Scientific Papers. Series A. Agronomy, Vol. LV-2012
ISSN Online 2285-5793; ISSN-L 2285-5785

SUSTAINABLE LAND MANAGEMENT IN AGRICULTURE - OBRENOVAC MUNICIPALITY (SERBIA) CASE STUDY

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Abstract

According to proposed EU Soil Directive, due to high variability in soil physical, chemical and biological state, site-specific soil degradation risk analysis is required. Important socio-economic drivers for agricultural soil degradation are also related to the local level (e.g. land use and land use change, farming practices, farming systems, holding structure, etc.) and must be taken into account in defining soil quality preserving measures. Having in mind these considerations, the authors in the paper analyze the agricultural land use and the state of the soil degradation processes in the Belgrade City municipality of Obrenovac. Pedological and geological structure of soils, climate and hidrology, intensive crop and livestock production in the urban fringe on the land exposed to erosion and landslides, underdeveloped hydro-melioration and waste water treatment systems and proximity of thermal power stations and lignite open-pits, produce serious obstacles for sustainable use of land and water in agriculture. The overall assessment of the soil degradation processes and its main drivers in the Obrenovac municipality enable definition of the set of soil conservation priority projects and measures for implementation at the local level.

Key words: *agricultural land use, soil degradation processes, sustainable land management, local community.*

INTRODUCTION

Soil degradation is a serious and increasing problem in Europe [5]. Soil degradation processes, such as erosion, soil organic matter decline, compaction, salinization, landslides and flooding (and at a national level: contamination, sealing, acidification and decline of soil biodiversity) are recognized in the EU legislation. The EU is adopted the Thematic Strategy on Soil Protection and proposed a Framework Directive as the best means of ensuring a comprehensive approach to soil protection whilst fully respecting subsidiarity and proportionality principles.[1]

Although the subsidiarity principle calls for common framework for actions to ensure a fair level playing field and to ensure that all Member States are tackling all threats to which soils are confronted in their national territory and do not address soil protection in a partial way, the proportionality principle left much scope to the Member States to identify the most appropriate specific measures at the most appropriate geographical and administrative level to ensure that the regional and local specificities as regards soil variability, land uses, local climatological conditions and socio-economic aspects can be properly taken into account. Integration of soil protection into sectoral policies and spatial planning is necessary, especially into agricultural and rural development policy documents [28].

Seven of the soil degradation processes commonly identified as matters of primary concern (water, wind and tillage erosion; decline of soil organic matter; compaction; salinization; acidification; diffuse contamination; and declining soil biodiversity) are closely linked to agriculture [3].

The prevention and mitigation of the effects of floods and landslides hazards need to be addressed in agriculture too. Sealing of agricultural land is becoming more intense as a result of urban sprawl and increasing non-agricultural land occupation.

Aspects of soil protection have been an integral part of EU Common Agricultural Policy. In the frame of overall CAP reform to 2020, the Commission proposed a further strengthening of the Good agricultural and Environmental Condition (GAEC) framework, particularly in relation with climate change. There is a clear case

[1] At the March 2010 Environment Council, a minority of Member States blocked further progress on the proposed Soil Framework Directive on grounds of subsidiarity, excessive cost and administrative burden. The proposal remains on the Council's table [5].

for a better protection of carbon rich soils, a general minimum land cover obligation and maintainance the soil organic matter level[2]. The new Rural Development proposal includes the objectives of the sustainable management of natural resources and climate action, including by means of improved soil management in agriculture [2].

Environmental legislation in Serbia is in the process of harmonization with the EU. Harmonization and decentralization of responsibilities was accelerated with the adoption of the Law on Amendments and Supplements to the Law on Environmental Protection in May 2009. In the area of soil protection and sustainable use, Law defines the measures of systematic soil quality monitoring, monitoring of risk assessment indicators for soil degradation and remediation of contaminated and degradated sites, as well as the obligation for seller to provide a soil status report for any transaction of land where a potentially contaminating activity has taken, or is taking place. The Government duty is to establish programme for systematic soil quality monitoring, indicators for risk assessment of soil degradation and methodology of creating remediation programmes [14].

National Programme for Environmental Protection contains sets of soil protection measures for the period 2010-2019 (establishment of landslides cadastre, systematic soil quality monitoring programme, inventory of contaminated sites and priority list of the sites for remediation, erosion control and definition of strategies and action plans and programmes for management of drought and land degradation and desertification, including awareness raising) and particularly agricultural soil protection measures (GAEC promotion, indicators of environmental impacts of agriculture, soil productivity evaluation, land capability monitoring, identification of nitrate vulnerable zones, nutrition balancing and monitoring of fertilizers and pesticide use, assessment of soil organic matter decline, land use change control, organic production and HNV area mapping, etc.) [13].

[2] This evolution should however be considered in conjunction with the development of the environmental legislation and with the definition of new, green direct payments [4].

The protection, consolidation and use of agricultural land in Serbia are directly regulated by the Agricultural Land Law [17]. Also, a number of obligations originate from ratified international conventions related to soil protection (UNCCD, UNFCCC and Kyoto Protocol).

The Law on agriculture and rural development defines direct, market oriented and structural incentives (including land protection measures) for agriculture and rural development. Producer payments are conditional on his compliance with environmental, public, animal and plant health, animal welfare and agricultural land protection standards [15].

Soil status analysis and conservation priority projects and measures for implementation at the local level are common parts of the local development strategies, especially rural development strategies.

This is in line with the EU Soil Strategy statement that risk acceptability and measures vary in response to the severity of the degradation processes, local conditions and socio-economic considerations [27].

Having in mind afore-mentioned, the authors in this paper analyze the agricultural land use and the state of the soil degradation processes in the Belgrade City municipality of Obrenovac, based on the research conducted in 2011, during the authors' work on the municipal strategy of rural development.

MATERIAL AND METHOD

Research was based on the statistical data and Serbian and EU legislation and projects' reports, on the results of the recent soil and water quality reports and studies and previous research of the authors in these fields, including above-mentioned work on municipal Rural Development Strategy. The overall assessment of the soil degradation processes and its main drivers in the Obrenovac municipality than enable definition of the soil conservation priority activities and measures that will be implemented at the local level.

In the discussion and conclusions formulating process, the SWOT analysis and analytic-synthetic scientific method were applied.

RESULTS AND DISCUSSIONS

The Obrenovac municipality is one of the Belgrade City municipalities and it lies in the south edge of the Panonian basin, on the left bank of Sava River.

Climate. Territory of Obrenovac municipality is mainly characterized by moderate continental climate, that is defined by warm summers and cold winters. The weather conditions within this area are strongly affected by the cyclones coming from Gulf of Genoa, which are moving across the valleys of Sava and Danube rivers and further to the Black Sea. Mentioned cyclones cause the maximum precipitation at the end of spring and beginning of summer, while the secondary maximum of rainfalls occurs in late autumn. During the period 1961-1990, the average amount of rainfall was 647.2 mm, where the rainiest month was June, with 84.4 mm.

Particularly, important element of climate for this area is wind. Annually there are on average 124 days with high wind (with strength of 6 and more by Beaufort scale). Ash landfills, located at the west and northwest, under the influence of western and north-western wind directly threaten great part of the municipality territory. No less dangerous is south-eastern wind, which usually blows (every third day) and has the highest average speed. It brings polluting substances from the lignite open pit mine on the whole territory of the municipality [1].

Hydrology. Obrenovac Municipality is rich as with surface, as well with ground waters. The rivers Sava in the north and Tamnava in the south form natural municipal boundaries, while across the middle of municipal territory flows Kolubara River, which is partly brought into the trough of its tributary, the Peštan River. Regulatory interventions caused the meandering watercourse and strong fluvial erosion. Kolubara River has in this part of its flow torrential character and represents a danger due to frequent flooding in the springtime.

Movement of ground water is caused by the terrain slope from south to north. Phreatic aquifer formed in this area represents part of spacious, hydraulically connected, phreatic aquifer of Mačva, Kolubara, Tamnava and Makiš, natural resource of immeasurable importance [1].

Relief and pedological structure. Territory of Obrenovac municipality belongs to the lowland agricultural area (terrains above 200 m msl occupy less than 8% of the whole territory, located at the easternmost of the municipality on the right bank of the Kolubara river). Within the geological structure dominate neogene sediments, which cause landslides on the slopes at the north-east and east [1].

About 70% of agricultural land belongs to I-IV soil quality class, suitable for cultivation (I class - around 6%, II – 14%, III - 27% and IV - 23%) [10]. There prevail developed, deep and potentially fertile lands, where, with the use of appropriate land ameliorative measures and good agricultural practice, could be achieved high yields of crops and fruits, before all: fluvisol and fluvisol on scraped humogley, humofluvisol and humogley soils in central part of the municipality and along rivers Sava, Kolubara, Tamnava and Peštan, as well as eutric cambisols and eutric cambisols luvic at the east and south-west. Pseudogleys (lowland and hillside type) are represented on the west and south-west, and diluvium at the east of municipality [7].

Land use. Arable land takes 88% of 31,826 ha of used agricultural land. Orchards occupy 5.3%, vineyards 0.2% and permanent lawns 6,2% (meadows 2.6% and pastures 3.6%) of mentioned area [19].

Crop and vegetable production are concentrated in central part of the municipality, especially on fertile alluvium and humogley in valleys of the rivers Sava, Tamnava and Kolubara. On nearly two-thirds of sown plowlands in 2010 there were cereals (mostly corn, wheat and in lesser extent barley and oat). After that came forage crops - alfalfa and clover, with the share in sown structure of 22%. Vegetables occupied 8%, and soybean, sunflower and sugar beet 5% of total sown areas.

In fruits growing the most represented were apple and plum plantations, and hills at the north-east, east and south-west are suitable for growing of other continental fruits and grapes.

Yields of green mass and hay from the meadows and pastures overcame the republic average and represent a good base for development of livestock production [23].

Intensive production of milk and pork has been developed on large farms in the central part of the

municipality, while the cattle, sheep and goats breeding for the combined production of meat and milk is located on family husbandries in the livestock breeding-fruit growing region, east from the Kolubara river (Fig. 1).

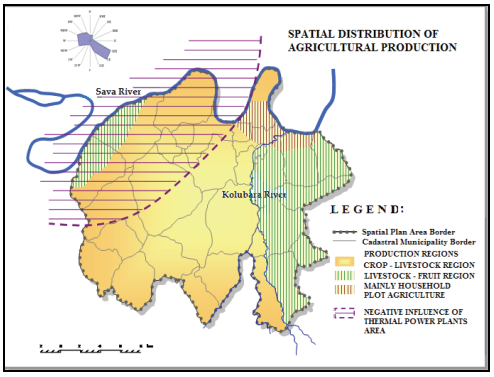

Fig. 1. Spatial Distribution of Agricultural Production (Source: LEAP, 2011, p. 106).

The number of livestock units at the end of 2006 was 58 LU/100 ha UAA, what is significantly above the national average, 31 LU/100 ha [25].

Most of the agricultural land is in private ownership. State owned about 3.425 ha - mostly plowlands (2.610 ha) and orchards (231 ha). Land owned by the state are usually subject to the lease. But, even 1.631 ha are out of this process (1.400 ha due to "differences between the legal and factual situation", i.e. fact that after the detal field insight is determined that it is not agricultural land and another 231 ha is in "co-owned relation with private persons" [20].

Family husbandries are small and estates are fragmented. The average size of used arable land at husbandries is 2.15 ha, what is more than the Belgrade level (1.72 ha), but less than the national average (2.46 ha). Farms usually have on disposal three separate parts of used land with average size of 1 ha (surrounded by other owners and composed of one or more parcels) [24].

The process of land consolidation has started 20 years ago and for this purpose is provided budget support from the city Program for protection, regulation and use of agricultural land in 2011 [10, 21].

Land use change. Used agricultural land, and what is particularly important, arable land, are reducing more slowly than the national and city of Belgrade average. This is not the case with orchards, although the development of this production is one of the priorities of agricultural development on the territory of Belgrade. In 2010 orchards occupied 10.2% less surface than in 2000, while in the same period at the city level there was recorded an increase of 8.9%. Areas under meadows and pastures have also increased in the same period [23, 26]. That is important because they have great role in protection of land endangered by intensive crop and vegetable production, development and revitalization of livestock breeding and preservation of biodiversity.

Besides continuous concern about the agricultural land preservation, particularly arable land from the unplanned transfer into the non-agricultural purposes, problem of land abandonment should be actively considered. Uncultivated surfaces of fertile agricultural land are increasing due to leaving of agriculture by young active population. One of extreme examples is the village Zabrežje where even 70% of arable land is abandoned [11]. This land is not maintained in good ecological conditions, and ragweed becomes a growing environmental and health problem.

Land protection. Pedological and geological structure of the terrain, applied agro-technical measures, emission of pollutants from thermal power plants, ash landfills and lignite open pit mines in surrounding, as well as certain infrastructure and socio-economic limitations are responsible for emergence of a number of land degradation processes, present in greater or lesser extent in this region: erosion, landslides, sealing, acidification, soil organic matter decline, contamination by heavy metals and pesticides and excessive use of nitrates and phosphates, compaction, salinization and flooding and soil biodiversity reduction.

Over the 80% of municipal territory is under the processes of mild and weak ***erosion***. Due to the loss of topsoil, the soil becomes less fertile and the aquatic ecosystem is contaminated. Expressed fluvial erosion processes are present along the relocated riverbed of the Kolubara. Fluvial erosion is also characterized for meanders of the Sava River near Obrenovac municipality. Application of anti-erosion measures are needed, such as specific tillage techniques (contour plowing, etc.), nurturing elements of so called environmental infrastructure (field-protection belts, hedges, etc.) and other anti-erosion measures envisaged by the

Law on agricultural land and Good Agricultural Practice.

Erosion in agricultural areas could result in undercut slopes which remove the slope base, causing ***landslides***. Active and mostly soothe landslides are connected to loose neogene sediments on the north-east and east of the municipality. Uncontrolled process of houses building, present in mentioned territory, is characteristic for the peripheral areas of big cities (urban sprawl) and like consequence has sealing of land and its additional destabilization. Within the ongoing construction of Corridor 11, on the section Umka-Barič is planned a stabilization of landslides "Umka" and "Duboko" [16].

Kolubara basin is one of the known locations with strongly acidic soil in Serbia. According to the analysis of the Institute of soil science, in the Obrenovac municipality acid soils are located in the south-west (pseudogley and cambisols luvic). Soils with stronger acidic reaction are characteristic for the eastern parts of municipality (cambisols and diluvium), while the land in wider area around the Kolubara River and central part of Obrenovac are medium to weakly acidic (alluvial, meadowlands), but they are intensively cultivated and fertilize, so during the the choice of mineral fertilizers have be taken into account about the prevention of acidification [7, 9].

Deposition of acidifying air pollutants (e.g. sulphur dioxide, nitrogen oxides) contributes to soil ***acidification*.** Nutrient leaching processes prevail in acidic environment. Increased acidity is neutralized by calcification but it accelerates the decomposition of organic matter what requires additional input of organic fertilizers.

By ***reducing of organic matter level*** the water-air regime is deteriorating and soil biodiversity is reducing. Factors that lead to decreasing of organic matter in soil are climate, constituent soil material, topography, vegetation, land use and applied agricultural practices. Preserving existing carbon stocks in the soil and fighting the depletion of humus (the most stable soil organic matter fraction) are of utmost importance for agriculture, environment and climate change mitigation. Southern Europe has a potential loss rate of less than 50 tonnes of carbon per hectare, due to the low actual content [6].

Land on the territory of Obrenovac municipality are medium to well stored with humus. Content of humus varied in range from 2.4% (hillside pseudogley and diluvium) to 4.3% (humogley), exept alluvium on scraped humogley (1.4%) [9].

Emissions of pollutants from thermal power plants, use of low quality water for irrigation and excessive use of fertilizers and pesticides are potential causes of agricultural land and water ***contamination*** with heavy metals, pesticide residues, nitrates and phosphorus.

Thermal power plants "Nikola Tesla A" and "Nikola Tesla B" are well-known emitters of sulphur-dioxide, nitrogen oxide and suspended particles. These plants annualy spent about 23 million tons of coal what make them as one of the global polluters. They have electro-filters for ash separation that is generated during the lignite combustion, but no equipment for desulphurization and removal of nitrogen oxides. Their instalation is expected no later than 2015. The ash is disposed at two landfill areas of 600 ha and 400 ha, that are the sources of ash wind erosion. Currently new technology is implementing, so called pneumatic transport and disposal of ash and slag, which will significantly reduce mentioned problem [10].

Soil analysis on the territory of municipality showed that presence of arsenic, mercury and cadmium in soil is below the maximally allowed concentration. Presence of lead exceeds standards only in small percentage of meadowland soil samples taken by road Draževac - Konatice. Increased content of nickel (21% of samples) has mainly geochemical origin (alluvial deposits within the Kolubara valley), although possible emission from thermal power plants and ash landfills haven't be ignored [8].

In groundwater, as well as in the Save and Kolubara river was determined higher concentrations of iron ions. There is necessity for continuous monitoring of drainage systems, as well as control of quality of surface and ground water in areas of ash and slag landfills.

An important source of water pollution is the nutrients coming from untreated wastewaters. Discharge of wastewater into recipients without previous treatment, such is case in Obrenovac with the main sewer outfall on Kolubara river, near to estuary to Sava River, represents serious threat to water quality in the wider area.

From 353 samples of well water, which is used for irrigation, analyzed in 2010 on the territory that is

not covered by the water supply network, 95% were rated as faulty. The usual cause of chemical incorrectness was higher content of nitrates and microbiological increased number of total coliform bacteria. Among polluters dominate sanitary unsecured septic tanks and manure warehouses, and nitrogen fertilizers [12].

One of the main sources of nitrate pollution of waters from diffuse sources in agriculture is excessive use of fertilizers and inappropriate manure management on the big livestock farms, as nitrate leaches through the soil into the water. Soil cover in general, and *catch crops*, in particular, reduce nitrate losses and thus have a positive impact on soil contamination.

Sustainable manure management requires investment in modern facilities and equipment that many small farms cannot provide without state support.

High concentrations of phosphorus were recorded in humogley on the north of municipality, as a result of intensive use of fertilizers in crop and vegetable production. Mentioned examination of well water quality showed the presence of low phosphate concentration [12].

Use of heavy machinery, especially in clay soils with compact structure leads to ***soil compaction,*** reduced degree of water infiltration, so ameliorative deepening of layer of arable soil has to be done to increase soil loosening and eliminate excess water.

Additional measures for water regime regulation are necessary especially in areas of pseudogley in the north-west and west parts of municipality, as well as in zone of heavier, clayey soils around the Obrenovac and valleys of the Kolubara and Peštan rivers (especially in part of unregulated flow of Kolubara, in zone Poljane-Draževac, endangered by ***floods***) [10].

Constructed drainage systems that have channel length of 267 km, are covering area of 21,000 ha, but in function is only 5,580 ha. There is necessity for reconstruction and upgrade of drainage system, as well as more than 20,000 ha need intensive irrigation [22].

Soils closer to the Sava River are with predominantly neutral and slightly alkaline reaction. High level of underground water and inadequate functioning of drainage systems on swamp soils in valley of Sava River emphasize processes of ***soil salinization and alkalization.***

On the soil reaction affects also emission of gases and particles from thermal power plants and ash landfills. Ash is generally alkaline, what is unfavorable for lands that are neutral or alkaline, and can be beneficial for acid soils (such as land around thermal power plant "Nikola Tesla B") [9].

It is recognized that ***soil biodiversity*** can be used as an indicator of soil quality and stable ecosystems. After analyzing the number of certain microorganisms and total soil microflora it was concluded that the larger soil biodiversity is characteristic of neutral soils and soils with slightly acid reaction, while in soils with acid reaction in eastern part, as well as at few locations in west part of municipality it is significantly reduced [8].

SWOT analysis. Favorable geographical position and relief, climate and hydrological characteristics, as well as preserved agricultural land fund with good characteristics and not too many limitations for agricultural production are the main ***potentials*** for sustainable land use within municipal agriculture.

Main ***weaknesses*** are the need for continual use of hydro and agro ameliorative measures on acidic, clayey and hydromorphic soils. That considers revitalization and improvement of hydromelioration systems, controlled application of fertilizers and pesticides and sustainable manure management. Diffuse pollution from mentioned sources burdens land and water. Small and fragmented estates of family farms in great number remain uncultivated. Also they are not maintained in good ecological conditions due to the abandonment of agriculture by younger and educated population, which is engaged in other economy branches.

Long-time ***threats*** to the preservation of agricultural land quality are: incomplete water supply and sewage system; sanitary unprotected wells and lack of system for waste water treatment; unreconstructed and incomplete system of drainage and irrigation; emission of pollutants from thermal power plants, ash landfills and pit mines; erosion, flooding and landslides and related to that uncontrolled residential building on unstable terrains, as well as inadequate waste disposal.

Establishment of the Fund for agricultural land at the Belgrade city level (2010), together with

existing Fund for environmental protection and Environmental fund of Obrenovac municipality, will provide greater ***opportunities*** for successful implementation of planned activities and projects in the field of sustainable use, improvement and protection of agricultural land and environmental protection. To soil protection will contribute rehabilitation and upgrading of drainage and irrigation systems, reconstruction of bank fortification and sanation of landslides within the process of construction of XI Corridor. Implementation of agro-ecological measures for protection of soil from erosion and water pollution by nitrates in nitrate sensitive areas is expected during the EU pre-accession period. Agricultural extension service personnel is strengthened during the period 2011/2012 and ready to assist farmers in adopting the rules of good agricultural practices in land management.

Based on the above mentioned analysis it could be concluded that limitations for sustainable land management in agriculture have primarily infrastructural, socio-economic, market and institutional nature, what is in accordance with the marks that are given on country level [18].

Priority activities and measures. For removal of existing limitations in sustainable land management in agriculture next activities and measures have to be carried out: 1) *prevention of erosion and landslides sanation*; 2) *preservation and improvement of agricultural land fertility* (GAEC promotion, encouraging farmers to participate in the fertility control of arable land and use the extension service services, more efficient implementation of annual programs for land use, regulation and protection); 3) *enlargement and organization of agricultural estates and parcels, and prevention of uncontrolled occupation of agricultural land for non-agricultural purposes* (completion of land consolidation, grouping of parcels and regulation of field roads, land sale and rent market development, cadastre update, timely preparation of regulation plans for areas where conflict of interests are expected); 4) *prevention of agricultural land and water contamination with heavy metals, pesticide residues, nitrates and phosphorus* (improvement of the monitoring system for pollutants in the air, water and land; construction of wastewater treatment plant in Barič; upgrade of sewer system; sanitary protection of septic tanks and manure warehouses, as well as respect for the sanitary protection zone of wells); 5) *Prevention of negative impacts of agriculture on soil, water, climate, biodiversity and landscape* (controlled use of fertilizers and pesticides, together with the promotion of integrated method of their application, discourage of marginal land usage and fostering of environmental infrastructure); and 6) *revitalization and upgrade of drainage, irrigation and flood protection systems*.

CONCLUSIONS

Pedological and geological structure of soils, intensive crop and livestock production in the urban fringe on the land exposed to erosion and landslide, underdeveloped hydro-melioration and waste water treatment systems and proximity of the thermal power plants, as well-known emitters of sulphur-dioxide, nitrogen oxide and suspended particles, produce serious obstacles for sustainable use of land and water in agriculture of the Obrenovac municipality.

Timely engagement of local community on implementation of appropriate actions and measures can significantly contribute to sustainable land management and agricultural development in this area.

ACKNOWLEDGEMENTS

The work is part of the integrated and interdisciplinary research project, no. 46006, funded by the Ministry of Education and Science of Serbia: "*Sustainable Agriculture and Rural Development in the Function of Accomplishing Strategic Objectives of the Republic of Serbia in the Danube Region*".

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