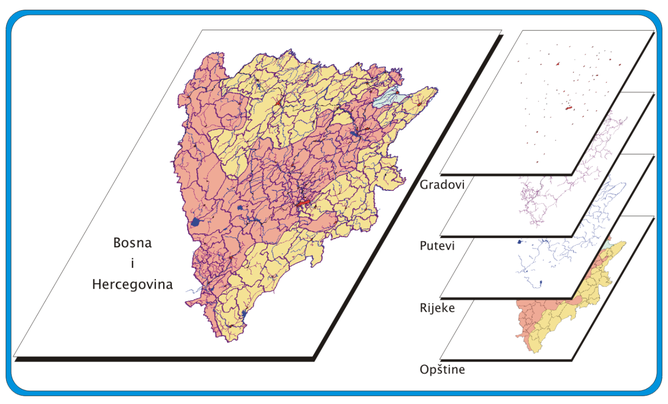
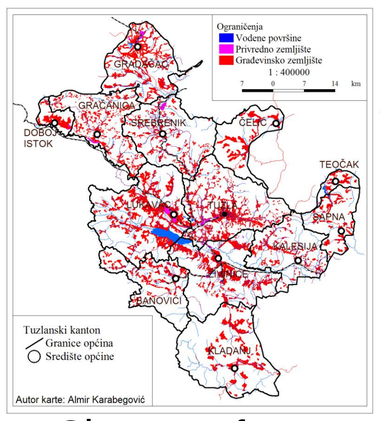
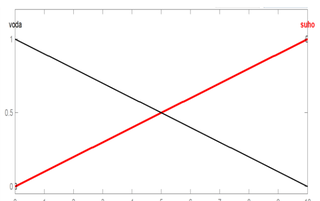


GIS layers

LIMITATIONS OF CURRENT GIS:

- This procedure is very demanding in time and it was unsuitable for decision making in real time. It produced useful results but it also emphasis some of limitations.
- Current GIS are predominantly based on Boolean logic.
- The representation of geographic data based on the classical set theory affects on reasoning and analysis procedures, adding in all problems of an "early and precisely classification".
- Final decision is made after steps which drastically reduce the intermediate results. Any constraint is accompanied with an absolute threshold value and no exception is allowed.
- Finally, another effect of classical set theory is that the selection result is flat, in the sense that there is no overall ordering of the valid entities as regard to the degree they fulfill the set of constraints.





Classes	Klase	Categories
dry	suho	not under water
wet	vedena površina	under water

Classes of constraint: wet areas

IF x IS A THEN y IS B

Fuzzy If-Then Rule

$\mu(x, y) = \Phi m\,[\mu_A(x), \mu_B(y)] \equiv \mu_A(x) \Lambda \mu_B(y)$

Membership function with Mamdani Min implication

min(ravno, jug, "veoma blizu", ravnicarska, agrozona3, vegetacija)

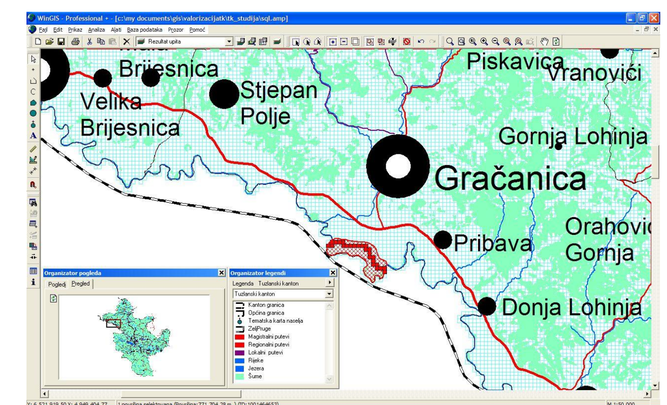
IF (slope IS flat) AND (aspect IS south) AND (accessibility IS close) AND (altitudes IS low) AND (usability IS agrozona3) AND (bio_value IS SmallBioVal) AND (wet IS NOT water) THEN area IS suitable (1)

Example of implication relation

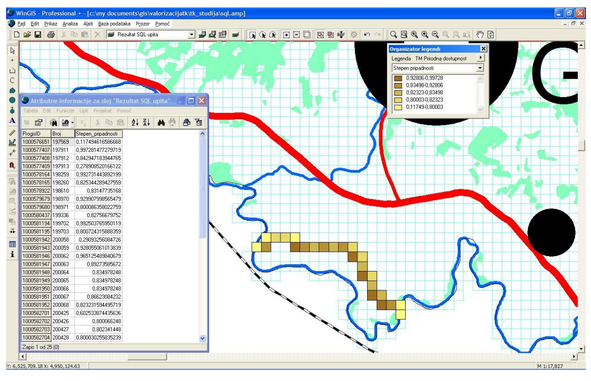
SELECT ID, Municipality
FROM TK
WHERE Slope Is Not Null AND South Is Not Null AND Close Is Not Null AND Low Is Not Null AND [Agrozona 3] Is Not Null AND [Vegetation 1] IS NOT NULL AND Water IS NULL;

SQL statement

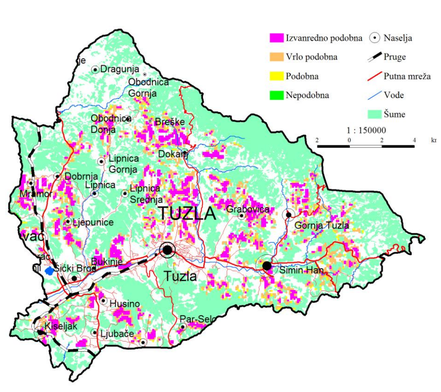
Rule Base Creation



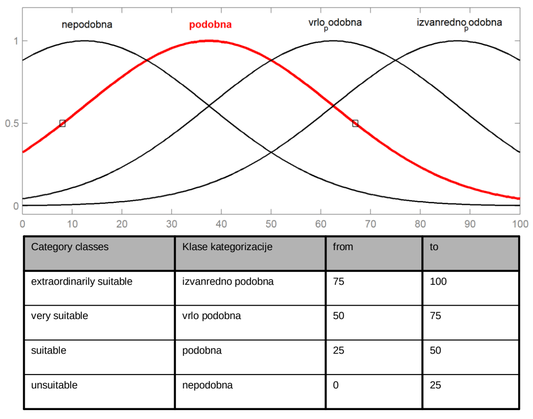
Query result in GIS



Thematic Query Result in GIS



Land Valorization for Municipality Tuzla



Category classes	Klase kategorizacije	from	to
extraordinarily suitable	izvanredno podobna	75	100
very suitable	vrlo podobna	50	75
suitable	podobna	25	50
unsuitable	nepodobna	0	25

Output: Category Classes

Municipality	unsuitable	suitable	very suitable	Extraordinarily suitable	*Total Categorized*
Banovici	1,52	29,45	412,25	421,39	864,62
Celic	1,31	23,18	314,07	413,11	751,68
DobojIstok	0,00	0,00	0,00	0,00	0,00
Gracanica	2,81	49,91	812,67	693,24	1558,64
Gradacac	1,33	33,09	780,24	1073,89	1888,56
Kalesija	0,14	18,94	404,03	814,79	1237,90
Kladanj	0,00	7,43	60,67	17,56	85,67
Lukavac	0,52	21,98	382,73	662,33	1067,57
Sapna	0,75	35,04	322,68	248,15	606,61
Srebrenik	4,83	83,31	1175,18	1519,72	2783,04
Teocak	2,33	22,48	214,89	156,70	396,41
Tuzla	1,49	96,69	1432,56	1632,59	3163,34
Zivinice	1,32	22,94	266,11	307,28	597,65
Tuzlanski kanton	18,36	444,45	6578,10	7960,77	15001,67

Results of Land Valorization in hectares

Naučno-tehnička saradnja Elektrotehničkog fakulteta Univerziteta u Sarajevu i kompanije GAUSS GeoInformacioni Sistemi iz Tuzle

Elektrotehnički fakultet Univerziteta u Sarajevu

gauss GEOINFORMATION SYSTEMS

APPLICATIONS OF FUZZY LOGIC IN GEOGRAPHIC INFORMATION SYSTEMS FOR MULTIPLE CRITERIA DECISION MAKING

CORP 2006
GEO·MULTIMEDIA·06
Sustainable solutions for the information society
11th International Conference on Urban Planning & Regional Development in the Information Society

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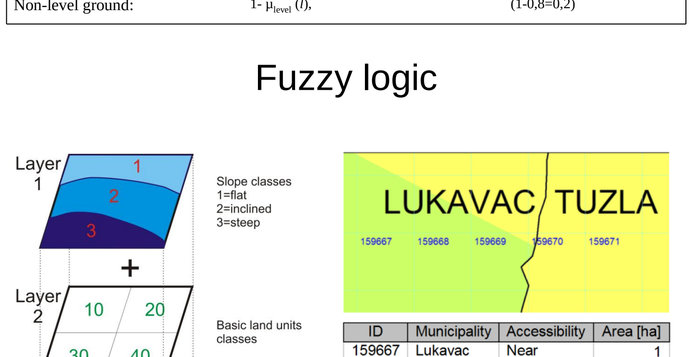


a) Layer 1 and 2	b) Result of additive	c) Result of subtractive

Polygon Overlay

IF X = {x} THEN A = {x, $\mu_A(x)$, }, $\forall x \in X$

Definision of fuzzy set A

Union:	$\mu_{A \cup B}(x)=\max\{ \mu_A(x), \mu_B(x)\}$,	$\forall x \in X$
Intersection:	$\mu_{A \cap B}(x)=\min\{ \mu_A(x), \mu_B(x)\}$,	$\forall x \in X$
Complement:	$\mu_{\sim A}(x)=1- \mu_A(x)$,	$\forall x \in X$

Basic operation of fuzzy set

Level ground and dry land:	$\min\{\mu_{level}(l), \mu_{dry}(l)\}$,	(min {0,8;0,4}=0,4)
Level ground or dry land:	$\max\{\mu_{level}(l), \mu_{dry}(l)\}$,	(max {0,8;0,4}=0,8)
Non-level ground:	$1- \mu_{level}(l)$,	(1-0,8=0,2)

Fuzzy logic

%	1	2	3
10	58	42	
20	67	33	
30		24	76
40		67	33

ID	Municipality	Accessibility	Area [ha]
159667	Lukavac	Near	1
159668	Lukavac	Near	1
159669	Tuzla	Moderate	0,000326
159669	Tuzla	Moderate	0,02652
159669	Lukavac	Near	0,943643
159669	Lukavac	Moderate	0,029511
159670	Tuzla	Moderate	0,945568
159670	Lukavac	Moderate	0,031038
159670	Lukavac	Near	0,023182
159670	Lukavac	Near	0,000206
159671	Tuzla	Moderate	1

Space Presentation

Project timetable

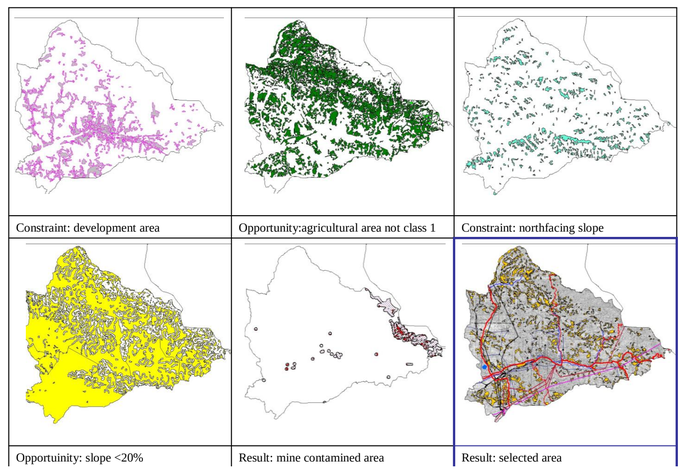
- 2004-2006/Jan-Dec, Sarajevo

Theoretical research :

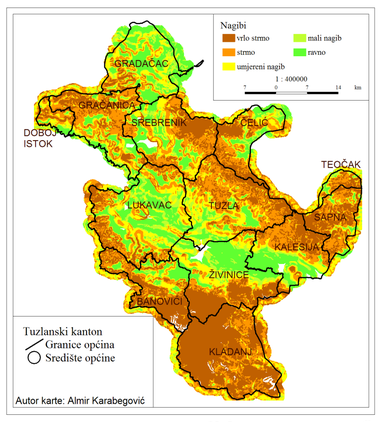
- Field: Artificial Intelligence
- Field: Geographic Information Systems
- Field: Urban Planning

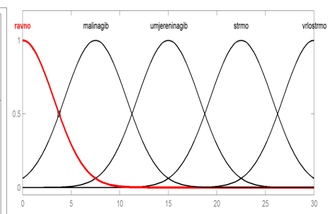
Practical implementation :

- MATLAB-Fuzzy Logic Toolbox
- MapInfo GIS and VerticalMapper



Constraint: development area	Opportunity:agricultural area not class 1	Constraint: northfacing slope
Opportunity: slope <20%	Result: mine contamined area	Result: selected area





Classes	Klase	from	to
flat (level)	ravno	0	2
small inclination (gentle)	mali nagib	2	4
inclined (moderate)	umjereni nagib	4	10
steep	strmo	10	20
very steep	vrlo strmo	20	30

Classes of slopes

Basic information	ID	Number	Municipality
	1000554913	188342	Tuzla

Slope classes	Flat	Small inclination	Inclined	Steep	Very steep
	0,036906179	0,251406435	0,479215376	0,211899903	0,020572108

Aspect classes	Horizontal	North	East	South	West
			0,71126	0,28874	

Accessability classes	Close	Near	Moderate far	Far	Very far
				1	

Altitudes classes	Lawland	Hill	Mountain
		1	

Agriculture classes	Agrozone1	Agrozone2	Agrozone3
		0,0333171	

Biological values classes	NoBioVal	SmallBioVal	MedBioVal	HighBioVal	VeryHighBioVal
	0,30296106		0,69703894		

Development classes and wet	Development	Economic	Water
	0,9415659		

Table of Fuzzified Values

$\mu_E(x)= \sum_{i=1}^{n} [\mu_{i}(x)]^2$ $\mu_{level\text{-}dry}(l)= [\mu_{level}(l)]^2+[\mu_{dry}(l)]^2$

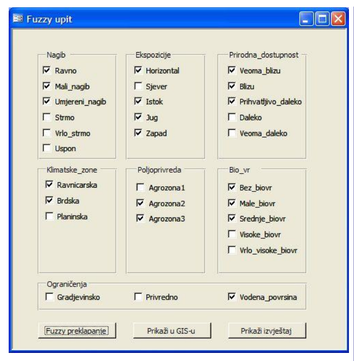
Exponental function

L_1: $\mu_{level}(l)=0,8$ i $\mu_{dry}(l)]=0,4$ $L_1=0,80$
L_2: $\mu_{level}(l)=0,6$ i $\mu_{dry}(l)]=0,4$ $L_2=0,56$

$\mu(x)= [\mu_{level}(x)]^2+[\mu_{south}(x)]^2+[\mu_{close}(x)]^2+[\mu_{low}(x)]^2+[\mu_{agrozone3}(x)]^2+[\mu_{vegetation}(x)]^2$

SELECT
ID, Municipality, ([Flat]^2 + [South]^2 + [Close]^2 + [Low]^2 + [Agrozone 3]^2 + [vegetation]^2) AS Result
FROM
TK
WHERE
Flat Is Not Null AND South Is Not Null AND Close Is Not Null AND Low Is Not Null AND [Agrozone 3] Is Not Null AND [Vegetation] Is Not Null;

SQL statement with exponential function



SELECT
ID, Municipality,
[flat]+[small_inclination]+[inclined] AS Slope,
[east]+[south]+[west] AS Aspect,
[close]+[near]+[moderate_far] AS Accessibility,
[lawland]+[hill] AS Altitude,
[agrozone2]+[agrozone3] AS Usability,
[nobioval]+[smallbioval]+[medbioval] AS BioValue,
([slope]^2+[aspect]^2+[accessibility]^2+[altitude]^2+[usability]^2+[biological_value]^2)/6 AS Result
FROM
TK
WHERE
Slope>0 AND Aspect>0 AND Accessibility>0 AND Altitude>0 AND Usability>0 AND BioValue>0 AND ALL CONSTRAINTS=0;

Land Valorization for Municipality Tuzla

CONCLUSION:

- Limitations of multi criteria analyses in standard GIS are necessity to define all steps in advance and inability to simple change criteria or thresholds later.
- Here is examined the incorporation of Fuzzy set methodologies into a DBMS of GIS. It is shown how the useful concepts of fuzzy set theory may be adopted for the representation and analysis of geographic data, whose uncertainty is an inherent characteristic.
- Getting results with such procedures is only matter of database and GIS is now just a tool for making spatial presentation of results.
- Every change of input data, now, requires only checking its influents to information (classic UPDATE statement in database). Also, data are ordered according to its impoertance for decision makers.