Recommendations for Soil Management in Croatia

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Summary

A trend of rapid forest and particularly agricultural land area reduction due to different types of degradation has been present worldwide in the last decades, and so also in Croatia, whereat soil losses caused by land reallocation are especially dramatic. Besides that, we are witnesses of different forms of soil degradation associated with climate changes - from acidification, dehumification, pollution, erosion to desertification. To protect soils from all types of impairment, this highly important natural resource should be managed in a sustainable way. Hence, the objectives of this work were to present the land potential of Croatia, identify existing processes of soil damages and expressed threats, and offer recommendations for systematic land management, including organizational, administrative and practical measures.

Key words

soil, damage, threats, management, measures, Croatia

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Received: October 22, 2010 | Accepted: January 19, 2011

Introduction

The world has entered recently the third millennium with a number of serious problems, the gravest being undernourishment and environmental pollution. The current world population is about 6.8 billion and it is assumed to surpass 8 billion by 2025, which means a population growth by more than 80 million people per year. At the same time, a trend of rapid forest and particularly land reduction due to different types of damage has been present over the last decades in the whole world, and so also in Croatia. Soil losses caused by permanent land reallocation are especially dramatic. Annual loss of agricultural land in the world due to reallocation has been estimated at 5-6 million ha (Urushadze, 2002). Agricultural land loss in Croatia amounted to about 10,500 ha in the period 1966-1975 (Pavlović and Dobrinić, 1977), and to about 6700 ha/year in the period 1953-1999 (Vidaček, 2001). This process is expressly negative nowdays and is mostly out of control. In this context, besides other negative effects of these losses, the issue arises of producing sufficient food in the future, though the world situation is already tragic since large numbers of people are starving.

On the other side, we are witnesses of different forms of soil degradation associated with climate changes, from acidification, dehumification, contamination, over erosion to desertification. As soil buffering capacities are restricted, these degradation changes are manifested in yield reduction, forest decline and reduced reserves of natural drinking water.

Soil management has always been a very important issue, because soil is the main resource for food production in agriculture, and for biomass in forestry. Owing to the exceptional importance of these and all the other roles of soil for life on Earth, the principal goal of soil management is protection of available resources, both with respect to land area and soil quality, namely soil fertility.

The first part of this study offers a survey of land resources of Croatia as well as of major soil damaging processes and threats, which have to be considered in soil management planning, aimed at soil conservation and protection from all potential forms of damage. In line with the listed soil degradation processes, soil management recommendations are then offered for provision of new regulations, plans, measures and base materials, which is also the principal objective of this work.

Land resources of Croatia

The largest part of the total land fund of Croatia belongs to the division of automorphic soils (65.6%), which includes all soils whose formation and development are characterized by moistening exclusively by precipitation water, which leads to excessive moistening (Bogunović et al., 1996; Husnjak et al., 2005). These are followed by the division of hydromorphic soil (34.4%), comprising soils with expressed signs of excessive moistening by excess water. Only 410.5 ha belong to the division of halomorphic soils, which are characterized by excessive moistening by saline or/and alkaline water. Only 321 ha are subaquatic soils, which were formed under a shallow level of stagnant water (Table 1).

According existing soil classification in Croatia, thirty-six soil types occur in Croatia. The largest area is covered by luvisol (12.1%). This is followed by pseudogley (9.87%), gley amphigley (9.62%), calcocambisol (8.36%), rendzina (7.50%), and dystric cambisol (5.48%). Other soil types cover areas much smaller than 5% each (Table 2). As eight soil types occur only sporadically, their areas are not separately presented.

Occurrence of almost all soil types has been recorded on agricultural land. The largest part of total agricultural land area is covered by gley amphigley (13.8% of total agricultural land area). It is followed by luvisol (13.3%), pseudogley (11.9%), calcocambisol (7.79%), rendzina (7.36%), terra rossa (5.48%), and hydroameliorated hydromorphic soil (5.21%). Other soil types cover areas smaller than 5% each; some soil types occur only sporadically (Table 2).

Luvisol prevails on forest land (15.7% of total land area under forests). It is followed by calcocambisol (12.46%), pseudogley (11.54%), dystric cambisol (10.8%), rendzina (10.8%), gley amphigley (8.42%), and terra rossa (6.82%). Other soil types cover areas smaller than 5% each; some soil types occur only sporadically (Table 2).

Table 3 gives a survey of the distribution of land suitability classes for cultivation purposes[1].

Soils suitable for intensive agricultural production cover 52.5% of the agricultural land, of which, suitable soils account for 9.3%, moderately suitable soils 19.0%, and marginally suitable soils 24.2%. Not suitable soils occupy 47.5% of agricultural land, of which 22.1% are currently not suitable soils, and 25.4% are permanently not suitable soils.

There are 44.3% of suitable soils in the area under forests. The area covered by suitable soils is much smaller then on agriculture land: 1.3% and 12.1% of suitable and moderately suitable soils, respectively. The remaining part or 30.9% are marginally suitable soils. Not suitable soils occupy 55.7%, of which 43.2% are permanently not suitable soils, and 12.4% are currently not suitable soils. Data showing that Croatia has the smallest number of soils that are suitable or moderately suitable for intensive agriculture is an additional reason for strict protection of these and other soils against all possible types of degradation.

Soil degradation processes and threats

Soil degradation implies each process or influence, or group of processes or influences, by which soil characteristics are changed either by natural factors or by human activity, thereby compromising its major roles (Bašić, 2009). Soil degradation processes prevailing in Croatia (Table 4) and their major consequences are described in further text along with some examples confirming the presence of soil damage and threats.

Soil management presupposes the undertaking of such plans and measures for soil use that will permanently preclude soil degradation and thereby conserve its surface area, quality and fertility.

[1] Application of the criteria of "soil suitability for cultivation" is conditionally applied here to forest ecosystems also, which gives an opportunity to specifically express soil fertility or soil quality in the entire area of agricultural and forest ecosystems in Croatia

Table 1. The area of soil division in Croatia

Soil division	Forestry land (ha)	Agriculture land (ha)	Total	
			ha	%
Automorphic soils	1,626,343.5	1,502,082.2	3,128,425.7	65.61
Hydromorphic soil	551,319.4	1,087,905.4	1,639,224.8	34.37
Halomorphic soils	-	410.5	410.5	0.01
Subaquatic soils	1.1	319.9	321.0	0.01
Total	2,177,664.0	2,590,718.0	4,768,382.0	100.00
Settlements			44,586.0	
Rockiness			795,704.0	
Water area			53,359.0	
Altogether			5,662,031.0	

Table 2. The area of the soil types in Croatia

Soil type number and name		Forest land ha*	Agricultural land ha**	Total	
				ha	%
1.	Lithosol	7,978.9	24,713.0	32,691.9	0.58
2.	Regosol	32,306.1	38,309.3	70,615.4	1.25
3.	Colluvial soil	28,305.0	62,420.2	90,725.2	1.60
4.	Arenosol	291.1	414.5	705.6	0.01
5.	Chernozem	2,764.8	47,685.3	50,450.1	0.89
6.	Calcomelanosol	148,571.0	114,092.3	262,663.3	4.64
7.	Ranker	66,365.8	16,865.8	83,231.6	1.47
8.	Rendzina	234,164.0	190,728.2	424,892.2	7.50
9.	Vertisol	479.7	2,154.3	2,634.0	0.05
10.	Eutric Cambisol	58,930.4	116,091.9	175,022.3	3.09
11.	Distric Cambisol	236,090.3	73,949.6	310,039.9	5.48
12.	Terra rossa	97,876.1	142,101.7	239,977.8	4.24
13.	Calcocambisol	271,352.7	201,768.8	473,121.5	8.36
14.	Luvisol	340,906.6	343,830.9	684,737.5	12.09
15.	Podzol	2,153.0	140.2	2,293.2	0.04
16.	Brown podzolic soil	5,713.9	769.3	6,483.2	0.11
17.	Rigosol	92,094.1	126,046.9	218,141.0	3.85
18.	Hortisol		Sporadic occurence		
19.	Deposol		Sporadic occurence		
20.	Flotisol		Sporadic occurence		
21.	Aeroprecipitate soil		Sporadic occurence		
22.	Pseudogley	251,278.7	307,453.2	558,731.9	9.87
23.	Fluvisol	40,124.5	93,026.3	133,150.8	2.35
24.	Humofluvisol	14,392.8	72,278.1	86,670.9	1.54
25.	Pseudogley-gley	34,902.3	71,569.1	106,471.4	1.88
26.	Eugley	186,462.7	358,296.8	544,759.5	9.62
27.	Humogley	22,645.4	45,505.1	68,150.5	1.20
28.	Histosol	1,513.0	4,879.3	6,392.3	0.11
29.	Hydroameliorated soil	0.0	134,897.5	134,897.5	2.38
30.	Subsoiled Histosol		Sporadic occurence		
31.	Solonchak		95.0	95.0	0.01
32.	Solonetz		315.5	315.5	
33.	Gytja	1.1	319.9	321.0	
34.	Protopedon		Sporadic occurence		
35.	Hydroameliorated Gytja		Sporadic occurence		
36.	Hydroameliorated Sapropel		Sporadic occurence		
	Total	2,177,664.0	2,590,718.0	4,768,382.0	84.22
	Rockiness			795,704	14.05
	Water areas			53,359	0.94
	Settlements			44,586	0.79
	Overall			5,662,031	100.00

* or within forest ecosystems; ** or within agroecosystems

Table 3. Areas of soil suitability classes for cultivation purposes in Croatia

Suitability classes*	Under forests		In agriculture		Total	
	ha	%	ha	%	ha	%
S-1	29,230.4	1.3	240,135.4	9.3	269,365.8	5.6
S-2	263,397.4	12.1	493,526.1	19.0	756,923.5	15.9
S-3	672,991.8	30.9	626,043.3	24.2	1,299,035.1	27.2
Total	965,619.6	44.3	1,359,704.8	52.5	2,325,324.4	48.8
N-1	270,320.7	12.4	572,266.6	22.1	842,587.3	17.7
N-2	941,724.0	43.2	658,746.3	25.4	1,600,470.3	33.6
Total	1,212,044.7	55.7	1,231,012.9	47.5	2,443,057.6	51.2
Altogether	2,177,664.3	100.0	2,590,717.7	100.0	4,768,382.0	100.0

*P-1=suitable soils; P-2=moderately suitable soils; P-3=marginally suitable soils; N-1=currently not suitable soils;; N-2=permanently not suitable soils

Table 4. Major soil degradation processes and threats in the Republic of Croatia

Soil degradation processes	Major consequences, with examples of soil damage and threats
Water and wind erosion	Loss of a part of soil surface layer 46% of agricultural land is exposed to high or moderate risk of soil erosion by water, and 45% of forest land to moderate risk (Husnjak et al., 2002); Long-term measurements recorded soil losses due to water erosion of 13.7- 71.0 t/ha in Pannonian Croatia (Kisić et al., 2005).
Land reallocation	Reduction of production area 1965-1987: ca 7,235 ha/year (Čamdžić, 1989); 1966-1975: ca 10,500 ha/year (Pavlović and Dobrinić, 1977); 1953-1999: ca 6,700 ha/year (Vidaček, 2001); 1988-1997: ca 20,900 ha/year (Martinović 2000). No data are available for the period 1997-2009.
Depletion of humus content	Deterioration of soil structure, water-air relationships and biological activity Average humus content determined in soils intended for establishment of permanent plantations is lower than 2% in nine counties, and varies from 2-3% in eight counties (Biško et al., 2009). Humus content in soils on agricultural land of Slavonia and Baranja is approximately two times lower compared to the same soils in the forest ecosystem (Martinović, 2000).
Acidification	Increased soil acidity, reduced nutrient bioavailability, increased toxicity of some elements About 830,000 ha of predominantly acid to highly acidic soils were determined on agricultural land (Mesić et al., 2009).
Salinization and alkalization	Deterioration of soil structure and water-air relationships, restricted potential for agricultural use, yield decrease, toxicity of elements Soils in which structural changes occur due to accumulation of high chloride and sodium concentrations are primarily endangered. Yields may decrease by more than 50%, directly reducing economic profits of agricultural producers (Romić et al., 2003). Application of saline water for irrigation leads to salt accumulation in the root zone, which in turn can have toxic effects on plants (Romić et al., 2008). Research has shown that under saline soil conditions plants may more intensively take up and accumulate certain elements that are carcinogenic and harmful to human health (Ondrašek et al., 2009).
Anthropogenic compaction	Enhanced soil compaction, destruction of soil structure and water-air relationships A number of researchers have determined high bulk density values (1.47-1.67 g/cm^3) in plough and sub-plough layers of arable soils (Košutić et al., 2004; Husnjak et al., 2002; Kisić et al., 2004; Turšić, 1996).
Soil biogenity decrease	Reduced mineralization and humification, the vitality reflecting soil quality Permanent decrease of the presence of certain groups of microorganisms as well as of diversity of microbial population has been recorded on a large part of agricultural land; this has an adverse effect on numerous processes in soil such as decomposition of plant residues, humus formation, soil structure degradation, etc. (Redžepović et al., 2009).
Contamination by heavy metals	Restricted potential of soil use in agriculture, toxicity for humans and animals, threat to water quality Anthropogenic soil contamination by heavy metals was detected in Croatia on locations exposed to imissions from industry, urban environments, transport and similar (Romić and Romić, 2003; Sollito et al., 2010). High concentrations of potentially toxic elements in agricultural soils are commonly associated with regular application of agricultural management practices, primarily plant protection against pests or fertilization (Romić et al., 2004).
Contamination by pesticides	Soil cannot be used in agriculture Residues of plant protection agents influenced a reduction of oats vegetative mass on cambisol, humogley and pseudogley (Šilješ, 1977) Concentrations of atrazine up to 26 ng/g and chlortolurone to 37.4 ng/g were determined in 1997 in the Karašica and Vučica basins (Vidaček et al., 1999).
Contamination by petrochemicals	Soil cannot be used in agriculture Average content of total oils (in 364 soil samples) on potentially contaminated locations amounted to 0.84 g/kg, while mineral oil content was 0.43 g/kg. Data indicate that soils on potentially contaminated locations are moderately to highly burdened with hydrocarbons (Kisić, 2009).
Forest fires	Loss of forest floor, destruction of structural aggregates, increased erosion risk Drastic loss of organic matter in the forest ecosystem is a side effect of forest fires. Almost entire organic horizon is often lost after ashes are taken away by water and/or wind erosion. Considering the extent of fire-affected areas and data on organic matter reserves in the O-horizon of forest stands, it was estimated that ca 45,000 to over one million tons of soil organic matter, mainly forest litter, is lost in the karst region (Pernar et al., 1999, Martinović, 2003).
War damages	Soil use is temporarily impossible Current status of potentially mine-infested areas in the Republic of Croatia is 95,000 ha (CROMAC, 2009) Highly valuable land resources for agriculture are located on a large part of this area (e.g., according to the data for 2006, there were 10,700 ha only in Vukovar-Srijem county). Multiyear inability to use these land resources has incurred huge losses to Croatia, notably in agriculture and forestry (Husnjak and Pavković, 2001).

Soil management recommendations

Pursuant to the Constitution, soil is a common good of special interest to the Republic of Croatia, so it is the duty of competent government institutions to pass legal regulations, create plans and measures that will provide prerequisites for sustainable soil use and its protection from damages and threats. The policy of sustainable soil management must be adopted at both political and social levels to meet the requirement of responsible soil use. Common guidelines for soil management and protection given in the European Commission's Thematic Strategy for Soil Protection will certainly be of help in the exchange of knowledge and experience between different countries; however, soil policies largely appertain to the domain of national responsibility and should be treated as such.

The European Union has been trying for a number of years to define a unique framework and guidelines for soil management, which will be mandatory for all member states. However, legal regulation of this area is by no means an easy task. It is a good thing that the issues of soil and land management, as well as of soil protection, have gained a high degree of political and social attention in Europe, and the common starting positions are contained in the Soil Thematic Strategy adopted by the European Commission in 2006.

Only nine EU member states have specific legislation on soil protection, targeted at very specific threats such as, for example, desertification in Greece, Italy, Portugal and Spain or contamination in the Netherlands, Germany and Belgium. Since the problems of soil degradation are constantly increasing, the available legal frames are not sufficient any more. It is up to each state to define its own priorities in soil protection by descending from the national to regional and local levels, all the way to the plot level. When defining the soil protection areas to be regulated, the focus should be on priorities, because an over-dimensioned legal framework can suit bureaucratization more than efficient soil protection.

Analysis of the effective Croatian legislation has shown that there is no integral approach to the issue of soil protection. Competences in this area are shared by several government ministries, while a number of agencies and other institutions have been established for operative purposes. The largest part of responsibility for soil protection is born by the Ministry of Environmental Protection and the Ministry of Agriculture, Fisheries and Rural Development. In this context, the problem of soil protection is a part of two key acts - Law on Environmental Protection (Official Gazette 110/07) and Law on Agricultural Land (Official Gazette 152/08).

The foregoing considerations point to the need of passing a national strategy for soil protection. Initiatives in this respect have been very modest so far. The national strategy for soil protection should integrate the following measures into a unique system:

- define a body to supervise the soil status
- define soil threats according to priorities at the national level
- organize soil monitoring according to priorities at the national level
- combine soil protection domains with agro-environmental measures and programs
- incorporate soil protection goals into all spatial planning systems
- define responsibilities of land users and supervision of implementation of sustainable use measures
- raise the awareness of the need of soil protection through promotional and educational programs in the community

Thus the strategy would propose amendments to the available or enactment of new laws, ordinances or regulations dealing with soil and, among others, a soil protection act as the basis for sustainable land use.

At this time when the Republic of Croatia is preparing to join the EU, most energy and funds are being spent on harmonization of its legislation and organization of administration to support such a system. However, full application of such legislation will require radical, politically and socio-economically very sensitive projects, like some of the ongoing projects, for example:

- Agricultural land consolidation
- Land Parcel Identification System - LPIS
- Agricultural pollution control project

According to spatial criteria, Croatia is a "rural" country and therefore the largest interventions in soil management are imposed by the Ministry of Agriculture, Fisheries and Rural Development. In this, and important role is that of defining the domains of "mandatory" initiatives and those involving "voluntary" participation of land users.

Upon Croatia's accession to the EU, two types of measures are, among others, foreseen and actively prepared:

- "Mandatory" measures - defining users' obligations in terms of necessary adherence to the prescribed rules of Good Agricultural Practice, which is directly associated with gaining incentives, and
- "Voluntary" measures regulated by the document Rural Development Regulation *(EC) 1698/2005* (referring to, e.g., agroecological measures aimed at maintenance of biodiversity, valuable forest resources, etc., or afforestation of arable areas). Such programs are not mandatory but voluntary, and participation in them brings extra incentives.

These examples indicate that many activities in the sphere of land management will be undertaken through the future system of incentives.

Recommendations for plans, measures and base materials

Taking into account the defined processes and threats from Table 4, Table 5 provides the basic land management recommendations in terms of developing new plans, measures and base materials.

Recommendations for new plans, measures and base materials that are not directly connected with the current soil degradation processes but are important for defining soil protection measures at different levels:

Establishment of a reference centre for the Croatian Soil Information System (HIST)

There are many reasons for establishing a reference centre for the Croatian Soil Information System. For example, one of the main tasks of the Croatian Environment Agency is to put together all data indispensable for monitoring the environment status

Table 5. Recommendations for creating plans, measures and base materials for sustainable land management

Soil degradation processes	Activities, legislation	Plans, measures and base materials provided	New plans, measures and base materials needed
Water erosion		Maps of potential and real risks of soil erosion by water at national level; "National project of irrigation and land and water management in the Republic of Croatia"; A number of studies providing results of stationary investigations of erosion under different agroecological conditions; "Irrigation and land management plans" for most counties.	Develop a program for soil protection against erosion by water at national level; Create the soil map of the Republic of Croatia, scale 1:25 000.
Land reallocation	Ordinance on land capability assessment is under preparation. Ordinance on agricultural land register (Official Gazette 37/98) is enacted.	Base materials for land/soil capability maps at national and regional levels (1:50 000 and 1:300 000 scale soil maps).	Create the soil map of the Republic of Croatia, scale 1:25 000.
Humus content reduction	Ordinance on agricultural land monitoring is under preparation.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring
Acidification	Ordinance on agricultural land monitoring is under preparation.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring
Anthropogenic compaction	Ordinance on agricultural land monitoring is under preparation.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring
Soil biogenity decrease	Ordinance on agricultural land monitoring is under preparation.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring; Develop a program for soil biogenity increase and conservation at national level.
Contamination by heavy metals	Ordinance on agricultural land monitoring is under preparation. Ordinance on the protection of agricultural land against contamination is enacted.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection; Geochemical map of Croatia; Ongoing project of the Ministry of Science, Education and Sports on assessment of agricultural soil contamination by toxic elements.	Start soil monitoring; Identify heavy metal contaminated locations and define protection measures.
Contamination by pesticides	Ordinance on agricultural land monitoring is under preparation. Ordinance on the protection of agricultural land against contamination is enacted.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring
Contamination by petrochemicals	Ordinance on agricultural land monitoring is under preparation. Ordinance on the protection of agricultural land against contamination is enacted.	Permanent soil monitoring program; Manual: Principles of good agricultural practice in soil protection.	Start soil monitoring
Salinization and alkalization		"National project of irrigation and land and water management in the Republic of Croatia "; "Irrigation and land management plans" for most counties; Monitoring of soil and water salinization in the Lower Neretva region; Production of the Soil salinity map of the Lower Neretva region is in progress.	Irrigation pilot project should provide solutions.
Forest fires	Amendments to the Forest Law; New Fire Control Act is under preparation.	- Forest Law (Official Gazette 82/06) - Fire Protection Law (Official Gazette 58/93) - Fire Control Law – amended text (Of. Gaz. 193/04) - Ordinance on data collection, record keeping, and conditions for use of forest fire data (Official Gazette 126/06, 101/07) - Forest Fire Prevention Act (NN 26/03)	Improve fire hazard assessment models and fire spread models.
War damages	Relevant acts and ordinances have been passed.	National mine clearance program for 2009-2019	

into a unique environmental protection information system, a component part of which is HIST. A number of institutions keep in their archives highly valuable data relating to soil research. Unfortunately, a large part of these data is mislaid, and some are permanently lost, which is a great pity. Due to the non-existence of HIST and the statutory obligation to forward data to HIST, it may happen that identical soil investigations are conducted on the same areas without researchers being aware of that fact, etc.

Design a national soil liming program

Excess soil acidity is a major limitation of agricultural land. It is estimated that there are about 830,000 ha of acid and very acid soils in Croatia. In addition to eliminating acidity, liming also exerts influence on a number of other soil processes, primarily on formation of a stable soil structure and creation of favourable water-air relationships. The program should foresee a solution to the problem of soil acidity, as a major agricultural management measure, in terms of governmental incentives.

Develop a program for revitalization and maintenance of hydroameliorative drainage systems in catchment areas

Hydroameliorative systems of surface drainage through open canals are installed at ca 1,050,000 ha in Croatia, of which systems with partially built canals are built on 325,000 ha, and systems with constructed pipe drainage on 150,000 ha. From 1991 and the Homeland War to 2005, there was practically no regular maintenance of drainage systems; parts of the systems were, and some still are, completely dilapidated. For these reasons, the drainage system functionality is very poor and requires revitalization. Since 2005, much has been done to restore and amend the canal network. However, a number of problems were encountered during execution of revitalization works owing to the fact that works are not systematically performed and are not professionally supervised; this should be, among other things, corrected and defined by the proposed program.

Develop a plan for building hydroameliorative drainage systems at ca 780,000 ha of hydromorphic soils

The problem of excess water is also present in about 780,000 ha of unameliorated hydromorphic soils. Most of these soils are privately owned and hence fragmented land plots are a serious problem. The plan should therefore foresee consolidation of this land, and then construction of hydroameliorative drainage systems. The plan should also include solutions for construction of hydroameliorative systems adapted to the new conditions, along with a detailed analysis of pedological and amelioration problems, agricultural regionalization, economic justification, property-rights relations, construction funding, system management and maintenance.

Pass a decree on establishment of perennial plantations on marginally suitable soils

Over the last few years, several thousands of hectares of new woody crop plantations have been established, or their establishment is being prepared, in the Adriatic agricultural region, that is, in the littoral zone and on the islands. Most of the plantations are established on substrates prepared by rock grinding (mainly limestone and dolomite) in very sensitive (risky) areas, with unforeseeable consequences for the environment. For this reason, professional base materials and studies of land amelioration, including environmental impact assessment, should precede all works on establishment of perennial plantations.

Appoint a task force on soils of the Republic of Croatia

The responsibility of the task force on soil should be to take constant and good care of the soils in Croatia. Among other things, the task force should promote programs and projects directly targeted at soil protection.

Conclusion

The paper stresses the importance of preserving existing land resources, both worldwide and in Croatia. Based on existing data, the area of the individual soil divisions, soil types and suitability classes in agricultural and forest ecosystems of Croatia is shown. By analyzing the data of previous research related to soil damage, it was found that there are 12 dominant degradation processes in Croatia. Therefore, the adoption of new plans, measures and backgrounds for sustainable land use in Croatia is suggested.

References

Bašić F. (2009). Oštećenja i tehnologije zaštite tala Hrvatske - otvorena pitanja. In: Zbornik radova znanstveno stručnog skupa „Tehnologije zbrinjavanja otpada i zaštite tla“, Zadar, Croatia, pp 179-201

Biško A., Milinović B., Savić Z., Čoga L., Jurkić V., Slunjski S. (2009). Sadržaj humusa u tlima RH namijenjenim za podizanje trajnih nasada. In: Zbornik radova znanstveno stručnog skupa „Tehnologije zbrinjavanja otpada i zaštite tla“, Zadar, Croatia, pp 61-66

Bogunović M., Vidaček Ž., Racz Z., Husnjak S., Sraka M. (1996). Namjenska pedološka karta RH, mjerila 1:300.000. Zavod za pedologiju Agronomskog fakulteta Sveučilišta u Zagrebu

CROMAC (2009). National mine action strategy of the Republic of Croatia. Croatian Mine Action Centre, Sisak, Croatia (available at: www.hcr.hr)

Čamdžić S. (1989). Ekonomski i proizvodni efekti melioracija. Izvještaj SIZ-u za znanost Hrvatske

Čoga L. (2008). Mogućnost uzgoja vinove loze na litosolima Dalmacije. SABATINA - stručni skup o vinogradarstvu, Korčula, Croatia

Husnjak S., Pavković N. (2001). Pedološke značajke područja ugroženog minama u Republici Hrvatskoj. In: Zbornik sažetaka IX Kongresa hrvatskog tloznanstvenog društva s međunarodnim sudjelovanjem “Gospodarenje i zaštita tla za buduće generacije”, Brijuni, Croatia

Husnjak S., Filipović D., Košutić S. (2002). Influence of different tillage systems on soil physical properties and crop yield. Rostlina Vyroba 48: 249-254

Husnjak S., Bogunović M., Vidaček Ž., Racz Z., Sraka M., Bensa A. (2002). Istraživanje rizika od erozije tla vodom u Hrvatskoj - II faza: potencijalni i stvarni rizik. Hrvatske vode 34

Husnjak S., Vidaček Ž., Bogunović M., Sraka M., Bensa A. (2005). Zemljišni resursi Hrvatske i pogodnost tla za navodnjavanje. Dio «Nacionalni projekt navodnjavanja i gospodarenja poljoprivrednim zemljištem i vodama u Republici Hrvatskoj». Agronomski fakultet Zagreb, Zavod za pedologiju

Kisić I. (2004). Znanstveni projekt: Rizik od erozije kao pokazatelj održivog gospodarenja tlom. Interni izvještaj. Agronomski fakultet Zagreb

Kisić. I., Bašić F. Butorac A., Mesić M., Nestroy O., Sabolić M. (2005). Erozija tla vodom pri različitim načinima obrade tla. Sveučilišni priručnik, Agronomski faklultet Sveučilišta u Zagrebu

Kisić I. (2009). Onečišćenje tla petrokemikalijama. Zavod za opću proizvodnju bilja, Agronomski fakultet Sveučilišta u Zagrebu

Košutić. S. (2004). Znanstveni projekt: Ekološki i energetski aspekti različitih sustava obrade tla u Ratarstvu. Interni izvještaj. Agronomski fakultet Sveučilišta u Zagrebu

Martinović J. (2000). Tla u Hrvatskoj - monografija. Državna uprava za zaštitu prirode i okoliša, Zagreb

Martinović J. (2003). Gospodarenje šumskim tlima. Šumarski institut Jastrebarsko, Hrvatske šume d.o.o., Zagreb.

Mesić M., Husnjak S., Bašić F., Kisić I., Gašpar I. (2009). Suvišna kiselost tla kao negativni čimbenik razvitka poljoprivrede u Hrvatskoj. In: Zbornik radova 44. hrvatski i 4. međunarodni simpozij, Opatija, Hrvatska, pp 9-18

Ondrašek G., Romić D., Rengel Z., Romić M., Zovko M. (2009). Cadmium accumulation by muskmelon under salt stress in contaminated organic soil. Science of the total environment 407, 7: 2175-2182

Pavlović R., Dobrinić D. (1977). Poljoprivredno zemljište u društveno ekonomskom sistemu. Savjetovanje u Zagrebu

Pernar N., Španjol Ž., Bakšić D. (1999). Neke značajke humizacije u borovim kulturama na otoku Rabu. Šumarski list 3-4: 101-108

Petošić D., Šimunić I. (2007). Revitalizacija postojećih i koncepcija rješavanja novih sustava detaljne odvodnje. In: Zbornik znanstvenog skupa Melioracijske mjere u svrhu unapređenja ruralnog prostora, Hrvatska akademija znanosti i umjetnosti, pp 99-115

Redžepović S., Sikora S., Blažinkov M., Husnjak S., Čolo J., Bogunović M. (2009). Microbiological characteristics of luvic soils in western Slavonia. In: Proceedings of International scientific thematic conference Soil Protection activities and Soil Quality Monitoring in South Estern Europe. Sarajevo, Bosnia and Hercegovina

Romić M., Romić D. (2003). Heavy metals distribution in agricultural topsoils in urban area. Environmental Geology 43: 795-805

Romić D., Borošić J., Poljak M., Romić M. (2003). Polyethylene Mulches and Drip Irrigation Increase Growth and Yield in Watermelon (Citrullus lanatus L.). European Journal of Horticultural Sciences 68, 4: 192-198

Romić M., Romić D., Dolanjski D., Stričević I. (2004). Heavy Metals Accumulation in Topsoil from the Winegrowing Regions. Part 1, Factors which Control retention. Agriculturae Conspectus Scientificus 69: 1-10

Romić D., Ondrašek G., Romić M., Borošić J., Vranješ M., Petošić D. (2008). Salinity and irrigation method affect crop yield and soil quality in watermelon (*Citrullus lanatus* L.) growing. Irrigation and Drainage 57, 4: 463-469

Sollitto D., Romic M., Castrignanò A., Romic D., Bakic H. (2010). Assessing heavy metal contamination in soils of the Zagreb region (Northwest Croatia) using multivariate geostatistics. Catena 80, 3: 182-194

Urushadze T. (2002). Soils in space and time: realities and challenge for the 21st century. In: Keynote lectures of 17th World Congress of Soil Science, Bangkok, Thailand, pp 3-23

Vidaček Ž., Sraka M., Čoga L., Mihalić A. (1999). Nitrati, teški metali i herbicidi u tlu i vodama sliva Karašica -Vučica. Poljoprivredno znanstvena smotra 64, 2: 143-150

Vidaček Ž. (2001). Gospodarenje i zaštita tla u Hrvatskoj - Globalno stanje i preporuke. In: Zbornik radova i sažetaka IX kongres Hrvatskog tlozanstvenog društva, Brijuni, Croatia, pp 5-17

Turšić I., Ćavlek M., Mesić M. (1996). Zbijenost tla - jedan od uzoraka nižih prinosa duhana u RH. Tobacco 46: 1-2

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