Co-funded by the Erasmus+ Programme of the European Union

MULTI-CRITERIA ANALYSIS IN WATER MANAGEMENT

Barbara Karleuša
University of Rijeka, Faculty of Civil Engineering

Training for WB teaching staff at UNIRIFCE
25.03.2022.

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Content:

- Introduction: The complexity of decision making in water management
- Multi-criteria analysis methods (MCA)
- Use of MCA for water management problems
- Example: IMPROVING DECISION MAKING IN DEFINING PRIORITIES FOR IMPLEMENTATION OF IRRIGATION PLANS USING AHP METHODOLOGY
- Conclusion

Introduction:

- 'Water management' covers a variety of activities and disciplines.

- These can be divided into three categories:
  - managing the resource,
  - managing water services, and
  - managing the trade-offs needed to balance supply and demand.
- The management of water is not merely a technical issue; it requires a mix of measures including changes in policies, prices and other incentives, as well as infrastructure and physical installations.
- Integrated water resources management (IWRM) focuses on the necessary integration of water management across sectors, policies and institutions.

Source: World Water Development Report 2012
http://www.unwater.org/topics/water-resources-management/en/

Introduction:

- WATER MANAGEMENT - STEPS:
  - **Planning**
  - **Design**
  - **Construction**
  - **Use**
  - **Maintenance**
  - **Monitoring and control**
  - **Reconstruction or improvement**

- In these steps, it is necessary to continusly **make decisions**.
- For the perceived problem there are **more alternative solutions** that can be generated and it is necessary to analyze these solutions and evaluate them with regard to the achievement of defined objectives.

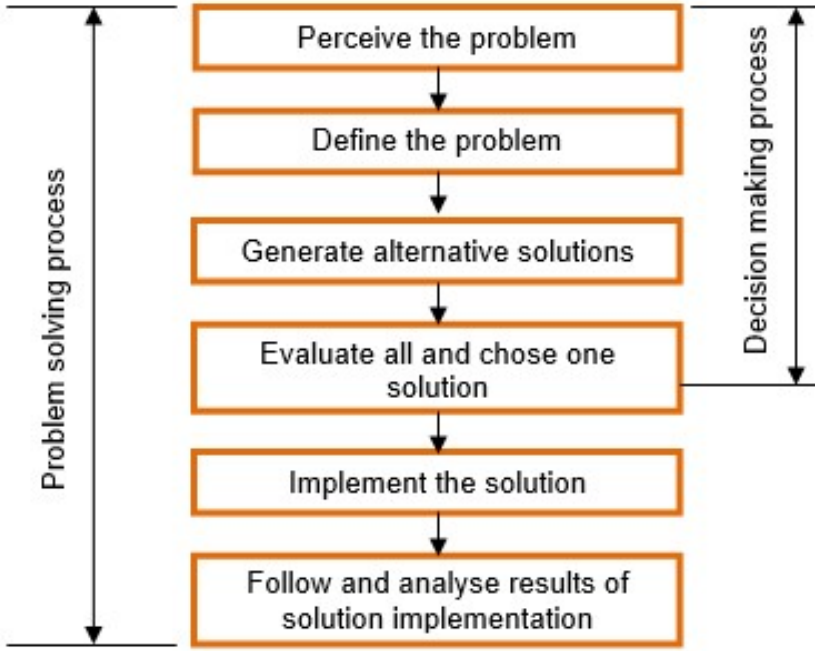


Figure 1. Phases of problem solving and decision making process

Introduction:

- Traditionally, for the analysis of the water management solutions **economic criteria** and **monetary measures** were used.
- Today, beside the economical aspect that was the most important criterion 40-years ago, the protection of environment (and water as a part of it) and the social impact of water management projects have a very important role in decision-making process in water management.
- It is necessary to take into account the social aspect of the implementation of the solutions by including **social criteria** and the impact of selected solutions on the environment through a comprehensive inclusion of **environmental criteria**.

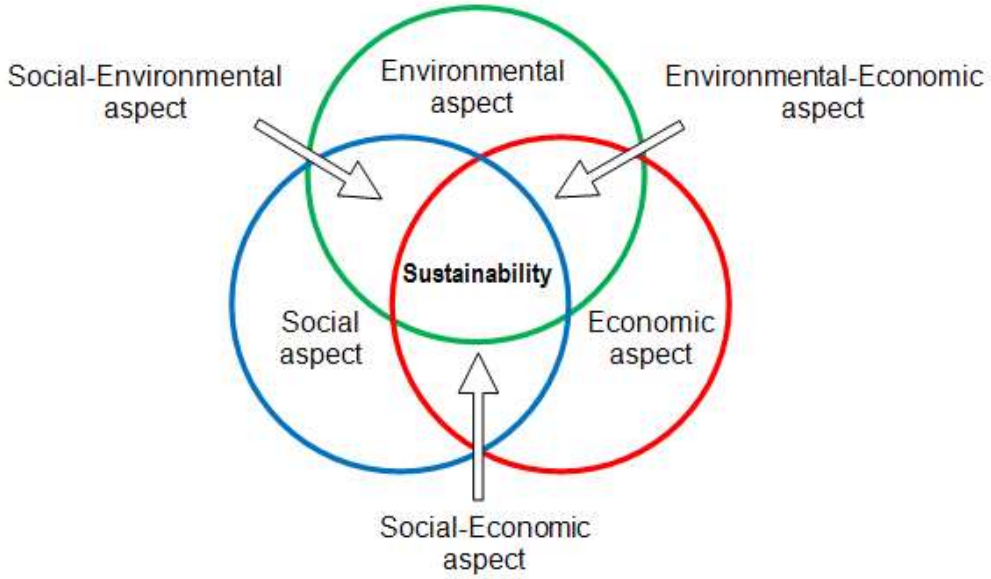


Figure 2. Three spheres of sustainability

Introduction:

- The complexity of decision making in water management planning process, is the result of:
  - **multiple objectives** that have to be satisfied,
  - **different criteria** (economic, social and environmental) and
  - **different measures** (quantitative and qualitative) that are used for objective fulfilment assessment, and also
  - **multiple stakeholders** that are usually involved in the process.

Introduction:

- In the **traditional approach** (the cost-benefit analysis method, CBA) **costs and benefits** were the basis for the selection of the solution, this puts in the first plan the **civil engineering proffesion** that is the economic valorisation of civil engineering solutions.

- In the **modern approach**, the problem and the solution of the problem is considered from more points of view, so experts in the field of civil engineering are becoming a necessary part of a broader, **interdisciplinary team** in which a significant role in the decision making process is given to professionals from other fields, but also to **the public**.

- In these circumstances the method of cost-benefit analysis, which is based on the calculation of the cost of construction, use and maintenance of the infrastructure on the one hand and benefits on the other, has certain limitations.

Introduction:

- To ensure, in the described complex conditions, the improvement of the decision making in water management, it was important to develop and apply **new tools** which also raise the level of transparency and objectivity of the solution selection process.

- **Multi-criteria analysis is applicable** if there is the needed to make a choice between more generated solutions on the base of a larger number of criteria and different, both quantitative and qualitative, measures.

- **Multi-criteria analysis methods** are, today, applied on selection of solutions in **planning, design, construction, maintenance and reconstruction** of water management systems.

Multi-criteria analysis methods:

- Multiple-attribute decision making or **multi-criteria analysis** model is appropriate for „ill structured“ problems.

- **Ill structured problems** are those with very complex goals, often vaguely formulated, with many uncertainties, while the nature of the observed problem gradually changes during the process of problem solving.

- The weak structure makes it impossible to obtain a unique solution. The ambiguity is originated from the goal structure, which is complex and expressed in different quantitative and qualitative measurement units.

- The model encompasses a **finite number of alternative solutions** that are known at the beginning.

- The problem is solved by finding the **best alternative** or a set of good alternatives in relation to defined attributes / criteria and their weights.

Multi-criteria analysis methods:

- dominant, maxmin, minmax, conjunctive / disjunctive method,
- lexicographic method,
- elimination by aspects,
- permutation method,
- linear assignment method,
- **simple additive weighting (SAW),**
- hierarchical additive weighting,
- MAUT (Multi-Attribute Utility Theory),
- **ELECTRE (ELimination and (Et) Choice Translating REality),**
- TOPSIS (Technique for Order Preference by Similarity to Ideal Solution),
- LINMAP (Linear Programming Techniques for Multidimensional Analysis of Preference),
- **PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations),**
- **AHP (Analytic Hierarchy Process)** and other

Multi-criteria analysis methods:

- Problems related to the water management, based on the complexity and other aspects that are described in detail in the introduction, are mostly ill- structured.

- Multi-criteria analysis can be defined as a decision model which contains:
  - A **set of solutions** (alternatives that need to be ranked or scored by the decision maker),
  - A **set of criteria** (typically measured in different units),
  - A **set of performance measures** (evaluations) **for each solution** (alternative) **against each criterion.**

- Multi-criteria analysis is an evaluation method that ranks alternative solutions or scores each solution regarding a larger number of criteria.

Multi-criteria analysis methods:

Each alternative is evaluated with respect to each criterion (attribute) using the appropriate measure.
The model of multicriteria analysis can be presented in the form:

$$\max\{f_1(x), f_2(x), \ldots, f_n(x)\}$$
$$x \in A = [a_1, a_2, \ldots, a_m]$$

Where:
- n – number of criteria (attributes), $j=1,2\ldots,n$
- m- number of alternatives, $i=1,2,\ldots m$
- f_j – criteria, $j=1,2\ldots,n$
- a_i – alternatives, $i=1,2,\ldots m$,
- A – set of all alternative solutions.

From the above it is possible to form the evaluation matrix X (2) of m-alternatives with respect to n-criteria:

$$X = \begin{array}{c} \begin{matrix} \textit{max} & \textit{max} & \ldots & \textit{max} \\ f_1 & f_2 & \ldots & f_n \end{matrix} \\ \begin{matrix} a_1 \\ a_2 \\ \vdots \\ a_3 \end{matrix} \begin{bmatrix} f_{11} & f_{,2} & \ldots & f_{1n} \\ f_{21} & f_{22} & \ldots & f_{2n} \\ \vdots & \vdots & & \vdots \\ f_{m1} & f_{m2} & \ldots & f_{mn} \end{bmatrix} \end{array}$$

where the performance score for alternative i with respect to criterion j is denoted by f_{ij}.

A minimum requirement is at least two alternatives and two criteria ($m \geq 2$ and $n \geq 2$).

Hajkowicz, S; Collins, K.: A review of multiple criteria analysis for water resource planning and management, Water Resources Management 21(2007) 9, 1553-1566.
Hajkowicz, S.; Higgins, A.: A comparison of multi-criteria analysis techniques for water management, European journal of operational research, 184 (2008), 255-265.

Multi-criteria analysis methods:

$$\begin{array}{c} \textit{max} \;\; \textit{max} \;\; \ldots \;\; \textit{max} \\ \begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_3 \end{array} \begin{array}{c} \begin{array}{cccc} f_1 & f_2 & \ldots & f_n \end{array} \\ \begin{bmatrix} f_{11} & f_{,2} & \ldots & f_{1n} \\ f_{21} & f_{22} & \ldots & f_{2n} \\ \vdots & \vdots & & \vdots \\ f_{m1} & f_{m2} & \ldots & f_{mn} \end{bmatrix} \end{array} \end{array}$$

Alternatives/Criteria	f_1	f_2	...	f_n
a_1				
a_2				
...				
a_m				

If all criteria are not of equal importance criteria weights are defined w_1, w_2, … w_n and the vector *W.*

Criteria can be of maximisation type (e.g. benefits) or minimisation types (e.g. costs).

Multi-criteria analysis methods:

- Most of the multi-criteria analysis methods rank or score alternatives the following is determined:

$$r_i = f_1(X, W) \quad \text{and} \quad u_i = f_2(X, W)$$

  where r_i represents the alternative rank, and u_i the overall performance score of the alternative.

- The methodology of multi-criteria analysis includes the following algorithm:
  1. **elaborate more alternative solutions,**
  2. **define criteria,**
  3. **evaluate solutions in regard to criteria,**
  4. **define the weight of each criterion,**
  5. **rank or sort solutions,**
  6. **perform the sensitivity analysis,**
  7. **make the final decision.**

Hajkowicz, S; Collins, K.: A review of multiple criteria analysis for water resource planning and management, Water Resources Management 21(2007) 9, 1553-1566.
Hajkowicz, S.; Higgins, A.: A comparison of multi-criteria analysis techniques for water management, European journal of operational research, 184 (2008), 255-265.

Use of MCA in water management:

- Multi-criteria decision analysis has been used for analyses of different types of water management problems, ranking and selection of:

- water management strategies and projects,
- alternatives of irrigation, and water supply systems,
- reservoir use alternatives,
- desalination procedures for drinking water production,
- waste water management alternatives and waste water disposal locations,
- urban storm water drainage management alternatives,
- locations for hydropower plants and dams etc.

Karleuša, Barbara; Ožanić, Nevenka; Deluka-Tibljaš, Aleksandra.
Improving decision making in defining priorities for implementation of irrigation plans using AHP methodology. // Tehnički vjesnik. 21 (2014) , 3; 673-680

EXAMPLE: IMPROVING DECISION MAKING IN DEFINING PRIORITIES FOR IMPLEMENTATION OF IRRIGATION PLANS USING AHP METHODOLOGY

- Agricultural irrigation plan for Primorsko-goranska county
- Problem: define the first area to be irrigated!!!
- Primorsko-goranska County in Croatia (3.582 km²) is relatively poor on agricultural resources.
- The area is characterized by division of small estates into several plots.
- The quality of the soil is also unfavourable as well as the attendance of plots and agricultural production.

- However, the significance of agriculture in the County is extraordinary and unavoidable due to its influence on different segments of the region and the society.

- On several locations the agriculture can be the most significant income and employment source for the population, can have the role of retaining the population in the country and prevent negative demographic migrations as well as further lithoralization of the area.

- 40 dispersely spread in Primorsko-goranska County, which make potential locations for irrigating relatively small agricultural plots (between 9 and 3525 ha in size), were singled out…

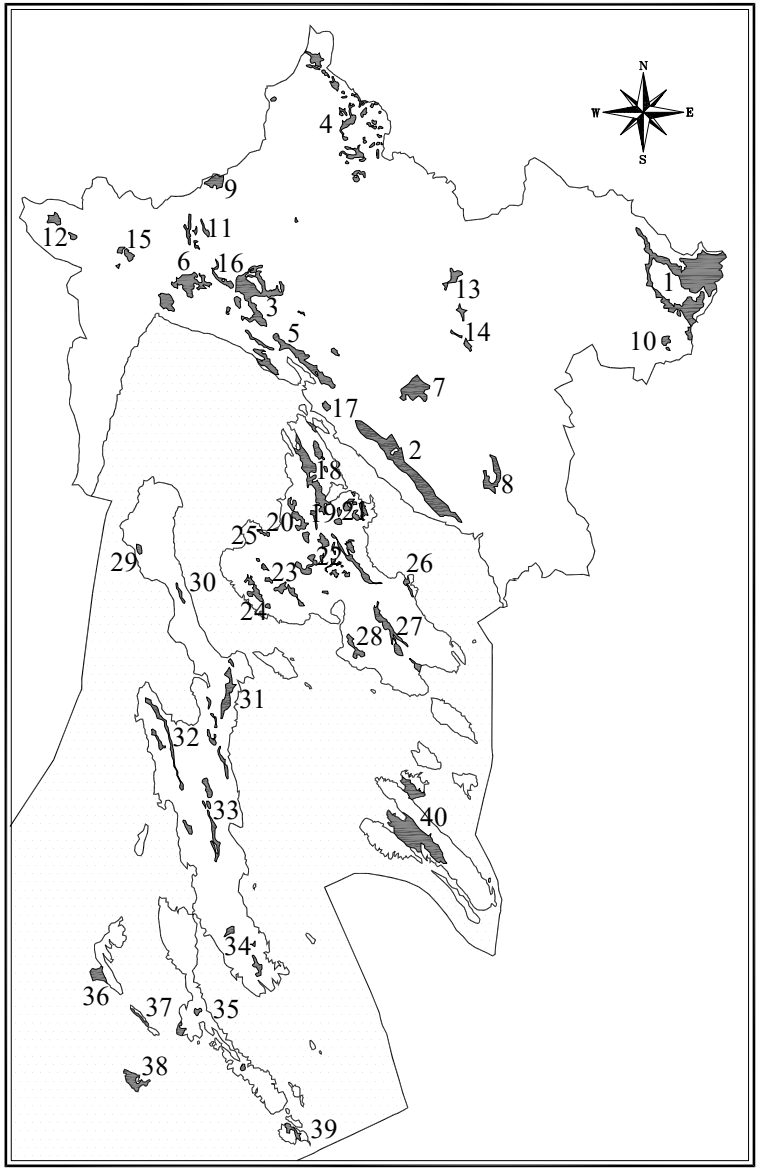


Figure 3. Potential agricultural areas

- The analysis of potential 40 locations was therefore conducted according to the following criteria:

- C1 - **Class of soil suitability for agricultural use**: the suitability was marked by: P1 – particularly valuable cultivable land (best), P2 – valuable cultivable land (worse), P3 – other cultivable land (worst),
- C2 - **Agricultural land area** (expressed in ha), the larger the farmland, the more favourable the location with respect to the criterion,
- C3 - **Current way of using the land**, since there are different ways the potential agriculture land is used today: the current use for agriculture (A) is favourable, use for agriculture and livestock farming (LF) or pasture (P) is less favourable and if the land is not used for agriculture the location is assest as worst with respect to the criterion,
- C4 - **Avaliability of water resources and water management structures** which could provide sufficient water amounts for irrigation (watercourses, ground water, existing wells, reservoirs, etc.),
- C5 - **Interest of local inhabitants for irrigation** (no expressed interest, expressed interest, very expressed interest).

Table 2 Locations for possible irrigation in Primorsko-goranska County with defined criteria analysis

No.	NAME OF LOCATION (Belonging to…)	Suitability class	Area (ha)	Current use of land	Existing watercourses or water management structures	Interest of inhabitants
		C1	C2	C3	C4	C5
1	SEVERIN (Town Vrbovsko)	P3	3525	P	-	not expressed
2	VINODOL (Municipality Vinodolska)	P3	1126	A	watercourse that dries up – mini reservoir	very expressed
		P1	1059			
3	JELENJE (Municipality Jelenje)	P3	1255	A, P	-	not expressed
		P1	153			
4	ČABAR (Town Čabar)	P-3	1167	A, P	watercourse that dries up – mini reservoir	not expressed
5	BAKAR (Town Bakar)	P3	1133	A	-	expressed
6	SROKI (Municipality Viškovo)	P3	616	A	-	not expressed
7	FUŽINE (Municipality Fužine)	P3	581	A, P	multipurpose reservoir and lake	expressed
8	BATER (Town Novi Vinodolski)	P3	271	P	-	not expressed
9	GOMANCE (Municipality Klana)	P3	260	P	-	not expressed
10	GOMIRJE (Town Vrbovsko)	P3	99	P, LF	watercourse that dries up	not expressed
11	KLANA (Municipality Klana)	P3	214	A	watercourse that dries up	expressed
12	MUNE- ŽEJANE - BRUSAN (Municipality Matulji)	P3	200	A	watercourse that dries up – mini reservoir	very expressed
13	DELNICE (Town Grad Delnice)	P3	167	A	-	not expressed
14	MRKOPALJ (Municipality Mrkopalj)	P3	156	A	-	expressed
15	VELI BRGUD (Municipality Matulji)	P3	154	A	watercourse that dries up	not expressed
16	KUKULJANI (Municipality Jelenje)	P3	140	A	watercourse that dries up	not expressed
17	MALI DOL (Town Kraljevica)	P3	63	A	-	not expressed
18	OMIŠALJ (Municipality Omišalj)	P3	657	A	-	not expressed
19	ČIŽIĆI (Općine Omišalj and Dobrinj)	P3	539	A	lake Njivice	not expressed
20	MIHOLJICE (Municipalities Malinska Dubašnica and Dobrinj)	P3	326	A	-	expressed

Table 2 Locations for possible irrigation in Primorsko-goranska County with defined criteria analysis

No.	NAME OF LOCATION (Belonging to…)	Suitability class	Area (ha)	Current use of land	Existing watercourses or water management structures	Interest of inhabitants
		C1	C2	C3	C4	C5
21	SVETI VID DOBRINJSKI (Municipality Dobrinj)	P3	338	A, LF	-	not expressed
22	**KRAS- GARICA-VRBNIK (Municipalities Dobrinj and Vrbnik and town Grad Krk)**	P3	758	A	-	**very expressed**
		P1	145			
23	NENADIĆI-VRH (Town Krk)	P3	304	A, LF	multipurpose reservoir Ponikve	expressed
24	ŠKRBĆICI (Town Krk)	P3	230	A, LF	-	expressed
25	PORAT (Municipality Malinska Dubašnica)	P3	49	A, LF	-	expressed
26	SRŠCICA (Municipality Baška)	P3	68	LF	-	not expressed
27	DRAGA BAŠČANSKA (Municipality Baška)	P3	592	A	-	very expressed
28	DOKOLOVO (Municipality Punat)	P3	163	A, LF	-	expressed
29	DRAGOZETIĆI (Town Cres)	P3	57	LF	-	not expressed
30	PREDOŠCICA (Town Cres)	P3	62	LF	-	not expressed
31	DRAGARSKA-ORLEC (Town Cres)	P3	644	LF	-	not expressed
32	PERNAT-BERTULČICI (Town Cres)	P3	358	A, LF	lake Vrana	expressed
33	VRANA-BELEJ (Town Cres)	P3	486	LF	lake Vrana	not expressed
34	OSOR-PUNTA KRIŽA (Town Mali Lošinj)	P3	245	A, LF	-	expressed
35	**LOŠINJ (Town Mali Lošinj)**	P3	83	A, LF	-	**expressed**
		P2	82			
36	UNIJE (Town Mali Lošinj)	P2	229	A, LF	-	expressed
37	VELE SRAKANE (Town Mali Lošinj)	P3	36	A, LF	-	not expressed
38	**SUSAK (Town Mali Lošinj)**	P2	134	A	-	**expressed**
		P3	217			
39	ILOVIK (Town Mali Lošinj)	P3	127	A, LF	-	not expressed
40*	**LOPAR - KAMPOR (Town Rab) *(on Figure 4 numbered as 40 and 41)**	P3	1385	A	-	**expressed**
		P2	9			
		P1	620			

Table 4 Assessment of 40 locations with respect to selected criteria

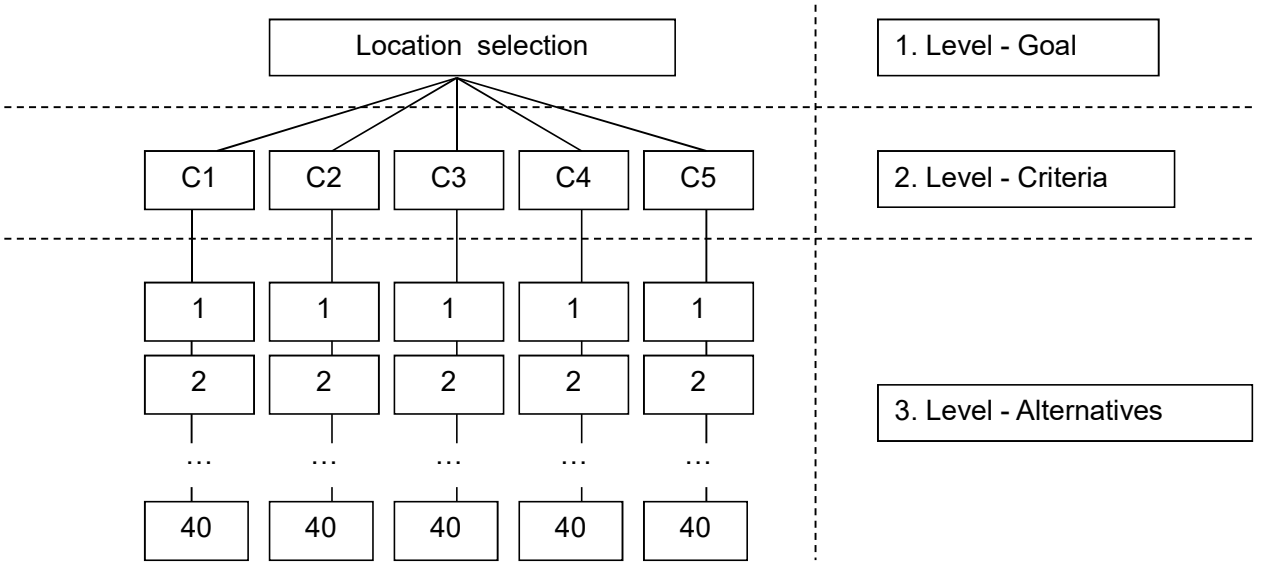


Table 4 Assessment of 40 locations with respect to selected criteria

CRITERIA		C1		C2		C3	C4	C5
No.	LOCATION	Location assessment						
1	SEVERIN	3		3525		1	0	0
2	VINODOL	3 1	2	1126 1059	2185	3	2	2
3	JELENJE	3 1	2.78	1255 153	1408	2	0	0
4	ĆABAR	3		1167		2	2	0
5	BAKAR	3		1133		3	0	1
6	SROKI	3		616		3	0	0
7	FUŽINE	3		581		2	3	1
8	BATER	3		271		1	0	0
9	GOMANCE	3		260		1	0	0
10	GOMIRJE	3		99		1	1	0
11	KLANA	3		214		3	1	1
12	MUNE- ŽEJANE - BRUSAN	3		200		3	2	2
13	DELNICE	3		167		3	0	0
14	MRKOPALJ	3		156		3	0	1
15	VELI BRGUD	3		154		3	1	0
16	KUKULJANI	3		140		3	1	0
17	MALI DOL	3		63		3	0	0
18	OMIŠALJ	3		657		3	0	0
19	ĆIŽIĆI	3		539		3	3	0
20	MIHOLJICE	3		326		3	0	1
21	SVETI VID DOBRINJSKI	3		338		2	0	0
22	KRAS- GARICA-VRBNIK	3 1	2.67	758 145	903	3	0	2
23	NENADIĆI-VRH	3		304		2	3	1
24	ŠKRBĆICI	3		230		2	0	1
25	PORAT	3		49		2	0	1
26	SRŠĆICA	3		68		1	0	0
27	DRAGA BAŠCANSKA	3		592		3	0	2
28	DOKOLOVO	3		163		2	0	1

C1 – class of agricultural suitability:

The lower the mark, the more favourable the location with respect to the criterion C1.

Class	Quantitative assesment
P1	1
P2	2
P3	3

C2 – Size of agricultural area:

The sizes of aricultural areas on potential locations were expressed in ha. The larger the farmland, the more favourable the location with respect to the criterion C2.

C3 – Current way of using the land:

The higher the mark, the more favourable the location under the criterion C3.

Current use of land	Quantitative assesment
agriculture	3
agriculture/livestock	2
livestock	1

Table 4 Assessment of 40 locations with respect to selected criteria

CRITERIA		C1		C2		C3	C4	C5
No.	LOCATION	Location assessment						
1	SEVERIN	3		3525		1	0	0
2	VINODOL	3 1	2	1126 1059	2185	3	2	2
3	JELENJE	3 1	2.78	1255 153	1408	2	0	0
4	ĆABAR	3		1167		2	2	0
5	BAKAR	3		1133		3	0	1
6	SROKI	3		616		3	0	0
7	FUŽINE	3		581		2	3	1
8	BATER	3		271		1	0	0
9	GOMANCE	3		260		1	0	0
10	GOMIRJE	3		99		1	1	0
11	KLANA	3		214		3	1	1
12	MUNE- ŽEJANE - BRUSAN	3		200		3	2	2
13	DELNICE	3		167		3	0	0
14	MRKOPALJ	3		156		3	0	1
15	VELI BRGUD	3		154		3	1	0
16	KUKULJANI	3		140		3	1	0
17	MALI DOL	3		63		3	0	0
18	OMIŠALJ	3		657		3	0	0
19	ČIŽIĆI	3		539		3	3	0
20	MIHOLJICE	3		326		3	0	1
21	SVETI VID DOBRINJSKI	3		338		2	0	0
22	KRAS- GARICA-VRBNIK	3 1	2.67	758 145	903	3	0	2
23	NENADIĆI-VRH	3		304		2	3	1
24	ŠKRBĆICI	3		230		2	0	1
25	PORAT	3		49		2	0	1
26	SRŠĆICA	3		68		1	0	0
27	DRAGA BAŠCANSKA	3		592		3	0	2
28	DOKOLOVO	3		163		2	0	1

C4 – avaliability of water resources which could provide the amount of water required for irrigation: assessed with a quantitative mark from 0 (if there are no available resources) to 3 (e.g., if there is an reservoir which could provide the amout of water required for irrigation). The higher the mark, the more favourable the location with respect to the criterion C4.

C5 – Interest of local inhabitants for irrigation: The interest of local inhabitants for irrigation was assessed according to Table 5 for every potential location. The higher the mark, the more favourable the location with respect to the criterion C5.

Interest of local inhabitants	Quantitative assesment
very expressed	2
expressed	1
not expressed	0

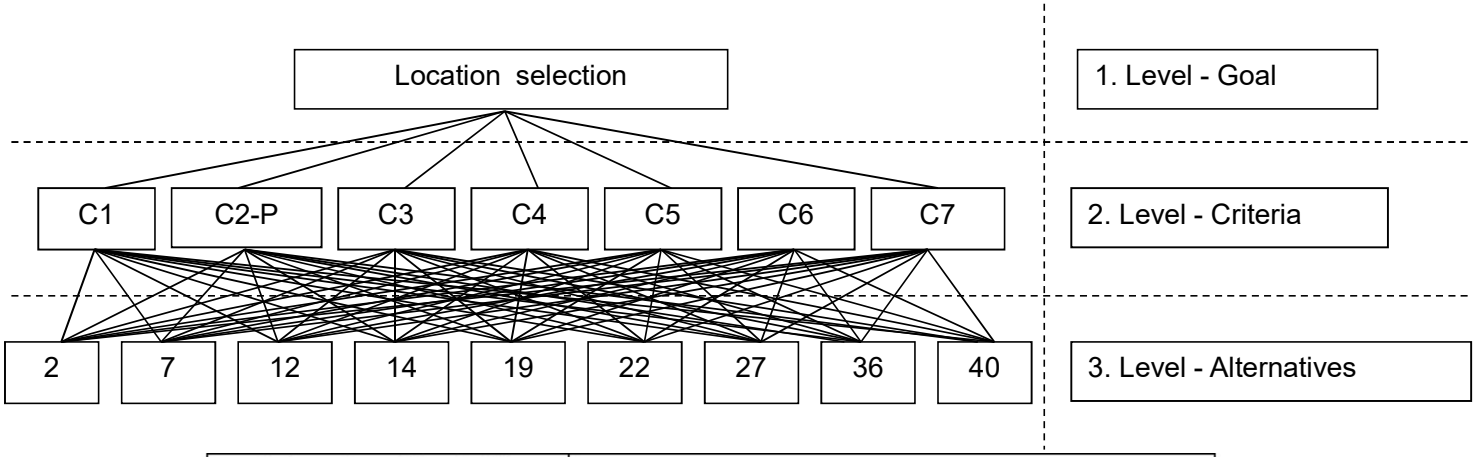
- Based on the results of analyses conducted on all locations and under all the selected criteria nine locations were sorted out where irrigation should be introduced in the County (the locations under number 2, 7, 12, 14, 19, 22, 27, 36 and 40).

- On those locations smaller areas of land were singled out where the pilot project of irrigation could be implemented, the approximative costs for ensuring the required irrigation water quantities were defined and the existing and available planning and project documentation was analyzed (Tab. 3) together with defining the following criteria:
- C2-P (instead of C2) - Agriculture land area for the pilot project (in ha),
- C6 - Cost of ensuring the required irrigation water resources (in Croatian kunas per ha),
- C7 - Existing documentation (studies, plans, projects) on potential water resources use on the analysed location.

Table 2 Locations for possible irrigation in Primorsko-goranska County with defined criteria analysis

No.	LOCATION	Area for the pilot project (ha)	Cost (kn/ha)	Existing documentation (projects, plans)
		C2-P	C6	C7
2	VINODOL	54	0,12	large number
7	FUŽINE	480	0,01	some
12	MUNE- ŽEJANE - BRUSAN	13	0,33	hardly any available
14	MRKOPALJ	63	0,10	hardly any available
19	ČIŽIĆI	62	0,12	large number
22	KRAS- GARICA-VRBNIK	200	0,10	large number
27	DRAGA BAŠČANSKA	418	0,04	some
36	UNIJE	229	0,01	hardly any available
40	LOPAR – KAMPOR	295	0,05	some

Table 4 Assessment of 40 locations with respect to selected criteria



Intensity of weight, importance, preference	Definition
1	Equal importance (no preference)
3	Moderate importance (moderate preference)
5	Strong importance (strong preference)
7	Very strong importance (very strong preference)
9	Extreme importance (extreme preference)
2, 4, 6, 8	Intermediate values

C1 (I=0,03)	2	7	12	14	19	22	24	36	40
2		9	9	9	9	4	9	1	6
7			1	1	1	(4)	1	(9)	(6)
12				1	1	(4)	1	(9)	(6)
14					1	(4)	1	(9)	(6)
19						(4)	1	(9)	(6)
22							7	(4)	(2)
27								(9)	(7)
36									6
40									
C2-P (I=0,09)	2	7	12	14	19	22	24	36	40
2		(8)	3	1	1	(6)	(8)	(6)	(7)
7			9	6	6	5	2	5	6
12				(3)	(3)	(7)	(9)	(7)	(8)
14					1	(6)	(8)	(6)	(7)
19						(6)	(8)	(6)	(7)
22							(5)	(2)	(3)
27								6	5
36									(2)
40									
C3 (I=0)	2	7	12	14	19	22	24	36	40
2		1	5	1	1	1	1	5	1
7			(5)	(5)	(5)	(5)	(5)	1	(5)
12				1	1	1	1	5	1
14					1	1	1	5	1
19						1	1	5	1
22							1	5	1
27								5	1
36									(5)
40									

Table 4 Assessment of 40 locations with respect to selected criteria

(I=0,01)	C1	C2-P	C3	C4	C5
C1		5	3	3	1
C2-P			(3)	(3)	(5)
C3				1	(3)
C4					(3)
C5					

Rank	Location	Rank	Location	Rank	Location	Rank	Location
1	**2**	11	**19**	21	25	31	1
2	**12**	12	**36**	22	28	32	37
3	**22**	13	**5**	23	34	33	39
4	**27**	14	**14**	24	6	34	10
5	**40**	15	20	25	18	35	31
6	7	16	35	26	33	36	8
7	23	17	4	27	13	37	9
8	32	18	15	28	17	38	26
9	11	19	16	29	3	39	29
10	38	20	24	30	21	40	30

Rank	Ranking depending on the group of criteria selected					
	B	C	D^1	D^2	E^1	E^2
1	**2**	**2**	**2**	**2**	**2**	**2**
2	**22**	**27**	**22**	**22**	**22**	**22**
3	**27**	**22**	**27**	**27**	**27**	**27**
4	**12**	**36**	**36**	**19**	**36**	**19**
5	**36**	**12**	**12**	**36**	**12**	**36**
6	**40**	**40**	**40**	**12**	**40**	**12**
7	**19**	7	7	**40**	7	**40**
8	7	**19**	**19**	7	**19**	7
9	**14**	**14**	**14**	**14**	**14**	**14**

Conclusion:

- Theoretical basis for application of the MCA lies in the nature of the problems that have to be solved.
- The problems regarding water management are predominantly ill-structured, the goals are complex and the conditions for their achievement, for example parameters that predict traffic and economic conditions, are variable and uncertain.
- It can be concluded that MCA, particularly in the framework of the decision support system, can contribute significantly to the improvement of the quality of decision making in water management.
- The preconditions for that are: well defined objectives, criteria and measures and criteria weights, developed alternatives and appropriate data for their evaluation in regard to selected criteria.
- In such conditions MCA can contribute to the quality of the decision making process in water management by ensuring objectivity, transparency and auditability of the decision making process.

References:

Karleuša, Barbara; Ožanić, Nevenka; Deluka-Tibljaš, Aleksandra: Improving decision making in defining priorities for implementation of irrigation plans using AHP methodology // *Tehnički vjesnik,* **21** (2014), 3; 673-680

Co-funded by the Erasmus+ Programme of the European Union

Thank you for your attention!

Training for WB teaching staff at UNIRIFCE
25.03.2022.