Regionalisation of Croatian Agriculture

Ferdo BAŠIĆ [1(✉)], Matko BOGUNOVIĆ [1], Miroslav BOŽIĆ [3], Stjepan HUSNJAK [1], Ivo JURIĆ [2], Ivica KISIĆ [1], Milan MESIĆ [1], Nikola MIROŠEVIĆ [1], Davor ROMIĆ [1], Ivan ŽUGEC [2]

Man... despite his artistic pretensions and many accomplishments, owes his existence to a thin layer of topsoil... and the fact that it rains...

Old Chinese proverb – from Soil Atlas of Europe (European Commission 2005)

Summary

After becoming self-standing state one of new needs of Croatia important for agricultural profession, farmers, policy makers and public needs was regionalization of agriculture. It is the analyse of state of agroecological conditions in agrosphere and based on results identification and territorial separation of agricultural regions as parts of agrosphere with similar conditions for plant and animal growing and similar farming systems. On this track within a special project we finished an inventory of agrosphere, result of which is Regionalisation of Croatian Agriculture presented in this paper. Following wise message of old Chinese proverb cited above, the starting approach is the MFCAL concept (Multifunctional Character of Agriculture and Land), which means that apart from very important and primary economic, agriculture and agricultural land (soil) in human life play other roles (functions) of similar importance; environmental, social, cultural and spatial, as well as the role of shaping the cultural landscape as a factor of rural development. As well, we respect the point of view prevailing in EU that all natural resources used in agriculture but at the first place soil as a major one, need sustainable use and efficient protection. Using the data on Land resource potential based primarily on data of General Soil Map of Croatia (GSM) in a scale of 1:50 000 and results of our research in the period 2000 – 2003, the agrosphere of Croatia is divided in three three agricultural regions; Pannonian with four, Mountain with two and Adriatic with three subregions

Key words

agricultural regionalization; land resource potential; MFCAL; farming systems

[1] University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
✉ e-mail: basic@agr.hr
[2] University of J. J. Strossmayer, Faculty of Agriculture, Osijek, Croatia
[3] Ministry of Agriculture, Forestry and Water Management of Croatia, Zagreb, Croatia

Received: December 19, 2006 | Accepted: January 30, 2007

Introduction

Croatian agriculture is entering into the third millennium as the traditionally essential branch of national economy with a respectable share of 7% in BDP (11% including food-processing industry). After becoming a self-standing state an expected need of decision makers, state administration, farmers, agricultural profession, and public was regionalisation of Croatian agriculture. Respecting this need, within a special project of Agricultural Research Council (ARC) of Ministry of Agriculture, Forestry and Water Management of Croatia in the period 2000-2003 after an inventory of agrosphere of Croatia (Bašić et al. 2001, Bašić, Mirošević 2006) we created regionalisation of agriculture summarized in this paper. For a scientific-based, useful and contemporary regionalization our starting approach is the MFCAL concept, which means that apart from very important and doubtless primary economic role (function), agriculture and agricultural land (soil) in in society - human life play other roles of the same importance; environmental, social, cultural and spatial, as well as the role of shaping the cultural landscape in rural development (Varallyay 2000, 2005, Bašić, Franić 2003, Bašić 1993, 2005, 2006). In some areas, such as national parks and other protected and/or environmentally sensitive areas like water protected area, catchments area of unpolluted rivers and lakes, water bodies under protection (total area of such land is 590 000 ha), the most important is the environmental role (function), in others it is the social function – profitable employment and maintenance of a desired demographic balance, and yet in others shaping of a cultural landscape with a important role in rural life, recreation and tourism (Varallyay 2000, 2005, Bullock et al. 2005, Montanarella et al. 2005, Kisić et al. 2005). Of course, in agriculture the main function of soil is a productive one, covered by the term land resource potential.

Methods of regionalization

For regionalisation we used practically all natural and human-influenced factors of spatial differentiation of agroecological conditions; the first of all land resource potential, means; soil types and properties of soil, land use and farming systems as its consequence, climatic conditions, natural vegetation, geomorphologic, lithological and hydrological properties. For analysis of agroecological conditions and making a distinction between agricultural regions – subregions as a basic document the data of General Soil Map of Croatia (GSM) in a scale of 1:50000 (Bogunović 1992, Bogunović et al 1997) were used. Results of numerous scientific research of all well versed authors included in the project (Bogunović 1992, Bogunović et al. 1997, Bašić 1993, Bašić et al. 1995, Husnjak 2000, Jones et al. 2005, Jurić et al. 1986, 1998, Kisić et al. 2005, 2006, Mesić et al. 2001, Mirošević 1975, Mirošević, Veršić 1996, Žugec 1984, Žugec et al. 1987) and other published papers (Butorac 1993, Butorac et al 1988, Bašić, Franić 2003, Maleš et al. 1976, Licul, Mirošević 1975, Petraš, Bašić 1998, Tomić et al. 1993). For characterization of climatic conditions the meteorological data of the 30-years period (1955-1984) are used. The data of land use, farm size, population density, farming practices, crop rotation, yields are the statistical data of the last Population Census 2001 as well as the Agricultural Census 2003.

Results of inventarization of agrosphere

Inventarisation of agrosphere of Croatia started with preparing data on soil distribution and main properties of soil types, especially properties influenced on soil fertility and suitability for growing of main crops and/or plantations as well as the best and sustainable farming systems.

Properties of pedosphere of croatia

Croatian pedosphere is a natural "soil museum", with practically all soil types possible to find in Europe, which means that land resource potential includes soils of high as well of low fertility. Soil order as the highest unit of soil classification is characterized by soil genesis in automorphic, hydromorphic, hallomorphic and/or subaqual conditions. The central unit of soil classification is soil type, characterized by properties of the soil profile (number and sequence of soil horizons), genesis, evolution and main physical and chemical properties, fertility and main limitations for agricultural production. The data of GSM in the scale 1:50000 presented in Table 1 refer to heterogeneity of pedosphere and soil types (Table 1).

There are a high percentage of hydromorphic soils, one of the highest in Europe. It is primarily the consequence of the fact that Croatia started investing into soil reclamation rather late and that such investment, unfortunately practically has been terminated after Croatia's independence (Bašić 2006).

Agricultural regions

Agricultural regions are agroecological - territorial units of Croatia's agrosphere of specific climactic conditions and land resource potential. Regions are divided into subregions - smaller units that stand out by their specific climate, soils, relief or farming system. Thanks to all these influences Croatia is divided into three clearly defined agricultural regions: Pannonian, Mountain and Adriatic (Figure 1).

With 56.7% in the total territory of Croatia, agriculture occupies the largest share of the total area, but the share of

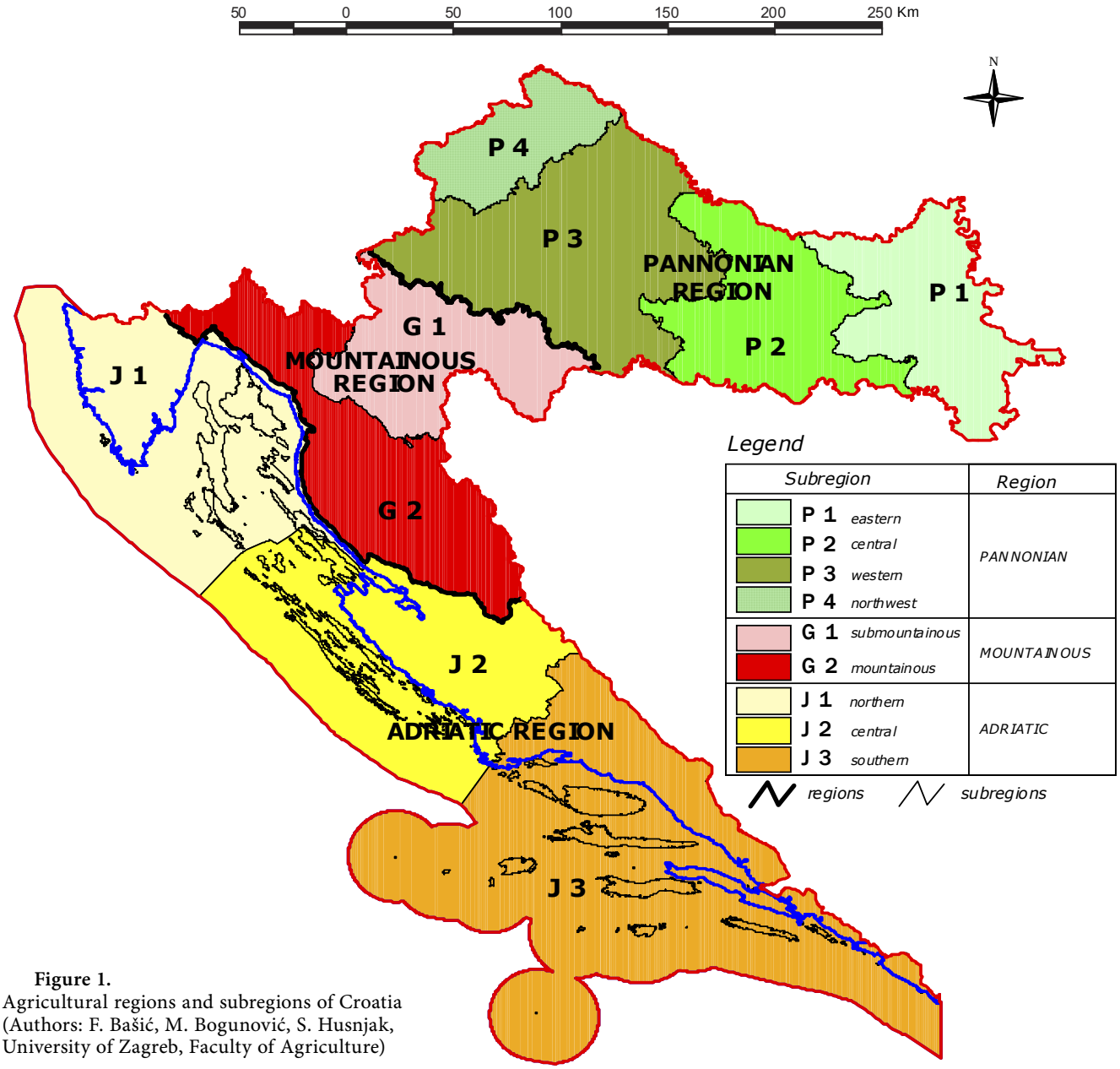

Figure 1.
Agricultural regions and subregions of Croatia (Authors: F. Bašić, M. Bogunović, S. Husnjak, University of Zagreb, Faculty of Agriculture)

Table 1.
Soil types of the Republic of Croatia (Bogunović, 1992)

I. Automorphic soils		3,153432	56.631
1.	Litosols	32,703	0.587
2.	Regosols	70,698	1.270
3.	Colluvial soil	91,938	1.651
4.	Arenosol	667	0.012
5.	Chernozem	51,808	0.930
6.	Leptosol on hard limestone and dolomite (calcic melanosol)	255,201	4.583
7.	Humic sillicate soil (ranker)	86,944	1.561
8.	Leptosol calcaric	420,184	7.546
9.	Vertisol	5,002	0.090
10.	Cambisol eutric	172,495	3.098
11.	Cambisol districic	316,184	5.678
12.	Cambisol rhodic (Terra rossa)	245,289	4.405
13.	Cambisol on limestone and dolomite	474,959	8.530
14.	Luvisol	703,215	12.629
15.	Podzol	1,382	0.025
16.	Brown podzolic soil	7,393	0.133
17.	Anthropogenic soils	217,370	3.904
II. Hydromorphic soils		1,617,640	29.050
18.	Stagnosols	577,025	10.363
19.	Fluvisol	136,343	2.449
20.	Humofluvisol	89,901	1.614
21.	Pseudogley-gley	84,713	1.521
22.	Gleysols	499,526	8.971
23.	Humogley	64,555	1.159
24.	Hydroameliorated soils	163,000	2.927
25.	Peat soils (histosol)	2,577	0.046
III. Halomorphic soils		532	0.010
26.	Solonchak	121	0.002
27.	Solonetz	411	0.007
IV. Subaqual soils		321	0.006
28.	Gyttja and protopedon	321	0.006
Rockiness		796,459	14.303
Grand total		5,662,031	100.000

agricultural land differs from region to region depended on relief, fertility of soil, population density and farming system (Table 2).

Out of the total land area of Croatia of 5662031 ha, agricultural land occupies 3212816 ha. From region to region land use differs a great deal (Table 3).

The Pannonian agricultural region is the most important and the largest in Croatia, albeit, as indicated in Table 4, the agricultural land per capita is the biggest in the mountainous region, due to the high share of pastures and intensive depopulation caused by the last war (Table 4).

In spite of quite favourable agroecological conditions yields of main arable crops in Croatia are much below of maximal one (biological potential of varieties) and real possibilities. According to Mihalić et al. (1981) reasons for lower yields than maximal one (100% of biological potential) expressed in % are as follows:

- low natural fertility of soils and lack of amelioration 20%
- lower quantity or unfavourable distribution of precipitation 16%
- unsuitable soil tillage 13%
- unsuitable crop variety 16%
- unsuitable crop density 14%
- crop diseases and pests 10%
- other factors 11%

Reason for 20% in yield reduction addressed to soil is, unacceptable and suggestive for the best way for advance of agriculture. It is soil amelioration – drainage and irrigation.

Pannonian region

Eastern Pannonian subregion (P-1)

This subregion comprises the easternmost part of the country; Syrmia, Baranja and Eastern of Slavonia known as "breadbasket" of country with very fertile soils and climatic conditions in which is "dry farming" a usual praxis in arable farming. The subregion covers an area of 605492 ha, or 10.7% of state territory and 13.5% of total agricultural land. According to the Census of 2001 the population of the subregion is 491860 or 81 inhabitants per km^2 (Bašić, Franić 2003).

Table 2. Land use in Croatia*

Region	Forests		Agricultural land		Water areas		Settlements		Total	
	hectares	%	hectares	%	hectares	%	hectares	%	hectares	%
Pannonian	904 617	38.5	1 643 844	51.2	38 267	71,7	30 702	68,9	2 617 430	46,2
%	34.6		62.8		1.5		1.2		100.0	
Mountain	849 813	36.1	531 505	16.5	4 583	8,6	2 847	6,4	1 388 748	24,5
%	61.2		38.3		0.3		0.2		100.0	
Adriatic	596 840	25.4	1 037 467	32.3	10 509	19,7	11 037	24,7	1 655 853	29,3
%	36.0		62.7		0.6		0.7		100.0	
Croatia	2 351 270	100.0	3 212 816	100.0	53 359	100,0	44 586	100,0	5 662 031	100,0
%	41.5		56.7		0.9		0.8		100.0	

* Bašić, Bogunović, Božić, Husnjak, Jurić, Kisić, Mesić, Mirošević, Romić, Žugec, 2001

Table 3. Agricultural land and land use*

Region	Subregion	Agricultural land	Arable land	Plowland	Orchard	Vineyard	Meadow
		hectares and percent					
Pannonian	P-1 – eastern subregion	418 577	390 200	373 662	4 926	4 158	7 454
	%	13	19	26	7	7	2
	P-2 – central subregion	329 932	296 024	242 003	7 699	3 817	42 505
	%	10	15	17	12	6	10
	P-3 – western subregion	607 944	549 058	358 303	15 766	12 695	173 747
	%	19	27	25	22	21	40
	P-4 – NW subregion	193 162	176 888	116 591	8 065	8 543	43 693
	%	6	9	8	12	14	10
	Total	1 549 615	1 412 170	1 090 559	36 456	29 213	267 399
	%	48	70	75	54	49	62
Mountain	G-1 – perimountainous	274 607	174 103	112 553	3 615	2 027	45 190
	%	9	9	8	5	3	10
	G-2 – mountainous	318 619	127 607	58 857	1 366	318	70 000
	%	10	6	4	2	1	16
	Total	593 226	301 710	171 411	4 981	2 345	115 190
	%	19	15	12	7	4	26
Adriatic	J-1 – northern subregion	258 501	122 612	75 802	4 281	7 695	31 448
	%	8	6	5	6	13	7
	J-2 – central subregion	409 775	100 266	65 606	10 524	9 551	14 585
	%	13	5	4	15	16	3
	J-3 – southern subregion	366 266	82 575	53 829	12 425	11 342	4 975
	%	12	4	4	18	19	1
	Total	1 034 542	305 453	195 237	27 230	28 588	51 008
	%	33	15	13	39	47	12
Croatia	Total	3 181 107	2 020 626	1 458 216	66 667	60 146	433 597
	%	100	100	100	100	100	100

* Bašić, Bogunović, Božić, Husnjak, Jurić, Kisić, Mesić, Mirošević, Romić, Žugec, 2001

Table 4. Agricultural land per capita*

Regions - Subregions	Population	Agricultural land, ha	Arable land, ha	Plowland, ha
P - 1 Eastern	491 860	418 577	390 200	373 662
ha per capita		0.85	0.79	0.76
P - 2 Central	382 360	329 932	296 024	242 003
ha per capita		0.86	0.77	0.63
P - 3 Western	1 483 058	607 944	549 058	358 303
ha per capita		0.41	0.37	0.24
P - 4 Northwestern	441 961	193 162	176 888	116 591
ha per capita		0.44	0.40	0.26
Pannonian total	2 799 239	1 549 615	1 412 170	1 090 559
ha per capita		0.55	0.50	0.39
G - 1 Perimountainous	169 921	274 607	174 103	112 553
ha per capita		1.62	1.02	0.66
G - 2 Mountainous	81 330	318 619	127 607	58 857
ha per capita		3.92	1.57	0.72
Mountain total	251 251	593 226	301 710	171 411
ha per capita		2.36	1.20	0.68
J - 1 Northern	484 853	258 501	122 612	75 802
ha per capita		0.53	0.25	0.16
J - 2 Central	267 171	409 775	100 266	65 606
ha per capita		1.53	0.38	0.25
J - 3 Southern	578 838	366 266	82 575	53 829
ha per capita		0.63	0.14	0.09
Adriatic total	1 330 862	1 034 542	305 453	195 237
ha per capita		0.78	0.23	0.15
Croatia total	4 381 352	3 181 107	2 020 626	1 458 216
ha per capita		0.73	0.46	0.33

*As per the Census of 2001.

The climate is moderately warm, with the average precipitation 688 mm (Ilok) - 729 mm (Donji Miholjac). Average yearly temperature in Ilok is 11.1 °C, in Osijek and Donji Miholjac 10.7 °C. An important characteristic of the climate is a chronically deficiency of water, which in Ilok ranges 1250-3360 m^3/ha. In such conditions the priority of soil tillage practice in "dry farming" is to infiltrate and accumulate in soil maximal quantity of rain and snow water during the wet period (autumn-winter) and save it for the dry one (Butorac et al. 1988, Butorac 1999, Jurić et al. 1998, Žugec et al. 1987).

The entire territory of the subregion is covered with loess, provided the bases for genesis of very fertile soil types; Chernozem, Cambisol eutric and Regosol (Bogunović 1997, Bašić 2005). Those soils provide almost optimal conditions for cultivation of all arable crops, vine, fruit and vegetables. In spite of semi-arid climate on slopes of Fruška gora and Baranjsko brdo there is registered quite high soil erosion after torrential rains, especially in inter-row space of plantations (Bašić et al. 1993). For soil conservation in vineyards and orchards of western Syrmia and Baranja Bašić et al. (1999) recommended to grass the soils on slopes steeper than 5% using a special mix of grasses. In arable farming the long tradition has a traditional crop rotation from "horse time" known as "Old Slavonian three-field crop rotation"; row crop (maize) - grain crop (winter wheat) – legume (common vetch). Vine growing has a long tradition, starting from the 3rd century A.D., when it was brought there by the army of the Roman emperor Probius. Vineyards survived the Turkish conquest and were vastly expanded on the renowned estates of Eugene of Savoy in Baranja, Odeschalchi in Ilok and Eltz in Vukovar in modern "Belje" and "Vukovar-VUPIK" state farm. This subregion comprises four internationally known vine growing districts: Syrmia, Baranja, Erdut and Đakovo. Traminac from Ilok is a most famous wine in subregion and wider (Mirošević 1975, Mirošević, Veršić 1996).

Investment in infrastructure for irrigation in P-1 subregion would guarantee economic revival and stable development. As much as 138013 ha of fertile land may be irrigated without any restrictions (Semigley on leached loess and Chernozem on loess) whereas on other soil types irrigation is not possible without drainage (Tomić et al. 1993).

Central Pannonian subregion (P-2)

This subregion stretches through the picturesque areas of western Slavonia, Podravina, Bilogora and central Posavina. The area of subregion is 642073 ha, from which 252207 ha of forest (39.3%) and 378358 ha of agricultural land (58.9%). According to the Census of 2001, there are 382360 inhabitants - 187300 (49%) in the rural and 195060 (51%) in the urban settlements (Bašić, Franić 2003).

Average annual precipitation is about 790 mm, air temperature is 10.5 °C. The coldest month is January, with the average temperature between –0.9 °C and –1 °C and the warmest July, with the average temperature between 20.4°C and 20.5 °C.

Prevalent are hydromorphic soil types – most spread are Stagnosols, Gleysols, Luvisol on loess, follows by Cambisol eutric, Leptosol on marl, Fluvisol, etc. This subregion lays at the edge of forestland, hence a higher share of forests then in the Eastern Pannonian subregion.

Prevalent in agriculture is intensive farming, especially in the flat eastern part of subregion. The hills and the slopes provide good conditions for vineyards and all continental fruits. That area also comprises the Golden Valley and its famous Požega - Kutjevo vine growing district. Further west in this subregion there are more and more cattle farms and fishponds, which are getting water from natural water flows (Bašić et al. 1993, Kisić et al. 1999, 2005, 2006). That is yet another reason why it is so important to protect waters from all sources of pollution. Compared to the previous subregion, this one has more precipitation and water erosion, especially in the spring, and the erosion sediment soil material brings into water flows and fishponds, significant quantities of different agrochemicals: nitrate and other nutrients, pesticides, etc. (Šimunić et al. 1993, Mesić et al. 2000, 2001).

This subregion has a strong need for land reclamation – irrigation and drainage. According to our assessment, drainage should be carried out in an area of 200000 ha of hydromorphic soils of this subregion. There is a strong need for irrigation. Conditions for it are very good and so would be the effects of such a practice. All the soils in this subregion, i.e. 303318 ha, are suitable for irrigation, including 88731 ha (Luvisol on loess, Cambisol eutric, Leptosol on marl, Fluvisols), where it can be done without any restrictions, whereas in other areas the soil must first be prepared by drainage of surplus water (Tomić et al. 1993, Bašić et al. 2001).

All the vineyards in this subregion are placed on the slopes of the central Slavonian mountain range with famous vine growing districts: Slavonski Brod, Požega, Pakrac, Feričanci-Orahovica and Virovitica-Slatina (Mirošević 1975, Bašić, Mirošević 2006).

Western Pannonian subregion (P-3)

Located in the westernmost, picturesque part of the Pannonian plain, this subregion covers an area of 1048047 ha, from which 402134 ha are forests and 617862 ha is agricultural land. The subregion comprises a significant share of Croatia's total population – according to the last census 1483058 inhabitants (33.8% of total), with density of as

many as 142 per km^2, with dominant urban people living in urban centres including Zagreb – capital of Croatia.

Thanks to favourable natural conditions the main characteristic of the subregion is developed cattle breeding, which has a long tradition. Average annual precipitation is 865 - 891 mm. An average annual temperature is 10, 1 - 10.6 °C, average water deficiency is 27.5 mm, but in dry years it can be to 274 mm.

The most common types of soil in the subregion are Luvisol on loess and Stagnogley, as soil types they have very unstable structure and make a compacted layer in profile on which stagnates rain water. Very fertile soil is Fluvisol widespread along the Drava River, than Gleysols, which needs drainage, following by Cambisol eutric on loess and Leptosol on marl and soft lime stones. Soil erosion, especially on Stagnosols and all soil types on marl is very high and destructive process of soil damage, caused by soil properties (unstable structure, high content of silt), topographic conditions, an adverse land management practices and to high share of maize as row crop and plantation of vineyard and orchards. Based on ten years monitoring of soil erosion on Stagnogley (Bašić et al. 1993, 1995, Kisić et al. 1999, 2006) for efficient soil conservation we recommend: correct tillage direction (contour tillage) and crop rotation with more crops of high density, but on steep slopes (steeper than 9%) to grow only crops of high density. The most efficient – without any soil erosion was double-crop (winter wheat with soybean). In plantations it is necessary to change traditional direction of rows with the slope to contour one, but in the case of row orientation with the slope (from top to the bottom) it is necessary to obligate land owners/users to grass the inter-row space. There is also a serious problem of narrow crop rotation or monoculture of tobacco in Podravina. After 18 years of comparative field investigation of efficiency of different crop rotations in tobacco growing Turšić et al. (2006) the best results in yield and quality of tobacco leaf realised in four-field crop rotation compared with three- and two-field one, or monoculture of tobacco.

Investment into land reclamation is the safest and most reliable way to establish stable and reliable crop production for direct consumption by urban population and the food processing industry. According to our assessment, this subregion requires drainage of hydromorphic soils on an area of 185000 ha, but irrigation is viable only for vegetable crops grown during the summer season on shallow soil and sandy soils (Tomić et al. 1993). High sufficiency of water causes leaching of nutrients especially nitrates in ground water (Šimunić et al. 1993, Mesić et al. 2000, 2001). The subregion offers favourable conditions for cultivation of all kinds of fruits, vegetables and vines. The vineyards are located on picturesque, attractive hills, at altitudes 150 - 400 m. The most renowned vine growing districts are: Plešivica, Vukomeričke gorice, Zagreb, Dugo Selo, Vrbovec, Moslavina, Kalnik, Koprivnica, Bjelovar and Daruvar. The common characteristic of all those vineyards is that they all consist of old, autochthonous varieties of grapes (Mirošević, Veršić 1996).

Northwestern Pannonian subregion (P-4)

This subregion occupies north-western Croatia, i.e. the areas of Zagorje, Varaždin and Međimurje. It covers an area of 321819 ha - 100195 ha under the forests and 212786 ha of agricultural land. The population is 441961, as many as 137 per km^2, 55.4% of whom lives in rural areas. The subregion features a wide range of different landscapes and types of vegetation, each specific and attractive even for the most refined nature lovers. The second characteristic, possibly linked to the first one, is a large population density, which is a consequence of traditionally high fragmentation of agricultural land and use of marginal land.

Average annual precipitation is 877-1104 mm and average temperature is 9.3-9.9 °C. The coldest month is January, with the average temperature of 0.1 °C to –1.4 °C and the warmest is July with the temperature between 18.9 °C and 19.7 °C.

Due to heterogeneity of parent material and to very different relief, the subregion abounds in very different soil types. Prevalent soil types are Gleysols, widespread in numerous valleys that have been formed by rivers, streams and brooks, follows by Leptosol on marl, Stagnosols and Humofluvisols. Most important for growth of crops and plantations of orchards and vineyards are Regosol, Anthropogenic soils and Leptosol as thin soils on marl. The common characteristic of the soils in this subregion is intensive water erosion, mostly due to limited permeability of the soils and intensive runoff of rain-water. Characteristics of the climate also contribute to the erosion, but the key factor is anthropogenic influence – high percentage of perennial plants – vineyards and orchards, with the rows mostly oriented up-down the slope - from top to the bottom. Erosion stimulates high frequency of row crops, especially maize and tillage up-down the slope. The eroded soil material washed away through erosion causes eutrophication and pollution of water flows and underground waters, especially by nitrates. Our investigations have proved it to be quite serious, in spite of rather extensive agriculture practiced in the subregion, where mineral fertilizers and other agrochemicals are used sparsely (Petraš, Bašić 1998, Bašić et al. 2001, 2003, Kisić et al.2006).

There are three vine growing districts in this subregion: Međimurje, Varaždin and Hrvatsko Zagorje. The vineyards differ a lot regarding their main characteris-

tics. The varieties of vine grapes are quite different from hill to hill. The most prevalent grapes are old, traditional as Kraljevina and Moslavac but also some new ones: Riesling, Pinot, Chardonnay, Traminac, Sauvignon and Yellow Muscat (Mirošević, Veršić 1996).

The Mountain region

The submountain subregion (G-1)

This subregion rises gradually from the Pannonian plane towards the massif of the Dinara mountain range. It covers parts of the areas of Lika, Banovina and Kordun. This territory of 569403 ha is populated by 169921 inhabitants – 30 per km^2 only. From the Holocene terrace of the Sava River raises a mountain the Petrova gora and the Zrinska gora. South of the towns of Karlovac and Duga Resa extends a large Karst plateau with very prominent and developed karst phenomena. The specific feature of landscape is a large number of karst holes, known in the geological literature as "pock-pitted karst". Its other characteristic is that it is covered with deep layers of well developed soil (Škorić et al. 2003, Bašić 2005).

Average annual precipitation in Karlovac is 1158 mm and in Ogulin as much as 1610 mm. Water balance in Karlovac and Ogulin shows an annual water sufficiency of 470-970 mm, but in dry years water deficiency ranges between 52 mm and 135 mm, which is rather high and affects the crops very negatively, especially in shallow soils on limestone.

On flatter and lower parts of the subregion prevalent is red soil, which has been described in our literature as the so called relict red soil (Terra rossa), as well as Luvisol acric and Cambisol distric formed on relict Terra rossa and/or Stagnogleys. On limestone and dolomites there one can find Cambisol, Leptosol and Melanosol (Škorić et al. 2003). This subregion offers very favourable conditions for growing of all arable crops, especially fodder crops for livestock breeding as a practice of a long tradition, which is necessary to sustain.

Mountain subregion (G-2)

This is a prominently forest subregion, with 61.0% of the area under the forest, and 38.3% of agricultural land. From the point of view of agriculture this is the most backward and least populated area of Croatia, with only 10 persons per km^2 – practically semidesert. Yet, this region features a gem of nature – the National Park Plitvička jezera.

Average annual quantity of precipitation is 1417-1904 mm, with the maximal monthly precipitation in November. Average annual air temperature is 7.0-8.4 °C, the absolute minimal ever recorded was – 33.5 °C in Gospić. Rather than water deficiency this subregion has a surplus, ranging from 830 mm to 1357 mm. However, in dry years Gospić suffers of a water deficiency most often in July and August. The water balance shows the total deficiency in a dry year may amount to 140 mm. Yet there are years when sufficiency ranges between 1100 mm and 1940 mm.

Although lithologically rather homogenous, due to a series of other factors that bear on formation of soil, especially the relief and the vegetation, this area is pedologically very heterogeneous. The dominant soil type is Cambisol on limestone and dolomite, Leptosol calcaric and Melanosol, Luvisol, and relict Terra rossa (Škorić et al. 2003). Common characteristic of soil types is a good and favourable physical but unfavourable chemical properties, especially extremely high acidity of soils. Our investigations show as the most important and absolutely profitable land reclamation measure in this subregion is liming. Using of high doses of fine liming material on very acid Acric Luvisol near Plitvička jezera Butorac et al. (1988) prepared that soil for successful growing of Alfaalfa as sensitive fodder crop of high quality. Farming systems in this subregion is dominantly based on cattle breeding. Traditionally pastoral farming is the past, but with a chance to survive and revitalise.

Adriatic agricultural region

North Adriatic subregion (J-1)

The area of this subregion is 452934 ha, 258501 ha of which is agricultural, most of which is native karst pasture, where live 484853 inhabitants, who have at their disposal 0.58 ha agricultural land per capita. On islands there is permanent tendency of depopulation and abandonment of land and agriculture as profession.

Average annual precipitation is ranging from 875 to 1215 mm, the wettest month is November and the driest one is February. The period with the minimum temperature of 10 °C begins between late March and mid April and ends between late October and late November, i.e. it lasts 191-244 days on the average.

In spite of high quantity of precipitation, due to its irregularity only Pazin does not experience water deficiency. In dry years water deficiency amounts to 146 mm, whereas in wet years there is a sufficiency of as much as 922.4 mm. During average summer period water deficiency is 120-140 mm, but in dry years it is 300-400 mm, and sufficiency is over 450 mm.

Genesis and properties of soils of Istria is in details described in monograph of Škorić et al. (1987). The dominant parent rock in this subregion, especially in Istria is Mesozoic – Cretaceous limestone, but most known and widespread soil type is Cambisol rhodic (Terra rossa), very fertile soil with typical red colour and favourable physi-

cal, chemical and biological properties. Part of Istria with Terra rossa is known as "Red Istria". On higher topographic positions and on Triassic and Jurassic lime stones and dolomites there is Cambisol on limestone and dolomites, Leptosol on hard limestone as well as Leptosol, Regosol and Anthropogenic soils on flysh (mix of marl and sandstone). Part of Istria with this soil types is called "Grey Istria", because of grey colour of this parent material and soils. In this subregion there is enormous, just catastrophic soil erosion. Generally, the climate in Istria, especially high average annual precipitation and high maximal daily precipitation, are conductive to erosion. Our research has proved that the annual average erosion of soil in the basin of the Mirna river is 18.84 t ha^{-1}, of the Raša river 31.97 t ha^{-1} and of the Boljunčica river 21.20 t ha^{-1} annually, which is several times over a tolerant annual erosion (Bašić et al. 2001, 2003).

For optimal growth and development of crops, under average climactic conditions, water deficiency needs to be compensated for by irrigation. Irrigation is a prerequisite for high yields of all crops, growing of vegetables, efficiency and stability of all agricultural systems. In order to ensure the water for irrigation, it would be advisable to build multipurpose water reservoirs of different sizes.

In the wine atlas of wine connoisseurs this agricultural subregion has an outstanding position in Istria, Hrvatsko primorje and on the Kvarner islands in northern Adriatic. Varieties of vine differ not only from one vine - growing hill to another but also from vineyard to vineyard, but the most common white grapes are: Istrian malmsey, Chardonnay, Pinot, Trebljano Toscano, Muscat of Momjan, and other less common quality grapes. The red grapes present there are Merlot, Cabernet Sauvignon, Cabernet Franc, Teran, Hrvatica, etc. In the vineyards of Rijeka and Kvarner region: the island of Krk has white Žlahtina, red Bašćanac and red Brajdica; the island of Susak red Trojšćina, white Krizol, red Suščan, and smaller areas under white Pljeskunac. The most renowned grape on the island of Pag is white Gegić (Mirošević 1975, Mirošević Veršić 1996).

Central Adriatic subregion (J-2)

This subregion is situated in central part of our littoral, i.e. the area of Zadar and its hinterlands - Ravni Kotari, as well as the vicinal islands, with the area of 570946 ha populated by 267171 inhabitants and agricultural land per capita 1.53 ha.

The Karst plateau has been crossed by water valleys of three Karst beauties – the rivers Zrmanja, Čikola and Krka. The valley of the Krka has been designated as national park and commercial activities there have been strongly restricted. This subregion also features our largest fresh water lake – Vransko jezero, which fresh water mixes with the seawater, so it is only partly usable for irrigation (Romić 1992).

Average annual precipitation is 950-1114.5 mm, minimal in July, a maximal one in November. Annual air temperature are 12.9-15.1 °C. Main characteristic of water balance is a regular sufficiency in winter and deficiency in the spring-summer (vegetation) period. According to the data on evapotranspiration in submediterranean part of subregion, (Knin) has a relatively low average water deficiency – only 75.7 mm, whereas the sufficiency may be as much as 727.2 mm. Zadar has an average deficiency of 166.3 mm and an sufficiency of 335.3 mm. In a dry year water deficiency may be as much as 318.4 mm and in a very wet year sufficiency may reach 539 mm.

The subregion is geomorphologically rather low. It consists of a variety of limestone, mostly from the Cretaceous age. The prevalent soil type is Cambisol on limestone and dolomite, following by Cambisol rhodic (Terra rossa), Leptosol on hard limestone and Leptosol calcaric.

Less prevalent are soils on flysh - mix of marl and sandstones.

Traditionally, this subregion has had very sophisticated and developed agriculture, especially the growing of vine, fruit and vegetables, and cattle breeding. The market in Zadar was famous as the richest and most picturesque one in this part of Europe. During the last war this subregion suffered severe devastation, depopulation and economic stagnation, which affects even once well organized and successful state farm Zadar and Vrana.

Local economy may be revitalized only by investment in agriculture, especially in irrigation systems. In the subregion hydro technical land reclamation has already been carried out by installation of draining pipe system on state farms. This was one of the first Croatian regions that introduced this system; the total area with hydro technical land reclamation was more than 4000 ha. Furthermore, in the Karst fields stable water levels should be ensured by prevention of flooding and by pipe drainage on additional 3000 ha. Yet, the need for irrigation is much more pressing. This subregion abounds in high quality water for irrigation but its needs for irrigation have not been realised due to impermissible lack of investment. The multipurpose water accumulation would prevent flooding, stabilize the chaotic and unfavourable water regime, embellish the landscape and guarantee stable and reliable supply of high quality water for the annual crops and the plantations. Especially important would be construction of mini-accumulations in Karst fields on the islands. The quality of surface water is satisfactory (Romić 1992).

The subregion offers excellent conditions for the growth of high quality vegetables throughout the year. Conditions

are also suitable for all Mediterranean fruits, especially for olives and figs, but also for peaches and cherries, and famous Maraska – especially variety of sour cherry. Vine growing has a long tradition in the areas of Zadar, Benkovac, Šibenik, Drniš and Knin. The prevalent varieties of grapes are: Plavina, Lasina and Gustopejnica (red), but the most prevalent old variety of white grape is Maraština (Maleš et al 1976).

South Adriatic subregion (J-3)

This subregion comprises the rest of the coast down to Dubrovnik and Konavle, i.e. to the state border, including the respective islands. The area is 631973 ha big, i.e. 11.2% of Croatia's total. According to the Census of 2001, the number of inhabitants in the subregion is 578838, including 11% of rural population. The subregion has 366266 ha of agricultural land or 0.63 ha per capita.

The Neretva valley is in many ways a special and extraordinary natural complex – a unique marsh habitat, one of the last remaining in Europe. In the valley natural soils have been covered with peat and most of the area has been cultivated.

Average annual precipitation is 855–1253.4 mm, the wettest month is November and the driest July, but annual air temperature in Split is 10.6 °C and in Hvar and Dubrovnik 16.3 °C. Thus, according to the temperature values, this is a warm climate. The evapotranspiration balance shows average water deficiency 269.4–282 mm, in dry years to 416.9 mm. Water sufficiency is 581- 756 mm.

The subregion consists mostly of limestone and dolomites, except for Konavle, where is flysh as a mix of marl and sandstone a dominant parent material. Prevalent area is a bare Karst, soil types are Cambisol on limestones and dolomites, following by shallow Leptosol (Melanosol), but there are also large areas under hydromorphic soil – Fluvisols and Gleysols, both in the Neretva valley and in the Karst fields, as well as Leptosol calcaric, Regosol and Anthropogenic soils on flysh.

Given the characteristics of soils, for stable production and high and stable yields it will be necessary to carry out hydro and agro technical land reclamation. It is necessary to renovate, expand and repair the old systems on an area of at least 2000 ha. Furthermore, water level should be regulated in flooded karst fields, the soil in Imotsko and Vrgoračko fields regulated and pipe-drainage should be carried out in a land area that we estimate at 15000 ha. Yet, much more important and economically more productive would be irrigation. For that one should ensure a sufficient quantity of water, build accumulations and obtain appropriate infrastructure and equipment for irrigation of a land area that we estimate at 150000 ha. According to our estimates, the total surface area of land that should be reclaimed through different agrotechnical measures is 115300 ha.

Revitalization of islands is a special and very complex problem, in centre of which is irrigation. It would be advisable to build reservoirs for collection of rainwater during the wet season. The most important agricultural area is undoubtedly the valley of the Neretva River. Soils are very high quality, it abounds in water, but due to influx of seawater quality of the water is dubious. Seawater penetrates even further upstream than the town of Metković. Also salinized are underground waters, where the degree of salinity varies.

This subregion comprises much known vine-growing areas: Split, Sinj, Makarska, Imotski, Vrgorac, Neretva, Dubrovnik-Mljet, Pelješac, Korčula, Lastovo, Vis, Hvar, Brač and Šolta. Every vine-growing area has a somewhat different selection of vines. The most widespread cultivars are: Babić crni, Plavac mali, Glavinuša, Ninčuša, Okatac, Kadarun and Vranac (red), and Trebljan, Mladenka, Maraština and Debit (white). The prevalent grapes in the Imotski vine-growing area are Kujundžuša (white) Rudežuša (Trnjak) and Vranac (red).

Conclusion

Result of a special project of inventory of agrosphere is agricultural regionalisation presented in this paper.

Croatia is a natural "soil museum" with very heterogeneous land resource potential. The data on even 28 soil types from which 17 soil types in automorphic, 8 in hydromorphic, two in hallomorphic and one in subaqual soil order, refers to heterogeneity of Croatian pedosphere and land resource potential.

The whole territory of Croatia is divided into three clearly defined agricultural regions: Pannonian with four subregions, Mountain with two subregions and Adriatic with three subregions.

High percentage of hydromorphic soils is the consequence of the fact that Croatia started with soil drainage rather late and such investment, unfortunately practically has been terminated after Croatia's independence.

References

Bašić F., (1993), Land resources evaluation of Croatia, Agricultural sector review, FAO, University of Zagreb, Faculty of Agriculture, Department of General Agronomy, p.41,

Bašić F., Butorac A., Mesić M., Sabolić M., (1993), Aktualna pitanja erozije i smjernice konzervacije oraničnih tala Hrvatske, Poljoprivredne aktualnosti 29, 3-4, 227-249,

Bašić F., Bićanić V., Bertić B., Igrc-Barčić J., (1995), Sustainable management in arable farming of Croatia, Proc. of Int. workshop on water pollution and prot. in agr. Prac., Hr. vode br.12., p. 237-253,

Bašić F., Kisić I., Mesić M., Knežević V., (1999), Smjernice gospodarenja na tlima izloženim eroziji na području Grada Iloka, Znan. skup u ovodu 100. obljetnice Poljoprivredne škole u Iloku, str. 130-152,

Bašić F., Bogunović M., Božić M., Husnjak S., Jurić I., Kisić I., Mesić M., Mirošević N., Romić D., Žugec I., (2001), Regionalizacija hrvatske poljoprivrede, rukopis, Sveuč. u Zg., Agr. fakultet, 254 str.,

Bašić F., Kisić I., Mesić M., (2001), Statements on problems of soil protection and sustainable land use in Croatia. Co-operation for Soil protection and Sustainable land use in CEEC, Vienna, str. 14-18.,

Bašić F., Franić R., (2003), Croatian Agriculture at the crossroads, Nature and man in Croatian Agriculture, Croatian food and food processing industry, PRO-TIM, Zagreb, p. 82,

Bašić F., (2005), Soil Resources of Croatia, Soil Resources of Europe, European Commission, European Soil Bureau, Institute for Environment and Sustainability JRC Ispra, II edition, p. 89-96,

Bašić F., Mirošević N., (2006), Regionalizacija hrvatske poljoprivrede s obzirom na sjemenarstvo i rasadničarstvo, Drugi hrvatski oplemenjivački i sjemenarski kongres, Poreč, Zbornik, str. 16.

Bašić F., (2006), Višenamjensko obilježje kao temelj održivog gospodarenja tlom u svijetlu pristupa Hrvatske EU, zbornik savjetovanja „Sustavsko mišljenje i proces integracije Hrv. u EU“, str. 103-117,

Bullock P., Jones R. J. A., Houškova, Beata, Montanarella L., (2005), Soil Resources of Europe, European Commission, European Soil Bureau, Ins. for Env. and Sustainab. JRC Ispra, II ed. p.15-34,

Bogunović M., (1992), Soil Map of Croatia, Agronomski fakultet Sveučilišta u Zagrebu,

Bogunović M., Vidaček Ž., Husnjak S., Sraka M., (1997), Namjenska pedološka karta Republike Hrvatske i njena uporaba, Agronomski glasnik, 5-6,

Butorac,A., (1993), Conservation Tillage in Eastern Europe, Conservation tillage in temperate Agroecosystem, Lewis publishers, 357-374,

Butorac A., Bašić F., Redžepović S., Vasilj Đ., (1988), Investigation into the possibilities of growing Alfa-alfa (Medicago sativa L.) on acric luvisol of thinly covered karst, PZS, Vol.33, 5-21,

Butorac A., (1999), Opća agronomija, Sveučilišni udžbenik. Školska knjiga, str. 1-648,

Husnjak S., (2000), Procjena rizika od erozije tla vodom metodom kartiranja u Hrvatskoj, disertacija, Agronomski fakultet, str. 138,

Jones R. J. A., Houškova B., Bullock P., Montanarella L., (2005), Soil Resources of Europe, European Commission, European Soil Bureau, Institute for Environ. and Sustainability JRC Ispra, II ed. p.420,

Jurić I., Žugec I., Kovačević V., Buljan V., (1986), Osvrt na kalcizaciju, fosfatizaciju i humizaciju pseudogleja Slavonije, Poljoprivredne aktualnosti, 26 (3), str- 441-446,

Jurić I., Žugec I., Komljenović I., (1998), Utjecaj agromeliorativnih mjera na prinos kukuruza na pseudogleju Istočne Hrvatske, Poljoprivredne aktualnosti, 30 (1-2), str. 113-118,

Kisić I., Bašić F., Butorac A., Nestroy O., Marušić J., Mesić M., Sabolić M., Petraš J., (1999), Zaštita tla od erozije s motrišta održivog gospodarenja tlom, Hrvatske vode, br. 26., str. 15-26,

Kisić I., Bašić F., Mesić M., (2005), Mjesto i uloga poljoprivrede u zaštićenim područjima, Zbornik Simpozija: Rijeka Krka i NP Krka - prirodna i kulturna baština, zaštita i održivi razvitak, Šibenik, s.14

Kisić I., Bašić F., Butorac A., Mesić M., Nestroy O., Sabolić M., (2006), Erozija tla vodom pri različitim načinima obrade, Sveučilišni priručnik, str. 95,

Licul R., Mirošević N., (1975), Bonitiranje zemljišta za vinograde – općina Sesvete, Republička geodetska uprava, st. 68,

Maleš P., Bubić J., Pezo I., (1976) Rajonizacija vinogradarstava SR Hrvatske, Institut za jadranske kulture i melioraciju krša, knjiga podrajona Dalmacija, Split,

Mesić M., Butorac A. Bašić F., Kisić I., Gašpar I., (2000), Influence of Black Fallow on Nitrate Leaching, Proceedings of 15th ISTRO Conference - CD, p. 7.

Mesić M., Bašić F., Kisić I., Bićanić V., (2000), Višeznačna uloga poljoprivrede i gospodarenja tlom u Hrvatskoj. str. 16-22. XXXVI znanstveni skup Hrvatskih agronoma, str. 44,

Mesić M., Bašić F., Kisić I., Butorac A., Gašpar I., (2001), Utjecaj gnojidbe mineralnim dušikom na sadržaj nitrata u tlu i na koncentraciju NO3 u vodi iz lizimetra, Znanstveno-stručni skup: Kako zaštiti vode Hrvatske s gledišta vodoopskrbe i odvodnje, st. 381-386, Pula,

Mihalić V., Butorac A., Čižek J., Gotlin J., (1981), Agroekološki potencijali biljne proizvodnje u SRH, Agronomski glasnik, No 3, 265-301,

Mirošević N., (1975), Gospodarski uvjeti proizvodnje grožđa kao jedan od čimbenika bonitiranja zemljišta za vinograde, Republička geodetska uprava, st. 7,

Mirošević,N., Veršić,V., (1996), Regionalizacija vinogradarskih područja Hrvatske, II međun. simpozij vinogradarstva i vinarstva, Zbornik radova st. 19-25,

Montanarella L., R.J.A., Jones, Jean Dusart, (2005), The European Soil Bureau Network, Soil Resources of Europe, European Commission, European Soil Bureau, Institute for Environment and Sustainability JRC Ispra, II edition, p. 3-14,

Petraš J., Bašić F., (1998), Erozija tla u Hrvatskoj u svijetlu predviđenih klimatskih promjena, Zbornik znanstv. skupa HAZU “Prilagodba poljoprivrede i šumarstva klimi i njenim promjenama”, 103-115,

Romić D., (1992), Rezultati istraživanja vode na području Vranskog bazena, rukopis, Sveučilište u Zagrebu, Agronomski fakultet, Zavod za melioracije,

Šimunić I., Tomić F., Pecina M., Romić, M., (1993), Djelovanje drenaže na koncentraciju dušika u drenažnoj vodi, Hrvatske vode, God.1, Br.2, 107-111,

Škorić A., Adam M., Bašić F., Bogunović M., Cestar D., Martinović J., Mayer B., Miloš B., Vidaček Ž., (1987), Pedosfera Istre (s pedološkom kartom Istre), monografija, Projektni savjet Pedološke karte Hrvatske, posebna izdanja, knjiga 2, Zagreb, 1-192,

Škorić A., Bogunović M., Martinović J., Pelcer Z., Racz Z., Vidaček Ž., (2003), Tla gorske Hrvatske, (s pedološkom kartom), monografija, MZOPU, Zagreb-Osijek, 1-169,

Tomić F., Marušić J., Buntić Z., (1993), Uređenje poljoprivrednih površina u RH, Hrvat. vode, 51-61,

Turšić I., Butorac A., Bašić F., Čavlek M., Mesić M., Kisić I., (2006), Utjecaj osamnaestgodišnje proizvodnje duhana u monokulturi i plodoredu na prirod i kvalitetu Flue-cured duhana te ispiranje nitrata na semiglejnom tlu sjeverne Hrvatske. X. Kongres HTD, Šibenik, str. 64-65,

Varallyay G., (2000), Soil Quality in Relation to the Concepts of Multifunctionality and Sustainable Development, Proc. Symp. Soil Quality, sustainable Agricluture and Environmental Security in Central and Eastern Europe, NATO Science Series, Vol. 69, p. 17-35.

Varallyay G., (2005), Role of Soil Multifunctionality in Future Sustainable Agricultural Development, Environmental Management; Contribution to solution, University of Zagreb, Faculty of Chemical Engineering and Technology, Editor Koprivanac N., p. 29-39,

Žugec I., (1984), The effect of of reduced soil tillage on maize (Zea mays L.) grain yield in eastern Croatia, Soil Tillage Research, 7. p. 19-28.

Žugec I., Jurić I., Kovačević V., (1987), Neke agromelioracijske mjere kao faktor povećanja plodnosti tla Istočne Hrvatske. Poljoprivredne aktualnosti, 28 (1-2), str. 285-293.

xxx, (2005), Soil Atlas of Europe, European Soil Bureau Network, European Commission, 128 pp

acs72_06