UDC 631.1:631.44(497.5 Dalmacija)

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A GIS BASED ASSESSMENT OF AGRICULTURAL RESOURCES FOR KARSTIC AREAS OF THE ADRIATIC COASTAL REGION

SUMMARY

The goal of this research was to develop a system for assessing of agricultural resources in typical karstic aeas of Adriatic coastal region. Data about land use/agricultural cover, soil and relief have been captured, stored, manipulated, analysed, managed and visualized in GIS. Ortho-photo of the study area and field work have been used for land use/agricultural cover and soil mapping, while 3D terrain model have been used for making slope and aspect maps. Soil properties were established by field and laboratory research. The study was conducted on municipality Marina located in central Dalmatia 25 km west of Split which occupies an area of 11.869 ha. This area is typical for entire Adriatic coastal karst region characterized with dominance shallow and stony Terra Rossa soil developed on Cretaceous limestones and dolomites, Mediterranean type of climate and a long lasting and intensive human impact. Anthropogenic soils on colluvial deposits are located in poljima and dolinama, and on steeper slopes are terraced, with specific type of terracing called „kazeta“. Agricultural crops occupying an area of 1.784 ha, of which the most frequent are: olives, almonds, figs and grapevine. This project is a case study to test the efficiency of the integration of GIS technologies and ecological principles in system for facilitate and improving sustainable managing agricultural areas of coastal zone. Demonstration of system efficiency was given on example of land suitability assessment for growing vine cultivar Babić.

Keywords: GIS, mapping, agriculture, Babić, Terra rossa.

INTRODUCTION

The area of the Marina municipality is typical for entire Adriatic coastal karst region. Geologically, this area is built of Cretaceous limestones and dolomites (Marinčić et all., 1966). Under the Köppen climate classification, it belongs to "dry-summer subtropical" climates classified as Csa and referred to as "Mediterranean climate with hot summer“. Study area characterized typical karst geomorphology and a long and intensive human impact. Karst terrains are characterized by barren, rocky ground, caves, sinkholes and the absence of

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Paper presented at the 5th International Scientific Agricultural Symposium "AGROSYM 2014".
Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.

surface streams. Sinkholes commonly coalesce into much larger depressions called “doci, uvale and polja”. Agricultural cover is characterized by a large proportion of abandoned agricultural land, dry farming, fragmentation of the plots and underdeveloped infrastructure. Abandoned areas inhabited flammable grass vegetation and weeds, bushes and forest of Allepo pine, which represent a high risk for fires. So, 2.629 ha were burnt in 2000. At the same time, due to the landscape attractiveness, particularly in the coastal zone, this area is exposed to strong pressure from the tourism industry. This suggests the need to implement the better strategy planning and managing with agricultural resources. The main objective of this paper was to demonstrate how to utilize and interpret soil, terrain, actual land use and agricultural cover data integrated in GIS for assessment of the agricultural resources. Demonstration of system efficiency was given on example of land suitability assessment for growing famous vine cultivar Babić. Babić is a native Croatian red wine grape cultivar planted on rocky terrain in the Central Dalmatia region.

MATERIAL AND METHODS

The study was conducted on municipality Marina located in central Dalmatia 25 km west of Split which occupies an area of 11.869 ha. Actual land use and agricultural cover map were created through a field survey using digital ortho-photo (DOF). Soil mapping was carried out according to the methodology of making detailed soil maps. A total of 70 soil samples were taken from 37 soil profiles during the soil survey. On collected soil samples laboratory analysis were carried out by following methods: pH (ISO 10390:2005), humus content (Kotzman method, JDPZ, 1966), total carbonate content (ISO 10693:2004), physiologically active lime (Drouineau-Gallet method, JDPZ, 1966), content of available phosphorus and potassium (AL method, JDPZ, 1966) and texture (International B method, JDPZ, 1966). Data about land use, agricultural cover, soil and relief have been stored, integrated and analyzed in GIS. Based on the digital terrain model (DTM) developed in GIS environment using the topographic map at 1:5000 we have created maps of slope and aspect. Application of created system was given on example of suitability assessment for growing autochthonic vine cultivar Babić. Assessment of suitability was performed using next parameters: soil depth, rockiness and stoniness, slope and aspect and actual land use and agricultural cover. All spatial data are geo-referenced to the national coordinate system (Zone 6 Gauss-Krueger projection). Overall the database is ready to use by the software package Arc View 3.2. and ArcGIS 10.0.

RESULTS AND DISCUSSION

Soils of the study area we classified as Lithosol, Calcomelanosol, Terra rossa, Calcocambisol and Anthropogenic soils, according to FAO, 1971-1981. Statistical parameters of basic chemical properties and soil texture are shown in the Table 1. Investigated soils are noncarbonate or slighty carbonate and weakly

acid. Humus content is medium in natural soil types and low (P2 horizon) to medium (P1 horizon) in anthropogenic soils.

Table 1. Statistical parameters of basic chemical properties and soil texture

Soil type	Hor.	Stat	pH		$CaCO_3$	CaO	Humus	K_2O	P_2O_5	Sand Coarse		Silt	Clay
			H_2O	nKCl	%			mg/100g.		2,0-0,20	0,2-0,02	0,02-0,00	>0,002
Calcomelanosol	A_{mo}	X	7,26	6,43	0,8	0	6,36	37,2	2,9	0,5	31,8	31,0	35,8
		min.	6,89	5,78	0	0	3,11	18,0	1,1	0,1	18,0	21,9	14,9
		max	7,90	7,02	1,6	0	15,3	73,6	4,2	1,1	54,1	37,9	53,8
Terra rossa	A_{oh} or A_p	X	7,21	6,15	1,4	0	7,52	31,8	4,7	0,5	21,8	31,0	46,0
		min.	6,72	5,70	0	0	4,99	28,0	1,8	0,2	18,4	29,2	40,2
		max	7,58	6,40	2,5	0	11,5	36,0	12,3	1,2	34,2	33,8	50,6
	$B_{(rz)}$	X	7,37	6,39	0,5	0	2,53	23,4	1,7	0,4	24,9	25,4	49,5
		min.	6,68	5,54	0	0	1,30	15,3	0,8	0,1	19,4	20,1	33,7
		max	7,9	7,16	1,0	0	4,21	44,2	3,5	1,0	38,7	31,6	58,0
Calcocambisol	A_{oh} or A_p	X	7,12	6,13	0,5	0	4,75	29,7	2,6	0,6	24,5	33,2	40,8
		min.	6,99	6,02	0	0	3,24	27,0	1,3	0,1	21,5	27,1	41,2
		max	7,39	6,48	1,2	0,2	5,77	61,0	4,1	0,9	31,4	36,4	39,3
	$B_{(rz)}$	X	7,09	6,09	0,5	0	3,42	18,2	1,6	0,5	21,9	30,2	47,5
		min.	6,80	5,91	0	0	3,19	13,0	1,1	0,1	18,9	29,9	45,3
		max	7,32	6,48	0,9	0,5	3,67	23,0	2,5	0,7	24,7	30,8	50,2
Anthropogenic soil	P 1	X	7,39	6,33	1,7	0,1	3,97	70,8	21,2	1,1	23,8	28,1	46,6
		min.	6,10	5,52	0	0	1,92	27,0	1,0	0,2	15,3	21,6	25,4
		max	8,00	6,75	8,8	2,0	6,59	246,	118,	4,3	29,5	39,9	58,5
	P2	X	7,51	6,30	1,7	0,2	2,74	44,2	11,9	1,1	24,5	27,8	47,8
		min.	6,60	4,95	0	0	0,95	20,0	1,2	0,2	14,4	17,7	25,0
		max	8,01	6,84	10,8	2,1	4,71	184,	84,0	7,1	38,7	45,2	67,7

Available potassium and phosphorus content is typical for soils derived from limestones and dolomites: medium content of available potassium and very low of phosphorus. In anthropogenic soils it is higher and varied from 27.0 to 246.0 mg/100 g K2O and from 1.0 to 118.0 mg/100 g P_2O_5. Calcomelanosol have silty clay loam texture. All other soil types have silty clay texture.

Soil map and legend are shown in Figure 1 and Table 2. The composition of soil mapping units (SMU) shows typical soil series derived on the limestones and dolomites. SMU are complex and differs in the intensity of human impact and important properties for use in agriculture (soil depth, rockiness and stoniness). In order to bring for agricultural purposes shallow, stony and rocky soils man is built drywalls (and terraces) from the stone dug up during the clearing of soil. This specific form known as cassettes (Figure 1) had the function of mulch.

Actual Land use/agricultural cover is shown on Figure 2. Agricultural crops occupying an area of only 1.784 ha or 15% of total area, of which the most frequent are complex cultivation pattern with area of 914 ha (51.3%) and olive

groves occupying 739 ha (41.4%). The vineyards occupying 131 hectares or 7.3% of agricultural cover, Table 3. Category Other agricultural and forest land occupying 6.550 ha (55%) and protected forest covering 3.461 ha (29%).

Table 2. Legend of soil mapping units (SMU)

No.SMU	Description of soil mapping unit	Area ha
1	Anthropogenic, deep, soils on Quartenary colluvium on Terra rossa	543
2	Anthropogenic soils, medium deep and deep on Terra rossa, typical and colluvial, *rockiness and stoniness <25%*	547
3	Terraced, shallow and medium deep soils, rocky and stony, from Terra rossa and Calcocambisol on limestone and dolomites, *rockiness and stoniness 50-75%*	2381
4	Terra rossa and Calcocambisol, shallow, rocky and stony – Lithosol on limestone and dolomites – Terraced, shallow, rocky and stony soils on Terra rossa and Calcocambisol on limestone and dolomites (30:30:40), *rockiness and stoniness >75%*	4122
5	Terra rossa and Calcocambisol, shallow, rocky and stony – Calcomelanosol - Lithosol on limestone and dolomites (60:20:20), *rockiness and stoniness >75%*	4276

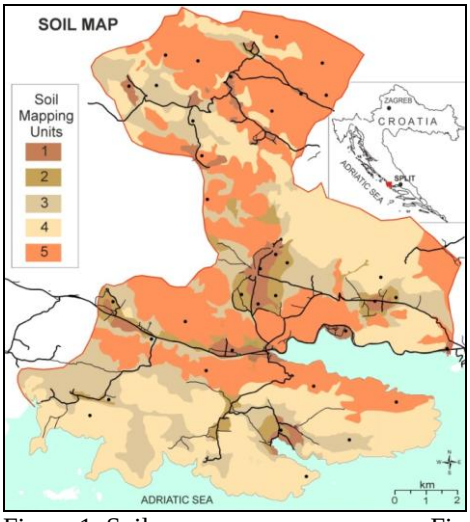

Figure 1. Soil map

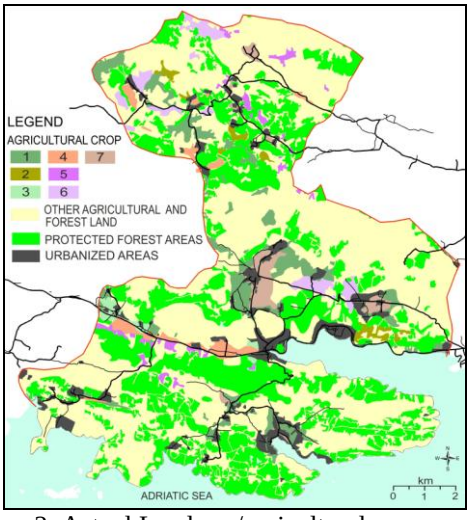

Figure 2. Actual Land use/agricultural cover map

Table 3. Structure of the agricultural cover

No. MU	Agricultural crops	Area, ha	Area, %
1	Olive groves	739	41.4
2	Olive groves and vineyards	93	5.2
3	The olive groves and orchards	78	4.4
4	Arable lands and orchards	194	10.9
5	Vineyards	131	7.3
6	Vineyards, abandoned olive groves, maquis	222	12.4
7	Orchards, arable lands, gardens	327	18.3
	Total	1784	100.0

Terrain slope and aspect maps are made using 3D terrain model (Figure 3 and 4). Elevation varied from sea level to 618 m above sea level. Distribution of terrain slope classes (Table 4) shows a wide range and prevalence of class 7-15%. Color-coded aspect map (Fig. 4) shows the dominance of sunny direction: south (21.3%), southwest (20.6%) and west (9.7%).

Table 4. Distribution of terrain slope classes

Slope terrain	%	0-3	3-7	7-15	15-25	25-40	>40	Total
Area	ha	2012	2769	4269	2537	279	3	11869
	%	17,0	23,3	36,0	21,4	2,3	0	100,0

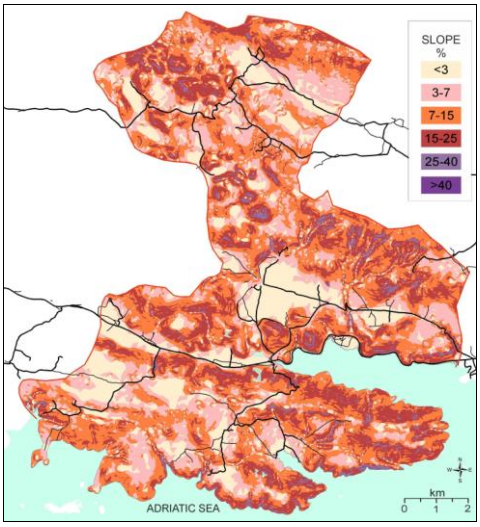

Figure 3. Percent of slope of the terrain

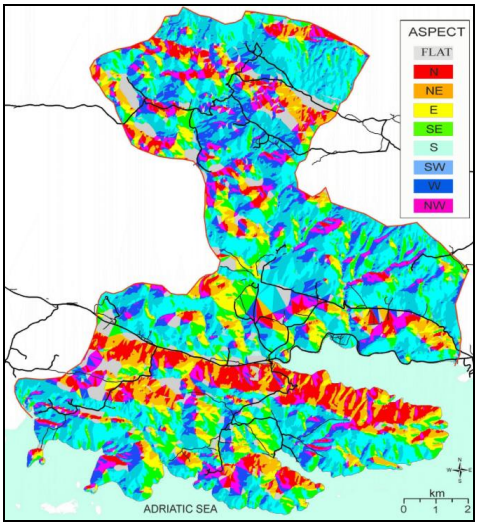

Figure 4. Cardinal direction of the terrain

Analyses in GIS showed strong relation between actual agricultural cover with soil and terrain parameters. Agricultural production is mostly retained in the vicinity of settlements and roads and on the flatted terrain, deeper soils and terrain with lower rockiness and stoniness. Furthermore, great area is abandoned and overgrown by maquis and forest of Aleppo pine that represent a risk for fires.

According to the Ordinance about the National List of recognized vine cultivars (Official Gazette 159/04) Babić is the recommended cultivar for studied area. The properties of the soil and relief are the critical factors in assessing land suitability for growing grapes. For growing vine cultivar of Babić the most important soil properties are good internal drainage, appropriate depth and relatively low soil fertility. This means that in the study area suitable are stony and rocky soils with the possibility of deep rooting. Geomorphological suitable are terrains with slopes between 7-25% and south, southwest and west aspects. One of the most useful applications of GIS is suitability mapping and analysis of agricultural resources **(**Malczewski, 2004; Bandyopadhyay et all, 2009). Based

on defined requirements for mentioned cultivar and taking into account actual land use/agricultural cover in GIS environment we established areas which meets requirements listed above (Figure 5). This areas covers total of 726 ha distributed at a number of locations and often far from roads.

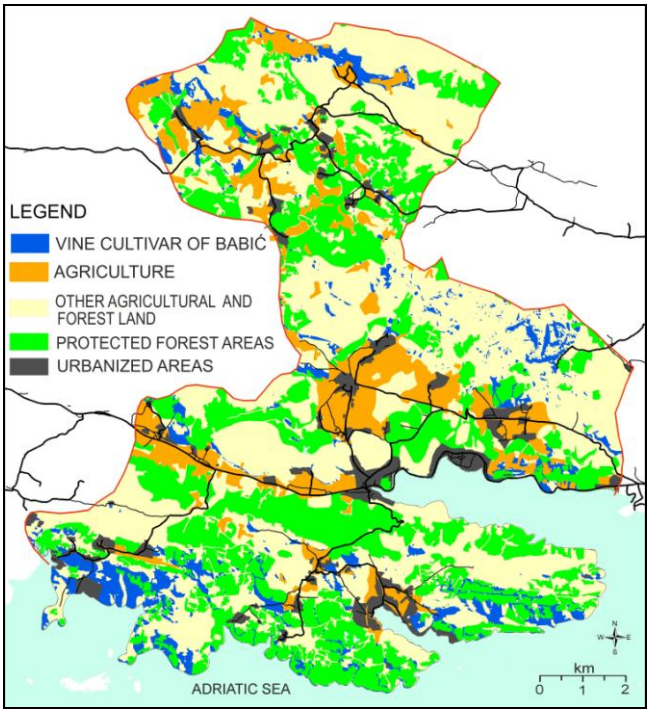

Fig. 5. Map of the areas suitable for cultivation of the vine cultivar of Babić

CONCLUSIONS

Agricultural production is mostly retained in the vicinity of settlements and roads and on the flatted terrain, deeper soils and terrain with lower rockiness and stoniness. Agricultural cover occupying only 1784 ha or 15% of investigated area (11.869 ha), of which the most frequent are complex cultivation pattern and olive groves covering an area of 914 ha and 739 ha, respectively. Applications of the created GIS system is shown on the example of the land suitability assessment for growing autochthonous Croatian red vine cultivar of Babić adapted to the previously described land limitations, especially rockiness and stoniness. Based on the defined requirements for mentioned cultivar and taking into account actual land use/agricultural cover, in GIS environment we established that total area suitably for growing Babić covering an area of 726 hectares. Created GIS system with integrated geospatial databases may be proposed as a useful tool for assessment of land suitability potentials for agriculture. We expect that, as such it, may provide guidance for making agricultural policies more suited to the complexity and fragility of the Mediterranean environment.

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