At national level, the responsible entity is the "Subsecretaría de Recursos Hídricos" and the "Dirección Nacional de Recursos Hídricos". In the different provinces we find organisms with similar status. At regional level "Comités de Cuenca" (Basin Committees) are being created with non-executive functions. Since 5 years ago when the privatizations took place, the maintenance and operative functions of waste and drinkable water systems were assigned to licensees.

In 2007 the Law Nº 7017 was published. This Law is the "Código de Aguas de la Provincia de Salta y los Reglamentos Técnicos de la Agencia de Recursos Hídricos" (Water Code of Salta Province and the Technical Rules of the WR Agency). In this Law were included the province competences in relation to provincial, interprovincial and international public WR. The definition, competences, etc., concerning the Consortia (definition, competences,...) are included in title VI of the above mentioned Law Also in article 198 appears the second degree Consortia (as "Asociación de Consorcios").

Other public entities: "Instituto Nacional del Agua" (INA ex-INCYTH), "Instituto Nacional de Tecnología Agropecuaria" (INTA), "Instituto Nacional de Tecnología Industrial" (INTI) are involved in this area. In the same way Universities and Provincial Technical Organisms. In relation with the water quality the "Dirección Nacional de Emergencia Sanitaria" (DINES) is the responsible entity. It is not yet established a National Data Collection System. For that reason it has been planned to establish the" Sistema Nacional de Información de Saneamiento Para Agua Potable y Saneamiento" in charge of the "Subsecretaría de Recursos Hídricos".

Regional Commissions have been created linked to the different basins, like the COREBE (Comisión Regional del Rio Bermejo). In the case of international basins there have been created

international commissions, the COBINABE ("Comisión Binacional para el Desarrollo de la Alta Cuenca del Rio Bermejo y Rio Grande de Tarija") created between Argentina and Bolivia at 9th of July of 1995 in Salta (Argentine).

Some of the most important problems are the lack of full WR information, the dispersion of databases and the lack of suitable data processing. The data can be stored in the Air Forces, Airports, INTA, Railways, Universities, Water Entities, etc. It is not possible to obtain complete time series in different zones.[2], [3], [4]

3. MULTI-CRITERIA DECISION (MCD) METHODS

Several methods can be used to decide the best alternative. In [2] we have used the three formal and well-known methods: ELECTRE I, A.H.P. and PROMETHEE I and II, but we think the set of probabilities associated with the change of social acceptance, political situation and flexibility as well as with the weights should be considered. [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [19], [20], [21], [23]

We consider now the result of decision taken in the present situation and that derived of the decision that in a fix future step should be taken. We start with initial decisional matrix, [2].

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**

Table 1. Decisional matrix. Index: +1 is "more is better", -1 is "more is worst"

The probabilities that the data indicated in Initial Matrix above are going up, maintaining the same level and going down are the following.
Regarding Legislation in Force:
Public Entity: 0; 0.7; 0.3
Institute: 0; 0.5, 0.5
Foundation: 0.2, 0.5, 0.3
Cooperative: 0.6, 0.4, 0
Private Company: 0.20, 0.5, 0.3
Regarding Social Acceptance
Public Entity: 0.10; 0.3; 0.6
Institute: 0.3; 0.6,; 0.1
Foundation: 0.2; 0.5; 0.3
Cooperative: 0.6; 0.3; 0.1
Private Company: 0.20, 0.4, 0.4
Regarding Flexibility
Public Entity: 0.20; 0.4; 0.4
Institute: 0.4; 0.4; 0.2

Foundation: 0.3; 0.5; 0.2
Cooperative: 0.6; 0.3; 0.1
Private Company: 0.5, 0.3, 0.2
The probabilities associated to the change of weights are:
Implementation Facility: From 0.30 to 0.15 is 0.7
Implementation Delay: From 0.10 to 0.10 is 0.6
Legislation in Force: From 0.15 to 0.15 is 0.6
Social Acceptance: From 0.2 to 0.3 is 0.7
Flexibility: From 0.25 to 0.3 is 0.7

LF	n	Pro.	n+1	Pro.	n+1	Pro.	n+1
P. E.	10	0	-	0.7	10	0.3	9
INS	8	0	9	0.5	8	0.5	7
FO	7	0.2	8	0.5	7	0.3	6
CO	7	0.6	8	0.4	7	0	6
P. C.	5	0.2	7	0.5	5	0..3	4
S.A.	n	Pro.	n+1	Pro.	n+1	Pro.	n+1
P.E.	5	0.1	6	0.3	5	0.6	4
IN	6	0.3	7	0.6	6	0.1	5
FO	7	0.2	8	0.5	7	0.3	6
CO	8	0.6	10	0.3	8	0.1	6
P.C.	4	0.2	5	0.4	4	0.4	3
FL	n	Pro.	n+1	Pro.	n+1	Pro.	n+1
P.E.	5	0.2	7	0.4	5	0.4	4
IN	6	0.3	7	0.6	6	0.1	5
FO	7	0.2	8	0.5	7	0.3	6
CO	8	0.6	10	0.3	8	0.1	6
P.C.	4	0.2	5	0.4	4	0.4	3

Table 2.- Probabilities associated to changes from n to n+1

Applying the probabilities to Table 1, we obtain the decisional matrix in n+1, Table 3.

Criteria / Alternatives	Implementation Facility	Implementation delay	Legislation in Force	Social Acceptance	Flexibility
Public Entity	8	12	9.7	4.5	5
Institute	7	18	7.5	6.2	6.2
Foundation	6	18	6.9	6.9	7.1
Cooperative	7	20	7.6	9	8.5
Private Company	6	15	5.1	3.8	9.3
Weights	**0.15**	**0.10**	**0.15**	**0.3**	**0.3**
Index	**+1**	**-1**	**+1**	**+1**	**+1**

Table 3.- Decisional matrix in n+1

Applying PROMETHEE II method we obtain in n+1

	Public Entity	Institute	Foundation	Cooperative	Private Company	Phi +
Public Entity	---------	0.4	0.4	0.4	0.7	0.475
Institute	0.6	---------	0.3	0.1	0.6	0.4
Foundation	0.6	0.6	--------	0.10	0.45	0.437
Cooperative	0.6	0.75	0.9	--------	0.6	0.712
Private Company	0.3	0.4	0.4	0.4	-------	0.375
Phi -	0.525	0.537	0.5	0.250	0.587	
Phi	-0.05	-0.14	-0.06	0.46	- 0.21	

Table 4.Results with PROMETHEE MCDM

Coope rative → Public Entity → Insti tute → Private Company → Founda tion
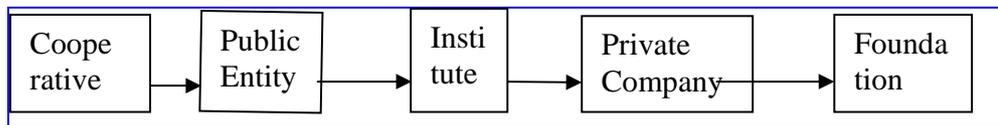
Table 5.- Results with PROMETHEE II in n+1

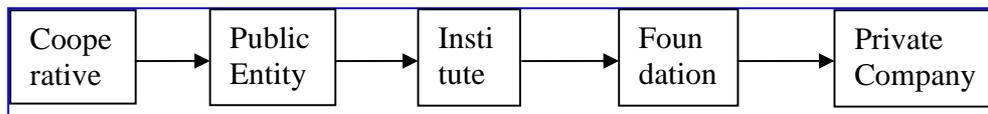Coope rative → Public Entity → Insti tute → Foun dation → Private Company

Table 6.- Results with PROMETHEE II in n [2]

4.-CONCLUSIONS

The results obtained with our method seem to be the best alternative to give the water management in the Salta Province to a Cooperative. This role could be played by the actual "Asociación de Consorcios de Usuarios de Aguas Públicas de Salta" (Consortium Association) with the competences delegated from the Agencia de Recursos Hídricos (WR Agency). The fundamental hydrology infrastructure works should be paid by the Province Government with funds coming from The Federal Investment Council. The canon due to water use would be transferred to the Cooperative. This Entity would be responsible for hydrologic information network, water distribution, maintenance task and police actions.

This election is robust, due to we have demonstrated that with the changes foreseen in a medium range level, the alternative elected does not change. [2]

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