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of Agricultural Economists

AGRI-FOOD SECTOR IN SERBIA

STATE AND CHALLENGES

Edited by

Academician Dragan Škorić
Danilo Tomić
Vesna Popović

Belgrade, 2013

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AUTHORS

DANILO TOMIĆ, Ph.D.: *Association of Agricultural Economists of Serbia, Nemanjina 6, 11080 Belgrade – Zemun, e-mail:* dtomic45@gmail.com

ZORAN NJEGOVAN, Ph.D.: *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, e-mail:* njegovan@polj.uns.ac.rs

MILADIN M. ŠEVARLIĆ, Ph.D.: *University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade – Zemun, e-mail:* miladin.sevarlic@agrif.bg.ac.rs

MILIVOJ GAJIĆ, Ph.D.: *University of Novi Sad, Faculty of Economics, Segedinski put 9-11, 24000 Subotica, e-mail:* mikag@ef.uns.ac.rs

STANISLAV ZEKIĆ, Ph.D.: *University of Novi Sad, Faculty of Economics, Segedinski put 9-11, 24000 Subotica, e-mail:* zekics@ef.uns.ac.rs

JOVANA ČIKIĆ, Ph.D.: *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, e-mail:* cikicj@polj.uns.ac.rs

ŽIVOJIN PETROVIĆ, Ph.D.: *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, e-mail:* zpetrovic@polj.uns.ac.rs

MILAN R. MILANOVIĆ, Ph.D.: *Megatrend University, Goce Delčeva 8, 11070 Belgrade, e-mail:* milanrmilanovic@yahoo.com

BRANISLAV VLAHOVIĆ, Ph.D.: *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, e-mail:* vlahovic@polj.uns.ac.rs

ANTON PUŠKARIĆ, Ph.D.: *Institute of Agricultural Economics, Volgina 15, 11000 Belgrade, e-mail:* anton.puskaric@gmail.com

VESNA POPOVIĆ, Ph.D.: *Institute of Agricultural Economics, Volgina 15, 11000 Belgrade, e-mail:* vesna_p@iep.bg.ac.rs

ZORICA VASILJEVIĆ, Ph.D.: *University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade – Zemun, e-mail:* vazor@agrif.bg.ac.rs

NATALIJA BOGDANOV, Ph.D.: *University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade – Zemun, e-mail:* natalija@agrif.bg.ac.rs

DEJAN JANKOVIĆ, Ph.D.: *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, e-mail:* jankovic@polj.uns.ac.rs

KOVILJKO LOVRE, Ph.D.: *University of Novi Sad, Faculty of Economics, Segedinski put 9-11, 24000 Subotica, e-mail:* klovre@ef.uns.ac.rs

SUSTAINABLE MANAGEMENT OF LAND, WATER AND BIODIVERSITY IN AGRICULTURE UNDER CLIMATE CHANGE

Vesna Popović, Zorica Vasiljević

INTRODUCTION

Agriculture has a potential to play the lead role in the sustainable development due to its multifunctional character and impacts: economic (as a provider of foodstuffs, fibres, bio-fuels, and timber, and a source of income for farmers), social (as a source of employment, quality of life and health) and environmental (as a protector of soil, water, biodiversity, landscape and climate). There is increasing evidence that society is demanding for farmers to become stewards of natural resources and rural landscapes, often without corresponding economic gains. Nevertheless, sustainable management of land, water, biodiversity and climate is a concern of society as a whole and the government is required to strengthen legislation in these fields, complemented through the promotion and subsidization of voluntary measures.[1]

According to the UN Earth Summit of 1992, sustainable land management (SLM) is the *use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions*. SLM comprises four main categories of land management technologies: improved cropland management, improved pasture and grazing management, restoration of degraded land, and management of organic soils [2].

Sustainable land management combines technologies, policies and activities that are aimed at integrating socio-economic principles with environmental concerns so as to simultaneously maintain or enhance production, reduce the level of production risk, protect the potential of natural resources and prevent (buffer against) soil and water degradation, be economically viable, and be socially acceptable [47].

Soil quality is defined as the capacity of a specific soil to function within natural or managed ecosystem boundaries to sustain plant and animal production, maintain or enhance water and air quality, and support

[1] Trading environmental liabilities, such as carbon and biodiversity credits also may help to achieve sustainable use of resources and inputs in agriculture, as well as the use of certification schemes for sustainable production practices [7].

human health and habitation [48]. Land quality refers to the condition or "health" of land and specifically to its capacity for sustainable land use and environmental management [34]. Soil quality is a condition of a site and it is studied using soil data. Land quality is a condition of the landscape and requires the integration of soil data with climate, geology and land use. Sustainable land management requires the integration of these biophysical conditions of land with economic and social demands. It is an assessment of human habitation impacts, and a condition of sustainable development [9].

The production of food and other agricultural products takes 70% of the freshwater withdrawals from rivers and groundwater. Water-use efficiency is fundamental for increasing agricultural production and addressing climate change impacts. Upgrading rain-fed agriculture by soil moisture conservation practices as well as irrigation systems by technological and managerial improvements will enable more productive and sustainable water use in agriculture. Before implementing change, there must be an understanding of basin hydrology and an overall perspective on water allocation at the basin level. Hence, it is important to develop integrated water resources management (IWRM) at the basin level that encompass multiple water uses, water quality protection and flood effects mitigation, with adequate emphasis on developing, managing, and maintaining collaborative relationships for basin governance [30].

The EU Water Framework Directive - WFD (2000/60/EC) establishes a legal framework to protect and enhance the status of waters and water depending protected areas within a river basin, and ensure sustainable, balanced and equitable use of water resources. It establishes several common principles for water management, including public participation in planning and the integration of water management into other policy areas such as energy, transport, agriculture, regional policy and tourism. In accordance with WFD, the Danube countries, including Serbia, have developed the Danube River Basin Management Plan entailing measures of basin-wide importance as well as setting the framework for more detailed plans at the sub-basin and/or national level [22].

Land use change and intensive agriculture have caused land degradation, including soil biodiversity loss, nutrients release into rivers and excessive water withdrawals for irrigation and landscape fragmentation. The Millennium Ecosystem Assessment pointed out that intensive agriculture have been responsible for the loss of biodiversity and habitats as well as the trade-offs with other ecosystem services, particularly regulating ones, essential for agriculture (pollination, biological pest and disease control, flood retention capacity, climate regulation) [25]. The loss of genetic variability in domesticated livestock breeds and crop sorts and varieties is very serious as genetic diversity is a key factor of sustainable intensification of agriculture in the future [54]. On the other hand, preservation of a large number of protected and rare plant and animal species depends of low-intensity agriculture, inherent to high nature value (HNV) farmland.

The outcome document from the Rio+20 UN Conference on Sustainable Development recognized that adaptation to climate change, conservation and sustainable use of biodiversity, desertification, land degradation and drought mitigation, and development of integrated water resources management represent an immediate and urgent global priority [56].

FAO strongly argues for priority actions in sustainable and adaptive natural resources management, such as land-use planning and soil, water, ecosystems and genetic resources management in order to improve resilience to climate change [13]. The agricultural sector can contribute to the climate change solution by capturing synergies that exist among activities to develop more productive and resilient food production systems and improve natural resource management. To be synergistic, these activities must be based on *ecosystem approach*[2], landscape scale and inter-sector coordination.

FAO uses term climate-smart agriculture (CSA) to determine agriculture that *sustainable increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals* [15].

Climate - smart agriculture encompasses sustainable agriculture, expanding it to include the need for adaptation and the potential

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[2] According to UNCBD, ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, http://www.cbd.int/ecosystem/default.shtml.

for mitigation with associated technical, policy and financing implications. The CSA approach involves site-specific assessments of the adaptation, mitigation and food security benefits of a range of agricultural production technologies and practices, and identifies those which are most suitable for a given agro-ecological and socio-economic situation. The development of a national CSA strategy is an opportunity for coordination of key agricultural development and climate change stakeholders in a unified vision of agriculture development under climate change, including instruments of support to agricultural producers in making the desired changes [14].

Serbia as a candidate country for EU membership, in the pre-accession period seeks to harmonize environmental and sector legislation and practice with the relevant in the EU, along with fulfilling the obligations in these areas it has assumed by signing international conventions (UNFCCC, UNCCD, UNCBD, etc.), but delays in by-laws adoption, lack of national strategic documents in agricultural and climate policy, underdeveloped local institutional infrastructure and financial bottlenecks significantly slow down the implementation processes.

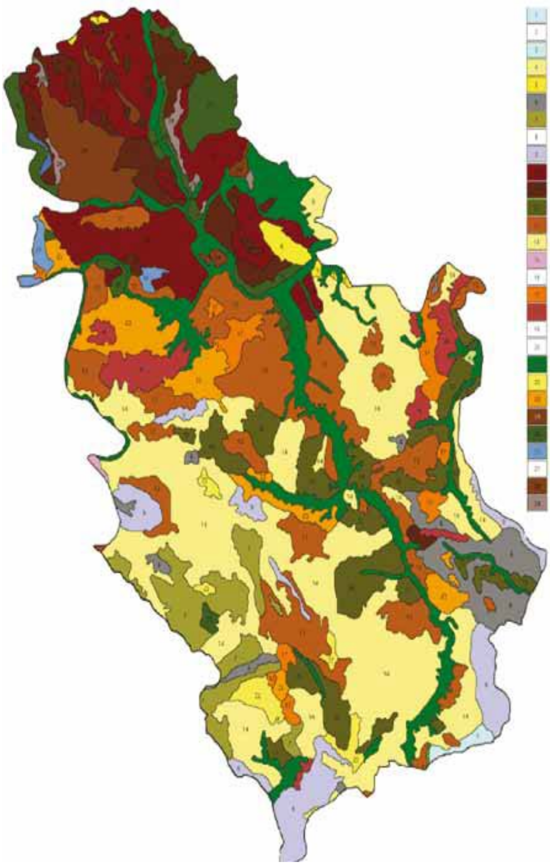
In this chapter, authors' attention will be devoted to assessment of land, water and biodiversity resources availability and capability for sustainable agricultural production as well as to the policies of their sustainable use in agriculture under climate change.

1. SUSTAINABLE LAND MANAGEMENT

1.1. Soil and Land Quality

The soils of the Republic of Serbia are characterized by great diversity and mosaic-like structure of the present soil types (Figure 1).

According to the data from the Institute of Soil Science, Belgrade (2011), the following types and associations of soils are the most common: distric cambisols on eruptive and metamorphic rocks – 1,890,600 ha (21.4%); chernozem – 1,212,700 ha (13.7%); fluvisols and humogleys – 928,820 ha (10.6%); soils on limestone (calcomelanosols and calcocambisols) – 907,630 ha (10.3%); brown soils on sandstones, flysch and other sediments – 816,100 ha (9.2%); smonitzas (*Vertisol*), including eroded and degraded smonitzas – 762,250 ha (8.6%); eutric cambisols, including luvic and eroded eutric cambisols – 729,350 ha (8.3%); pseudogleys and ilimerised pseudogley soils – 490,375 ha (5.6%); serpentine soils – 267,700 ha (3%); halomorphic soils – 242,200 ha (2.7%); and rankers – 123,875 ha (1.4%) [19].



Legend:
1. Karst (rocky soil) with spots of terra rossa, brown soil and lithosol
2. Lithosols and eutric cambisol
3. Lithosols on acid rocks and rankers
4. Regosols, rendzinas and eutric cambisols
5. Arenosols and eutric cambisol on sand
6. Lime dolomite black soils, lithosols and rendzinas
7. Lime dolomite black soils, cambisols and terra rossa
8. Rendzinas and regosols
9. Rankers and distric cambisols
10. Chernozem on loess
11. Chernozem and chernozem-semigley soil
12. Smonitzas
13. Eutric cambisol
14. District cambisols, luvisols and calcocambisols
15. Cambisols, luvisols and calcomelanosols
16. Terra rossa (ilimerised) and calcocambisols
17. Luvisols and eutric cambisols
18. Luvisols
19. Pseudogley soils and rendzinas
20. Acric soil and cambisols on limestone
21. Fluvisols and eugleys
22. Pseudogleys
23. Pseudogleys and ilimerised pseudogley soils
24. Chernozem-semigley soil
25. Humogleys
26. Gley and semigley soils
27. Eugleys
28. Histosols
29. Halomorphic soils

Figure 1: Soil map of Serbia
Source: [53].

Based on the natural characteristics of land (soil type with certain characteristics in terms of natural fertility, and landscape features related to altitude, rainfall, slope and exposure) and the degree of contamination with dangerous and harmful substances, and regardless of the current mode of use, land parcels are classified in eight capability classes, designated by the numbers 1 through 8.

Land capability classification shows, in a general way, the suitability of soils for agricultural production and forestry. The numbers indicate progressively greater limitations and narrower choices for cultivation, i.e. productive uses of land in agriculture and forestry (Tab.1).

Capability classes	*Area – km²*				*%*			
	Republic of Serbia	*AP Vojvodina*	*Central Serbia*	*UNMIK Kosovo*	*Republic of Serbia*	*AP Vojvodina*	*Central Serbia*	*UNMIK Kosovo*
I	11,650	9,688	1,675	287	14.4	51.4	3.2	2.8
II	9,357	3,284	5,481	592	11.6	17.4	10.6	5.8
III	10,522	3,823	5,383	1,316	13.0	20.3	10.5	13.0
IV	8,682	355	7,133	1,194	10.8	1.9	13.8	11.8
Suitable for cultivation	40,211	17,150	19,672	3,389	49.8	91.0	38.1	33.4
V	11,073	531	9,002	1,540	13.7	2.8	17.4	15.2
VI	20,144	889	17,185	2,070	25.0	4.7	33.2	20.4
VII	8,069	193	5,232	2,644	10.0	1.0	10.1	26.1
VIII	1,178	72	604	502	1.5	0.5	1.2	4.9
Unsuitable for cultivation	40,464	1,685	32,023	6,756	50.2	9.0	61.9	66.6
Total fertile land	80,675	18,835	51,695	10,145	100.0	100.0	100.0	100.0
Infertile land	7,686	2,671	4,273	742	-	-	-	-
Total	88,361	21,506	55,968	10,887	-	-	-	-

Table 1: Land capability structure
Source: [20].

1.2. Land Use and Land Use Change

According to data of the Statistical Office of the Republic of Serbia (without data for UNMIK Kosovo) in 2011 it was involved in agricultural production 5,056,051 ha, while additional 40,216 ha were occupied by swamps and marshes, so that the total agricultural area amounted to 5,096,267 ha (65.8% of the country territory). In the same year the arable land and gardens occupied 3,293,577 ha (65.1% of utilized agricultural land), orchards 239,948 ha (4.7%), vineyards 56,434 ha (1.1%), meadows 621,418 ha (12.3%) and pastures 844.674 ha (16.7%). The most of sown arable land is under cereals (62.3%), while it is 14.8% under fodder crops, 14.0% is under industrial plants and 8.9% under vegetable crops. The rest of 176,988 ha is uncultivated one [44, 51].

The family farms make up 99.6% of the total number of farms in the Republic of Serbia. The average family farm in the Republic of Serbia uses 4.5 ha of agricultural land and has one head of cattle, four pigs, three sheep, 26 heads of poultry and one bee-colony. There are significant regional differences. The largest area of agricultural land are used by the farms in the region of Vojvodina, while the largest number of livestock has been raised on farms south of the Sava and Danube rivers [49].

Agricultural production is carried out under the four **climatic-production zones** (according to the Rulebook for cadastral classification and land evaluation, Official Gazette of RS, No 61/12) - in the plain, hilly, hilly-mountainous and mountainous zones.

The plain zone extends to an altitude of 250 metres. The average annual temperature is higher than 10.5 °C; the average annual precipitation is not higher than 700 mm (in AP Vojvodina at Zemunska, Titelska and Telečka loess plateaus, and in the Central Serbia, in the South Morava River valley, up to 600 mm). The rainfall in the vegetation period amounts to an average of 350 mm and in this region there is no limit for cultivation of all crops. There are more or less represented the soils of the first, second, third and fourth capability classes. This is a zone of intensive crop production, first of all the grains and industrial crops (Vojvodina, Mačva, Stig, Pomoravlje), on family farms and estates of entrepreneurs as well as the legal entities.

The hilly zone extends to an altitude between 250 m and 650 m, south of the Sava and Danube (Šumadija, Pomoravlje, Kolubara, Metohija). The average annual temperature is higher than 9.5 °C, the average annual precipitation ranges up to 750 mm (at the Kosovska plateau on 700 mm, while at Metohija, influenced by the Mediterranean climate even to 1000 mm, but the most important summer months, July and August are extremely drought). The precipitation in the vegetation period is up to 400 mm. With very few restrictions, in this region there can be grown all crops, while there are mainly represented the soils of the second, third, fourth and fifth capability classes. An intensive production of grains and forage crops is mixed with intense, indoor cattle breeding, as well as the pig and poultry ones, mainly on the family farms (Fig. 2).

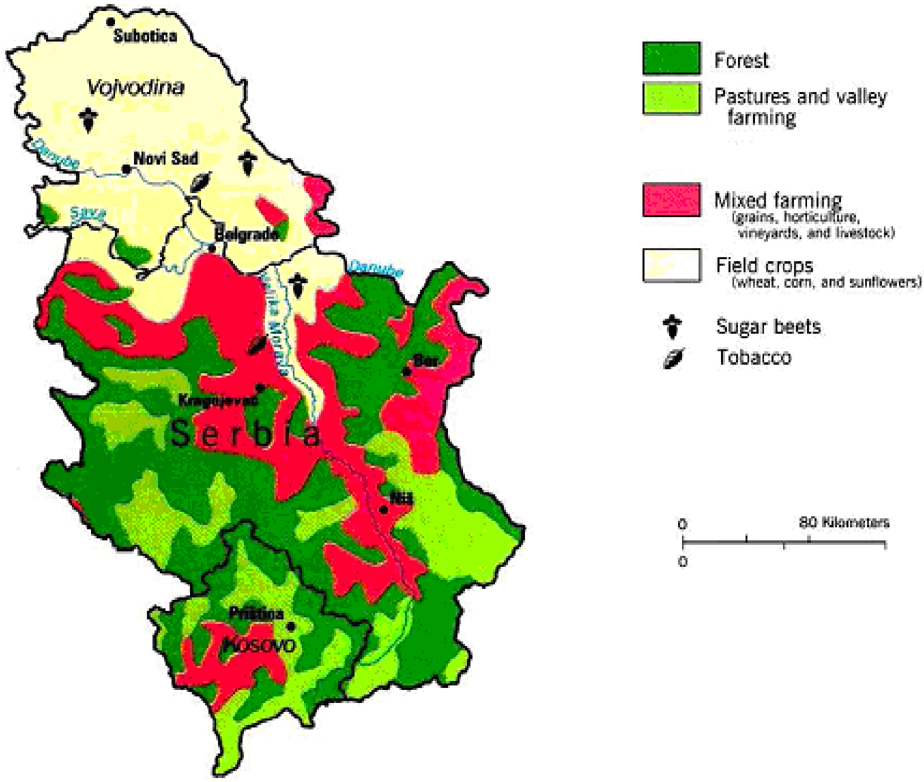


Figure 2: Land use and agriculture in the Republic of Serbia
Source: [32].

The hilly-mountainous zone extends to an altitude between 650 m and 1000 metres. The average annual temperature is up to 8 °C. The average annual precipitation is up to 800 mm, while in vegetation period it exceeds 400 mm. The number of crops is limited, there cannot be grown the maize or vineyards. Here are represented mainly the soils of the fourth, fifth and sixth capability classes, while this region, specifically its western part, is known by production of raspberries and potatoes.

The mountainous zone cover an area at an altitude above 1,000 metres, with average annual temperature below 6 °C and an average annual precipitation of 900 mm or more, while in the vegetation period it exceeds 450 mm. The number of crops is limited onto the spring small types of grain, while there cannot be grown vineyards or orchards. Here are represented mainly the soils of the V-VIII capability classes. This is the zone of the livestock grazing, as well as the low-intensive agriculture and high nature value farmland.

1.3. Land Degradation

The production practices of intensive agriculture, especially those whose use is not harmonized with the natural conditions of the area (relief, soil, and climate) influence the occurrence / intensification of the land degradation process: erosion and landslides; compaction; organic matter decline; acidification; and salinization and alkalization. Agricultural land is exposed to contamination by pesticides and heavy metals from fertilizers and non- agricultural sources – of the geochemical and anthropogenic origin, as well as to the sealing caused by occupation for construction and infrastructure.

Geological and pedological base, relief, climate, and land use are the main factors that determine the occurrence and intensity of *erosion*. According to Lazarević (2009), 76,354.4 km^2 or 86.4% of the country territory has been affected by erosion, of which: 513.5 km^2 (0.7%) by *extensive erosion* (the first of the five categories of erosion), 2,919 km^2 (3.8%) by *strong erosion* (the second category) and 14,750.2 km^2 (19.3%) by *erosion of medium strength* (the third category) [24].

Fluvial erosion, with collapse of the riverbeds and flooding the surrounding terrain, is present along the river flows and it is caused by heavy rain and rapidly melting snow, as well as the torrential activity and slope erosion in the upper, hilly-mountainous parts of the river flows.

Erosive action of slopes, developed on terrains built of unbound, weakly bound and bound degraded rock masses and associated with torrential activity, is the mostly intensive on the edge of Vranjska valley, in Grdelica gorge, in the basin of the rivers Vlasina and Pčinja in South-East Serbia; then in the Binačka Morava river basin at area of Kosovo; in the valley of the river Lim as well as in the upper course of the river Ibar in South-West Serbia as well as in hilly areas of Šumadija. The wind erosion is characteristic for the most part of the Vojvodina plain. Between 20% and 25% of Serbia's territory has been affected by *landslides,* while the deepest landslides have been formed in the coastal area of the Danube and Sava rivers (northern slopes of Fruška gora mountain, the area of Belgrade and Smederevo cities) [43].

Intensive land cultivation by heavy machinery leads to the process of *soil compaction*, thereby deteriorating its water-air regime, as well as a *reduction of soil organic matter*. Maintaining of the organic carbon level in the soil is extremely important, both from the standpoint of soil fertility, and to mitigate climate change. According to the systematic control results of the agricultural land fertility on the territory of the Republic of Serbia, carried out in 2011, 58.2% of the samples had a content of organic carbon in the range of 1-2%, 30% of the samples had 2-5%, and 11.4% of the samples had only 0-1% [43]. The land in Vojvodina is best provided by the humus. The natural content of humus in Vojvodina chernozem is higher than 3%, which is the limit between the land well and poorly provided with humus, but in the last decades it has been significantly reduced - by an average of 0.38% [1], mostly because of inadequate agricultural practices (insufficient application of manure, as well as crop residue removal/burning and intensive cultivation of land in the crop, fruit and grape production).

The mentioned systematic control of the agricultural land fertility made in 2011 showed that in AP Vojvodina there are dominant the soils of weakly alkaline reaction, calcareous ones, with optimal content of easily accessible phosphorus and high content of easily accessible potassium. In Central Serbia, situation is slightly different. There are dominant the soils of acid reaction, the slightly calcareous ones, with a very low content of easily available phosphorus and high content of easily available potassium. By *acidification* there are particularly endangered the areas of the South-East Serbia, Šumadija, Kolubara basin, Jadar, Pocerina and surroundings of Leskovac city. Application of the inappropriate composition fertilizer without previously done analysis of the soil nutrients contributes to further soil acidification/alkalization and endangers the quality of waters.

Over 240,000 ha of land are *salinized and alkalized*. Salinized and alkalized soils are localized in Vojvodina. A high level of ground water, as well as the use of inadequate quality of water for irrigation, increases the concentration of salt in the soil. Analysis of the quality of irrigation water in Vojvodina, conducted in 2004, showed that the surface water were moderately saline and mostly belonged to the class of middle salt water, with low content of sodium (C2S1),[3] and a much smaller number of cases belonging to the class of salt water, but also with low sodium content (C3S1). In a class of salted water with middle content of sodium (C3S2), which can lead to alkalization of the low permeability soil, it was found only one sample of well water [6].

[3] US Salinity Laboratory Classification.

On the issue of *contamination* of agricultural soil with heavy metals and pesticide residues, land in rural areas is almost clear, if it is excluded the excessive content of potentially available nickel (Ni), cadmium (Cd) and chromium (Cr) in Vojvodina and nickel (Ni), cadmium (Cd), chromium (Cr), arsenic (as),and lead (Pb) in Central Serbia, that is of geochemical origin, as well as an increased content of copper (Cu) in a small number of fruit and wine-growing districts (Petrovaradin, areas around Vršac, Negotin, Aleksandrovac, Kruševac and Niš, Kosmaj, Jošanička spa, Krupanj). An increased content of copper is present in the vicinity of Bor copper mine and Majdanpek. In the vicinity of the Bor copper mine and near Resava and Zvornik coal mines it was registered a high content of arsenic (As), while in the agricultural land in the vicinity of the Kostolac and Kolubara coal basins and TENT Obrenovac there have been registered increased concentrations of cadmium (Cd), cobalt (Co), copper (Cu) and nickel (Ni). Testing of soil quality in urban areas indicate exceedance of limit values for the presence of certain heavy metals, polycyclic aromatic hydrocarbons and pesticide residues, which should be closely monitored, having in mind the developed peri-urban agriculture. In a small number of soil samples in the vicinity of busy roads it was found an increased content of lead (Pb) [6; 43; 46].

Preliminary researches carried out on the part of agricultural land of UNMIK Kosovo territory (EULUP Project), primarily in the areas of (previously) developed industrial and mining activities, confirm the presence of excess contents of heavy metals, especially chromium (Cr), nickel (Ni), lead (Pb), arsenic (As) and cadmium (Cd) [12].

According to the SEPA data, there were identified 332 potentially contaminated sites on the territory of the Republic of Serbia in 2011[4] (public municipal landfills 38.9%, sites related to the exploitation and oil refining 28%, industrial and commercial sites 10.8%). Remediation was performed on 2.4% of identified sites [43].

Soil sealing is related to the occupation of land in the construction and infrastructure purposes, causing the land forever denied the ability to perform its ecological functions, increasing the risk of flooding, causing

[4] Determination of contaminated sites was carried out on the basis of the Regulation on the program of systematic monitoring of soil quality, indicators for assessment of the soil degradation risk and methodology for developing the remediation programs (Official Gazette of RS, 88/10).

in the cities the heat island effect, while agriculture loses valuable basic resource for production. According to the Corine Land Cover data, in the 1990-2006 period it was occupied in Serbia 5,623 hectares for the purposes aiming at the expansion of urban areas and the construction of sports and recreational facilities, 2,026 hectares for the industrial and commercial sites, 28 ha for the road network and supporting infrastructure, while 3,825 hectares for the needs of mines, waste disposal and construction sites. There have been mostly occupied the land under pastures and the mixed agricultural areas (5,098 ha), as well as the arable land and permanent crops (3,407 ha) [45; 46].

The surface coal mines occupy about 12,000 ha, with a tendency of taking over a new 200 ha per year. The thermal power plant ash landfills occupy around 1,200 ha, dispose of the metal ores waste products 3,000 ha, while 1,000 ha is under land borrow sites. Revitalization of degraded agricultural areas represents a legal obligation of users of these lands, but due to the lack of financial resources it does not goes by anticipated pace [31].

In the 2002-2011 period the total agricultural area has been decreased by 11 thousand hectares (from 5,107 thousand hectares to 5,096 thousand hectares). It is observed trend of reduction in arable land and vineyards, the areas under orchards and meadows are stagnating, while areas under pastures and ponds, swamps and marshes are increasing [51; 52]. Since Serbia has 4 million hectares of the I-IV capability class land, suitable for cultivation, the grassing and reforestation of marginal arable land and increasing areas under reeds and marshes can be estimated as positive, particularly in terms of carbon sequestration, without fear of the availability for agricultural purposes.

2. INTEGRATED WATER RESOURCES MANAGEMENT

2.1. Water Resource Availability

The elements of the hydrological balance of Serbia have the following values: average rainfall 734 mm/year, the domestic water runoff of 509 mm^3/s (181 mm/year), the average evapotranspiration 552 mm/year and the average runoff coefficient of 0.25 [33].

With the specific annual availability of *domicile surface water* of about 1,500 m^3 per capita (of about 2,500 m^3 which is the lower conditional limit of the long-term self-sufficiency for the sustainable development of a country), Serbia is one of the poorer regions in Europe in terms of water [10]. Poorest in terms of water are densely populated low-lying areas, with the highest quality of land resources (Pomoravlje, Kolubara, Šumadija, Vojvodina, Kosovo, South Serbia), while the high qualitative water resources are positioned along the edge of the country (Podrinje, Starovlaške mountains, Šara, Prokletije, Vlasina). Most of the annual flow is realized in the short torrential high water, after which occur the long-term periods of low flows.

The average flow of *the transit waters* is significant and amounts to about 5,163 m^3/s, but it should be kept in mind its time unevenness (in the low-water period the flow amounts to 1,500 m^3/s)[5] as well as the fact that availability and quality of transit water depend on interventions in upstream countries [10]. Utilization of transit waters requires rehabilitation and upgrading of regional hydro-systems as well as an active international cooperation. Total gross potential of *groundwater* is estimated to about 67m^3/s [33], but from the ecological and hydraulic reason it cannot be used more than half of these potential [10]. Excessive exploitation (Bačka, Banat) and inadequate protection of water sources limit their sustainable use.

2.2. Water Quality

According to the SWQI (Serbian Water Quality Index) composite index of the surface water quality[6], in 1998-2011, the lowest quality had the waters of rivers and canals in Vojvodina Province. In relation to the total number of samples from all river basins, in the category of "very bad" almost 83% of the samples were from the territory of Vojvodina, while 46% of the total number of samples from this river basin area were in categories marked as "very bad" and "bad" (Fig. 3).

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[5] Danube flows when entering Serbia are oscillating from the average 2,268 m^3/s to a maximum 4,738 m^3/s in the period of high water, i.e. to a minimum 839 m^3/s in the period of low water [26].

[6] SWQI covers the ten parameters of physical-chemical and microbiological quality (oxygen saturation, BPK, ammonium ion, *pH* value, total nitrogen oxides, orthophosphates, suspended solids, temperature, conductivity and coliform bacteria).

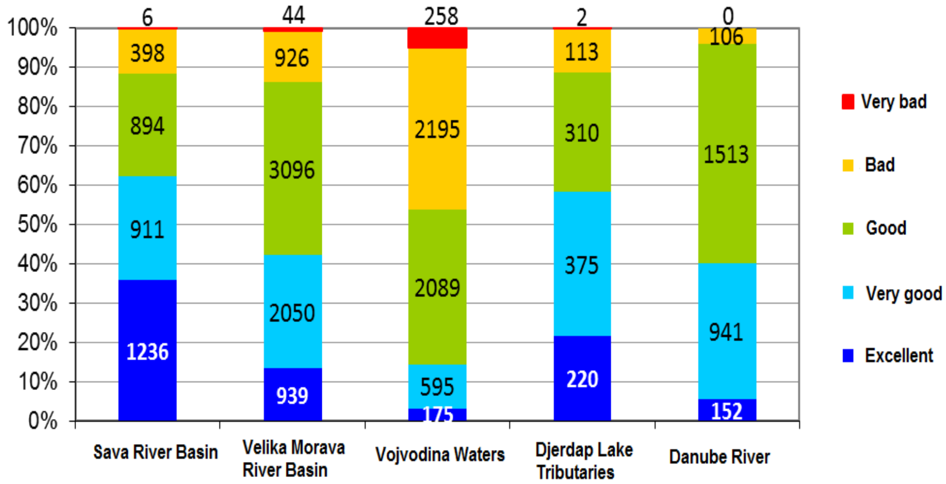

Figure 3: Ranking of the quality of water samples using SWQI index
Source: [43].

They are especially disturbing the monitoring results of the priority and priority hazardous substances[7], which enter the river flows due to discharge of untreated municipal, industrial and agricultural wastewater. In 2011 there was registered exceeding of the maximum allowable concentration (MAC) of cadmium (Cd) and mercury (Hg) on total number of 39 measuring profiles, and on most of them even several times during the year [43].

Regarding the quality of surface and ground water, agriculture is monitored in terms of diffuse water pollution by mineral and organic fertilizers and pesticide residues. Analysis of the frequency distribution of the nutrients' concentration classifies the surface waters into two ranks - satisfactory with the corresponding concentrations of the parameters in I and II classes of ecological status, as well as *unsatisfactory* with concentrations of parameters in III, IV and V ecological status class.[8] Concentration of nutrients (ammonium ion NH4-N; nitrates NO3-N; and orthophosphates PO4-P) range within the limits prescribed for the class

[7] The Regulation on limit values for priority and priority hazardous substances that pollute surface water and deadlines for their achieving (Official Gazette of RS, 35/11).
[8] According to the Regulation on limit values for pollutants in surface and ground waters and sediments, and the deadlines for their achievement (Official Gazette of RS, 50/12), the limit values for the class III amount to: BPK = 7 mgO/l, nitrates = 6 mgN/l, ammonium ion = 0,6 mgN/l, orthophosphates = 0,2 mgP/l).

I and II, which corresponds to the waters of excellent and good ecological status[9] (Fig. 4).

The results of the analysis of long-term trends in nutrient concentrations in surface waters showed that orthophosphates were the most common nutrient pollutants of water, so it is necessary to pay special attention to the application of phosphorus fertilizers in agriculture as one of the major source of diffuse water pollution.

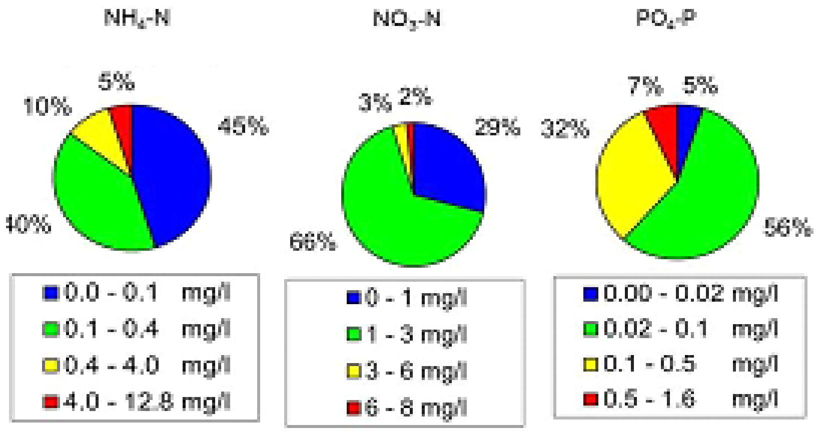

Figure 4: Distribution of nutrient concentration frequency in Serbianwatercourses, 2001-2010.
Source: [43].

Analysis of the groundwater quality in the coastal areas of major rivers done in 2005-2011, concerning the presence of nitrate, chloride and ammonium ions, showed that the share of the nitrate concentrations (NO_3) above maximum allowed (MAC) of 50 mg/l amounts less than 5%; that chloride concentrations do not exceed the limit value of permitted presence in drinking water of 200 mg/l; that in about 15% of the samples the content of ammonium (NH4) is above the EU MAC of 0.5 mg/l (Directive 98/83/EC), and in less than 5% of the samples exceeded the MAC of the World Health Organization of 1.5 mg/l, which leads to the conclusion that the observed contaminants do not compromise the deeper aquifers [43].

[9] According to the Regulation on the parameters of the ecological and chemical status of surface waters and the parameters of the chemical and quantitative status of groundwater, (Official Gazette of RS, 74/2011).

2.3. Irrigation and Drainage

Around 3,641 million hectares of land in the Republic of Serbia are in the classes I-III as appropriate for irrigation, of which in the first two classes there are approximately 1.6 million of the most productive land in the plains and valleys of major rivers (Fig. 5).

According to the preliminary data of the Statistical Office of the Republic of Serbia (without data for UNMIK Kosovo), in 2012 it was irrigated 52,986 ha of 94,532 ha covered by irrigation systems, more than in 2011 (34,175 ha) and the greatest area since 2003.[10]

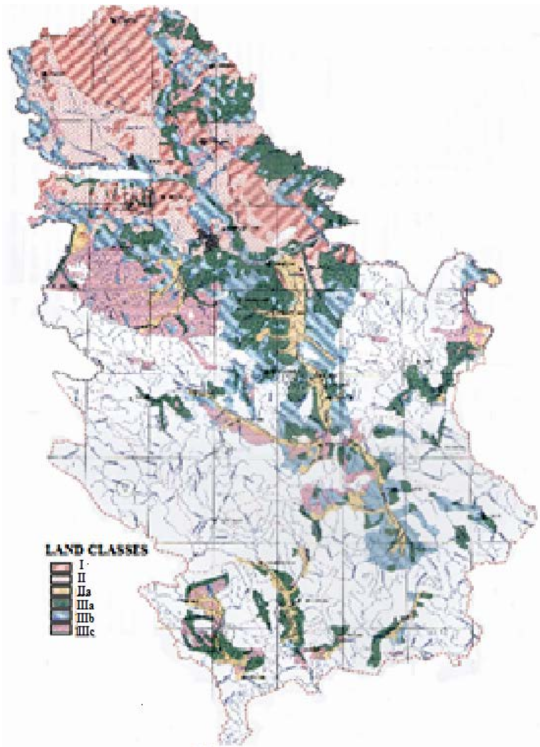

Figure 5: Land classes suitable for irrigation
Source: [11].

[10] According to data of The Institute for Water Management "Jaroslav Černi" for areas of the Central Serbia and AP Vojvodina – in addition to 106 built hydro-systems, with capacity of 105,522 hectares, of which there are operating 40,914 ha, there are irrigated additional 57,000 ha: 30,000 ha within technically completed, individual systems in private property, 15,000 ha within technically non-completed systems in private property, 2,000 ha on the experimental fields of agricultural schools (technically completed systems) and 10,000 ha locally, on the garden plots (technically non-completed systems) [26].

The irrigation is carrying out by sprinkling (47,744 ha), drip system (2,566 ha) and surface method (2,676 ha). The share of irrigated area related to the total used agricultural area is amounted to 1.26%. In 2012 it was drawn 110,445 thous.m^3 of water for irrigation, the most from rivers (91%), and the remaining from groundwater, lakes and reservoirs, and public water supply network [43, 50].

Most of the irrigated areas are located in Vojvodina - about 30,000 ha, and there is the responsibility of the country's largest hydro-system Danube-Tisa-DanubeCanal (HS DTD). The irrigation capacity of HS DTD is 510,000 ha, the systems currently cover the area of 84,644 ha, but in operation conditions, fully or partially, the system is on area of 46,192 ha, while it is functioning only on the area of 29,948 ha [41] (Figure 6).

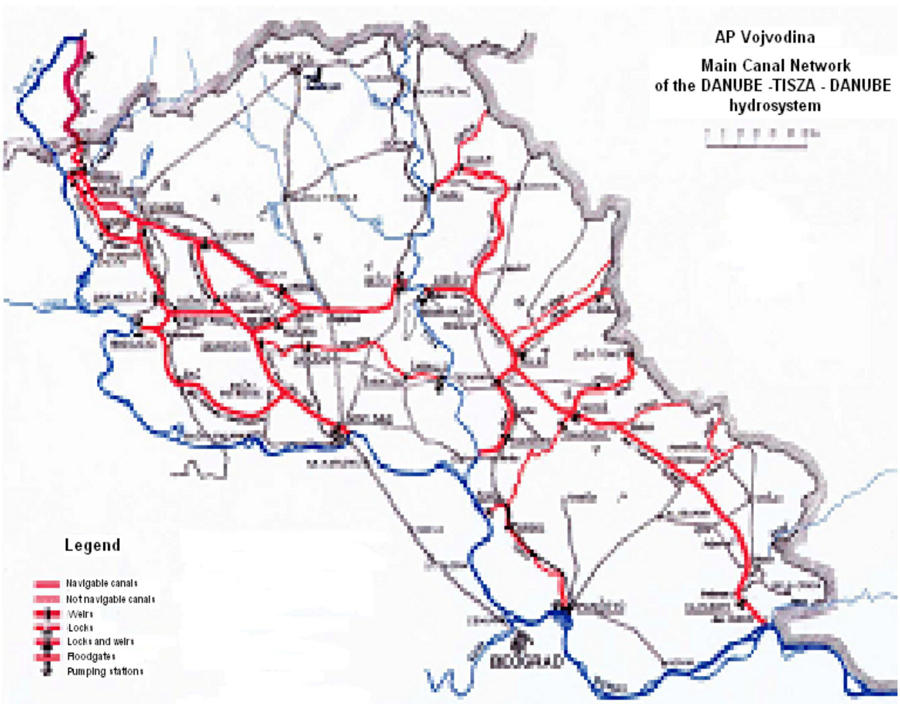

Figure 6: DTDCanal - Main canal network

Source: [41].

About 2.5 million ha of net used agricultural land and other facilities in Vojvodina and valley regions of Central Serbia as well as in Kosovo is necessary to be protected from the groundwater and waterlogging.

The drainage systems (400 systems) are covering approximately 2.08 million ha, of which 1.63 million ha in Vojvodina [11]. Within HS DTD the drainage is carrying out on 1.06 mil. ha, in Bačka 0.55 mil. ha and in Banat 0.51 mil. ha.

Faced with forecasts of deteriorating climatic conditions in South-East Europe[21], Serbia has been committed to the improvement of irrigation as the basic measure to mitigate the effects of drought [8].

On the basis of that there have been made the credit arrangements with the World Bank (IBRD/IDA Development Credit Agreement, 2005 and Additional Financing Loan Agreement, 2007) for financing of the *Irrigation & Drainage Rehabilitation Project* (P087964) in the 2005-2013 period. In addition, MAFWM has been started in 2012 with implementation of wider project for rehabilitation, revitalization, reconstruction, modernization and construction of irrigation systems on the area of 1.1 million ha in the next four years' period (*Irrigation Development in the Republic of Serbia* Project) (Official Gazette of RS, No. 17/2012).

3. AGROBIODIVERSITY AND LANDSCAPE PROTECTION

3.1. Genetic Resources in Agriculture

Agrobiodiversity is a vital subset of biodiversity and encompasses the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of the agro-ecosystem, including its structure and processes for, and in support of, food production and food security [16].

Traditional production practices and local knowledge and culture are integral parts of agrobiodiversity, because farmers as the custodians of agro-environment assist in the evolution and adaptation of plant and animal species for centuries. Agrobiodiversity is threatened around the Planet by intensive agricultural production, based on a smaller number of improved, high yielding varieties and breeds. Consequently, there were rapidly disappearing from the fields and farms the traditional local varieties of plants and animals. Together with urbanization and abandonment of agriculture in marginal rural regions, there are also disappearing their wild relatives in the immediate environment of agricultural holdings, and with disappearing of traditional agriculture there is lost as well the knowledge and experience that become valuable at this time facing with the climate changes and new challenges related to nutrition and health of the people, plants and animals. Serbia has been also affected by these processes.

On the territory of Serbia there have been grown over 150 plant species. According to the MAFWM Directorate of Plant Protection, in the last 50 years there have been developed in Serbia over 1,200 varieties of agricultural plants (more than 740 varieties of small and millet-like grains, 170 varieties of industrial crops, 70 varieties of forage plants, 120 varieties of vegetables, 40 varieties of fruits and 50 varieties of vines, as well as 6 varieties of horticultural and medicinal plants) [27].

It is important for food production and agriculture a large number of wild relatives of the cultivated fodder crops, as well as the medicinal and aromatic plants, fruits and forest fruits, which, in addition to ecological importance, have a significant economic potential at the market of organic food and products with the geographic origin protection.

On the list of indigenous breeds of domestic animals and endangered livestock breeds[11] there are the following:

- ***Endangered autochthonous breeds*** - horse (Domestic Mountain Pony and Nonius), donkey (Balkan Donkey), cattle (Busha and Podolian Cattle), buffalo (Domestic buffalo), pig (Resavka, Moravka and Mangalitza), sheep (Pirot Zackel, Karakachan Sheep, Krivovir Sheep, Bardoka Sheep, Lipska Sheep, Vlaška Vitoroga Sheep and Čokan Cigaja), goat (Balkan Goat) and poultry (Svrljig Black Hen, Sombor Kaporka and Banat Gološijan).

- Not endangered autochthonous breeds – sheep (Svrljig Sheep, Sar Mountain's Sheep and Cigaja), turkey (Domestic Turkey), duck (Domestic Duck), goose (Danube Goose), guineafowl (Domestic Helmeted Guineafowl), pigeon (Serbian High Flying Pigeon), bee (Apis mellifera carnica) and dog (Sarplaninac).

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[11] Regulation on the List of genetic reserves of domestic animals, methods of preserving genetic reserves of domestic animals, as well as the List of indigenous breeds of domestic animals and endangered livestock breeds, Official Gazette of RS, No. 38/10.

Genetic resources of relevance for food production and agriculture are held in *ex-situ* conditions or they are held in traditional farming systems.

In the national gene bank collection in Belgrade there are 4,238 samples of plant genetic resources (2,983 cereals, 367 industrial plants, 214 vegetables, 285 forage plants and 389 medicinal and aromatic plants), while the measures of the *in-situ* or *on-farm* protection are particularly important for preservation of indigenous and ancient varieties of crops and breeds of animals in their natural habitats, i.e. in extensive production systems.

3.2. High Nature Value Farmland

Maintenance of extensive production systems is particularly important for the protection, preserving and development of agricultural areas of high natural value (HNV farmland), which includes the protected areas as well (PA, IBAs, IPAs and PBAs).

The concept of the HNV farming is interesting for Serbia, given the vast mountain pasture areas rich by biodiversity, whereas it has been developed for centuries an extensive, so-called mountain agriculture (HNV farmland Type 1), as well as a large number of protected areas. Also, the distinctive mosaic agricultural landscapes of Central Serbia is due to the small holdings, where there has been traditionally represented a mixed plant-animal production, mainly of low intensity (HNV farmland Type 2).

By the mapping of HNV farmland (where precedence had HNV farmland Type 1 and, to a less extent, HNV farmland Type 2) it was determined their area of about 11,872 km^2 (19% of agricultural land or 13% of the country territory) [5].

Protected areas cover 527,152 ha (5.91% of territory of Serbia) [43]. By the Spatial Plan of the Republic of Serbia (Official Gazette of RS, 88/10), it is projected that until 2015 there would be protected by some form of protection around 10% of Serbian territory, and until 2021 around 12% of the territory of Serbia.

4. CLIMATE CHANGE AND AGRICULTURE

4.1. Basic Climate Characteristics

Most of the territory of Serbia has the temperate continental climate with distinct local variations, caused by relief, vegetation and degree of urbanization. It is characterized by cold winters and hot summers, while the autumn is warmer than spring. Maximum rainfall is in early summer, in June, and a minimum is in February and October. The South-western part of the territory is on the border of the Mediterranean and continental climate (cold winters and hot and dry summers, with maximum rainfall in November-January period and minimum in August). The mountain areas with an altitude of over 1,000 m have a continental climate.

According to the Republic Hydrometeorological Service of Serbia (RHMS) [58],an average annual air temperature in 1961-1990, for the areas with an altitude up to 300 m, amounts to 10.9 ^{o}C. The areas with an altitude of 300-500 m have an average annual temperature of about 10.0 ^{o}C, and over 1,000 m of altitude have around 6.0 ^{o}C. The absolute temperature maximums in 1961-1990, were measured in July (37.1 - 42.3 ^{o}C in lower areas, and 27.6 - 34.0 ^{o}C in the mountain areas). The absolute minimum temperatures were recorded in January (from -30.7 to -21.0 ^{o}C in the lower regions, and from -35.6 to -20.6 ^{o}C in the mountain areas).

Areas with annual rainfalls below 600 mm are in the northeast part of the country and in the valley of the South Morava as well as in the part of Kosovo. In the Danube Basin, Great Morava valley and further on to the south-east, the rainfalls are reaching 650 mm. In the mountainous areas of Southeast and Eastern Serbia the annual rainfalls amount to near 800 mm. The rainiest areas are the mountain ones to the west and southwest of the country where the annual values of this climate parameter reach and even exceed 1,000 mm. The snow cover appears in the November-March period, while the largest number of days with snow is in January.

The annual insolation amounts ranged from 1,500 to 2,200 hours. North-western and western winds are blowing in the warmer part of the year, and eastern and south-eastern winds during the colder part of the year (in the mountain areas of south-western Serbia the south-western winds).

4.2. Climate Change Trends

The average annual temperature in Serbia since 1980 has recorded a positive trend[12] that has been intensified in two recent decades. The growth of temperature has been the most intensive in Vojvodina, near Loznica city, in the wider area of Belgrade and in Negotinska krajina. Only the southeast part of the country is characterized by a negative trend.

For most of this period (1982-2000) the increased temperatures have been accompanied by a trend of prevailing negative values of annual rainfalls, which were most pronounced in the east of the country – in Negotinska krajina, in the valleys of the Great and South Morava Rivers and in the Vranjska valley. The positive trend of annual precipitation sum was recorded in the areas of Pešter and Zlatibor, in the southern part of Kosovo, as well as in the north part of the country [35; 42].

According to IPCC Fourth Assessment Report (2007), it has been anticipated deterioration of the climate in the region of Southern Europe, which includes Serbia. In the scenario of partial implementation of measures for reduction the emissions of greenhouse gases (GHGs) in the second half of the 21st century, by the end of this century the average annual air temperature in Serbia would be increased by 3-4°C, while the rainfalls would be reduced by about 22% [42].

An increase in the mean annual air temperatures and the decreasing trend in the annual rainfalls' sum, followed by increasing long dry periods, as well as an appearance of a new absolute temperature records, indicate that it could be expected the trend of rapid decomposition of organic matter in the soil, reducing the average long-term water flow rates at the national level,[13] yields' reduction in agriculture in the long term and intensive attacks of plant diseases and pests, phenological changes, i.e. changing of the time for biological processes during the year[14] as well as changes in number and distribution of the plant and animal species and habitats in the nature.

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[12] According to RHMS data, intensity of trend in annual air temperature for the 1975-2004 period amounted to 4.54°C/100 years [35].

[13] Results of several climate models (NCAR, MPI and RegCM) point to the possible reduction of the average long-term flow rate, by 12.5% until 2020, and by 19% until 2100 (in the vegetation period by 11.1% and 5.4%, respectively) [28].

[14] See more in the Report EC-JRC AVEMAC Project-a (2012), http://mars.jrc.ec.europa.eu/mars/Projects/AVEMAC.

Agriculture is also the sector that significantly contributes to the greenhouse gas emissions. The Government is engaged in an analysis of agriculture contribution to the GHG emissions as well as to the mitigation measures within the commitments undertaken by the ratification of the UNFCCC (2001) and the Kyoto Protocol (2008). Measures of adaptation have been also discussed in the Initial National Communication of the Republic of Serbia under the UNFCCC (2010), but still there are no results in their development at national and sectoral level, as well as in the horizontal and vertical implementation.

5. POLICIES OF SUSTAINABLE NATURAL RESOURCES MANAGEMENT IN AGRICULTURE UNDER CLIMATE CHANGE

As highlighted in the introduction of this chapter, Serbia as a candidate country for EU membership, during the pre-accession period has done a lot on harmonization of legislative with the relevant EU one, in the field of sustainable use of natural resources. Initial results are visible in domain of fulfilment the obligations according to the signed international conventions in this area (UNFCCC, UNCCD, UNCBD, etc.).

However, the delay in the adoption of bylaws and strategic planning documents in the areas of adaptation to the climate changes and in combating against land desertification and degradation, non-inclusion of climate changes' issues into the sectoral sustainable development strategies and programs, as well as undeveloped initiative at the local level, clearly indicate that the achieved results represent more the partial responses to the requests from abroad, than the wise designed and comprehensive policies at all levels.

According to the ***Law on Environmental Protection*** (Official Gazette of RS, 36/09), the strategic planning for sustainable use and protection of natural resources is provided in the *Spatial Plan of the Republic of Serbia* and the *National Strategy for Sustainable Use of Natural Resources and Assets*. According to the Spatial Plan, sustainable use and protection of natural resources are among the major objectives of the country spatial development. The Strategy for Sustainable Use of Natural Resources and Assets (Official Gazette of RS, 33/12) analyses the availability and management of the natural resources of the country and creates a long-term policy framework for their sustainable use. The National Strategy is implemented through the plans and programs for each natural resource, adopted by the Government.

Protection, development and use of agricultural land are regulated by the ***Law on agricultural land*** (Official Gazette of RS, 62/2006, 41/2009). The law is regulating the issue concerning change of use and fragmentation of cultivable agricultural land; prohibition and control of agricultural land and irrigation water contamination by hazardous and noxious substances; undertaking of erosion control measures; conducting of fertility control for cultivable agricultural land as well as the control of mineral fertilizers and pesticides amount applied; and prohibiting of the crop residues' burning. In domain of agricultural land reclamation there have been foreseen the measures of land consolidation, voluntary grouping as well as agro and hydro melioration. The owner or user of agricultural land ensures sustainable use by regular cultivation and grazing and/or mowing, according the rules of good agricultural practices and in accordance with the national and provincial agricultural bases.

The agricultural bases for protection, reclamation and utilization of agricultural land represent the basic planning documents, which are synchronized with the spatial, master and other planning documents, as well as mutually, and they are implementing through the annual programmes. However, their adoption as well as the adoption of codes for good agricultural practice has been delayed.

The Manual *Regulations on good agricultural practices for management of manure coming from agriculture and organic fertilize*r, has been elaborated within MAFWM DREPR Project,[15] containing practical measures to reduce the discharge of nitrogen and phosphorus in surface water and groundwater and ammonia emissions, and to reduce the risk of pesticide use and land degradation, has got, as the whole project, the unexpectedly good response from the Serbian farmers. This fact encourages and urges the immediate adoption of the good agricultural practice codes, whose measures to a large extent correspond with measures of the climate change mitigation by reducing emissions of GHGs from agriculture, especially in the zones of intensive agriculture.

[15] Serbia Danube River Enterprise Pollution Reduction Project - DREPR project (2006-2010) is financed under the GEF-WB Investment Fund for Nutrient Reduction in the Black Sea/Danube Basin and implemented in the regions of Požarevac and Šabac in Central Serbia, and Novi Sad and Vrbas in Vojvodina. The Project's main objectives were introducing good agricultural practices and promotion of environmental protection, in addition to protection of the Danube River water flows and its tributaries from nutrient pollution. According to WB and MAFWM data, with more than one hundred farmers enlisted for project activities, the project falls into the category of the most successful agriculture related projects in the Republic of Serbia, http://archive.iwlearn.net/www.drepr.org/indexeng.htm.

In HNV agricultural areas priority should be given to the agri-environment measures supporting farmers in conservation of natural resources and agro-biodiversity as well as for development of extensive production [38; 40].

The Law on Incentives in Agriculture and Rural Development (Official Gazette of RS, 10/13) provides support for agri-environment measures and obliges the incentives' beneficiaries to respect the regulations governing standards of environmental quality and public health, animal and plant health, and animal and agricultural land welfare.

The National Rural Development Programme 2011-2013 (Official Gazette of RS, 15/11) provides during this period only the budget support for organic farming[16] and preservation of indigenous breeds of domestic animals, while introduction of other agri-environment measures, similarly as done in EU RDP, is expected in the next programming period.

Similar to the above-mentioned Manual of good agricultural practices, even in this case the initiative has been taken by foreign organizations and donors, so within IUCN Project *Support for Agri-environment Policies and Programming in Serbia* (2008-2010) it was made the publication *Developing a National Agri-Environment Programme for Serbia*, in which it is proposed to provide support schemes for:

- keeping of autochthonous breeds on the mountain, sandy, salty or wetland grasslands,
- restoration of traditional mountain pastoralism in protected areas,
- restoration and management of HNV grassland and maintenance of habitats of protected species in arable land of Important Bird Areas,
- conversion and production by organic method, maintenance of traditional orchards, and crop rotation and soil erosion control for protection of land and water, in the entire territory of the country.

These measures are vital for the preserving of agro-biodiversity, erosion protection, conservation of water quality and carbon sequestration [5].

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[16] Organic production (areas in the organic status and in the period of conversion), including areas used for the collection of wild berries, mushrooms and medicinal herbs, according to recent research (2012) is taking place in Serbia on 829,000 hectares. Almost 11,100 ha of those areas is agricultural land under orchards (46.4%), field crops (41.3%), meadows and pastures (7.6%) and vegetables (4.8%) [29]. Organic livestock husbandry is still a large unused opportunity of Serbian agriculture [23], while it is encouraging tendency of a growing number of animals in conversion period [29].

The Law on Water (Official Gazette of RS, 30/2010) is following the requirements of the EU Water Framework Directiveand defines the principle of integrated water resources management at the level of the river basin[17], on the principle of sustainable development. Integrated water management involves the maintenance and improvement of the water regime, provision the necessary amount of water of the required quality for different purposes, protection against pollution and protection against harmful effects of water. Operationalization of the water management measures is done by the long-term and annual programmes for the respective water districts, at the national, provincial and local level.

Agriculture is directly interested in participating in the implementation of measures related to the following: flood control and the harmful effects of erosion and flood, utilization and quality control of water used for irrigation, and the protection from pollution of the surface and groundwater, including the transboundary impacts. The irrigation management, or rather the reform of irrigation management system is particularly important for agricultural development in the conditions of climate changes. It implies an *integrated approach of technical and managerial upgrading of irrigation schemes combined with institutional reforms*[18] *with the objective to improve resource utilization (labour, water economics, environment) and water delivery service to farms* (FAO Concept of Irrigation Modernization[19]) [17].

The Republic of Serbia concluded with the IBRD/IDA Development Credit Agreement (2005) and Additional Financing Loan Agreement (2007) for financing *Irrigation & Drainage Rehabilitation Project* (P087964) in 2005-2013. According to Implementation Status & Results Overview (June 2012), major bottleneck occurs in relation to the transfer of competencies from the public water companies to water users associations (WUAs) [59].

The Law on Water provides possibility of establishment the ***water users' associations*** in accordance with the special law, made by the interested parties in the melioration area or part thereof, in order to ensure the conditions for the various uses of water and protection from the

[17] According to the Law on Water, the *water district* consists of one or more neighbouring river basins and sub-basins or their parts on the territory of the Republic of Serbia, together with associated groundwater.
[18] Irrigation Management Transfer is defined by FAO as the (full or partial) reallocation of responsibility and authority for management of irrigation systems from government agencies to non-governmental organizations such as water users' associations (WUAs) at irrigation system or subsystem levels.
[19] The irrigation modernization refers to both irrigation and drainage related actions.

damaging effects of water. Work on drafting legal documents that will regulate WUA's functioning are on-going, but with significant delays. It is expected that by these documents it will be enables even the establishment of the Federations of the water users' associations (FWUAs), given the experience of neighbouring countries with a developed network of WUAs, according to which better irrigation services and participation in decision making will only be possible by federating WUAs at scheme level and preparation for future steps to provide representation in the river basin councils, as basis for real irrigation management decentralization. Experience in the region are in favour of the establishment of multifunctional WUAs, that would, among other things, take care on the sustainable use and protection of land and water (drainage, flood protection, anti-erosion measures) [55].

In that case, these associations could cover to some extent even the measures of adaptation to climate changes in agriculture, and in this direction there should be encouraged their activation and strengthening as soon as possible. FAO experts recommend land users to organize in ***Local Resource Management Groups (LRMGs)***, supported by off-site land specialists from extension, university and R&D institutions, NGO, government and international organizations. ***Participatory land-use planning*** then becomes interactive, mutual learning process, based on scientific knowledge from government and off-site specialists and the experience and traditional knowledge of local land users. To be fully effective, LRMGs should be legal entities with a recognized mandate [18].

CONCLUSIONS

Irrespective of the form of institutional organization, the sustainable and climate-smart agriculture and management of natural resources in agriculture require the ***site-specific approach*** [39] and active participation of local stakeholders in the planning and implementation of measures within a defined ***strategic framework at the national level*** together with provided support of scientific and research sector, extension and advisory services as well as the budget and financial institutions.

Serbian agriculture has long been operating without a strategic development document. Given that the activities on the strategy of agricultural development in Serbia for the period 2014-2024 are underway, this is a good opportunity for an inclusion of the climate changes' items and defining the ***sectoral adaptation plan*** in the text of the new Strategy of agricultural development, using the multi-sectoral approach and synergy effects[20] of adaptation and mitigation measures, as well as the measures of land, water and biodiversity protection.

Starting from the EU legislation and practice [3; 4] and the solutions contained in the National Communication under UNFCCC [28], possible climate change measures in agriculture to be applied at the ***local/sectoral level***, could be systematized in to the following sets: *sustainable soil management practices*, *sustainable bio-physical processes management techniques*, *technological and infrastructural solutions* and *socio-economic and policy responses*[36].

Sustainable soil management practices in climate change **adaptation** aim to prevent erosion and optimizing water resources by keeping soil moisture (management of crop rotations and crop residues, permanent vegetation cover, tillage reduction methods, green infrastructure maintenance and afforestation of marginal and degraded agricultural land).

Sustainable bio-physical processes management techniques foster resilience to changing vegetative cycle, heat stress and water shortage, and pest and disease risk (compliance of sowing dates and pesticide and fertilizer treatment dates and methods and use of crops and varieties better adapted to the new growing conditions, more heat-tolerant livestock breeds and diet patterns suitable for heat stress conditions).

Technological and infrastructural solutions in adaptation to climate change include: maintenance of flood protection system, investing in new irrigation and drainage systems, improving irrigation practices and reducing water losses; investing in ventilation and cooling systems in animal shelters and equipment for protection of orchards from wind, heal and frost damage; adaptation of crop varieties using existing genetic diversity and biotechnology improvements; climate and pest and diseases risk monitoring and modelling, development of early warning systems of droughts and other extreme weather events, use of integrated pest management, and agricultural advisory and RHMS agrometeorology service capacity building.
Socio-economic and policy responses to climate change imply: diversification of farm activities, development of risk and crisis

[20] With careful management of potential trade-offs.

management, yield insurance instruments and climate, water and other agro-environment payment schemes, land use planning, adoption of sectoral adaptation plan, improved intersectoral cooperation and public awareness.

In the area of climate change **mitigation,** these sets should contain measures as follows.

***Sustainable soil management practices* -** prevent erosion and carbon losses from the soils and enhancing soil carbon levels (diversified crop rotations, permanent vegetation cover, catch crops, conservation agriculture practices, organic farming, precision farming, traditional agriculture, grassland improvement, restoration of wetlands and peatland and afforestation of marginal and degraded agricultural land).

***Sustainable bio-physical processes management techniques*-** reduce methane and nitrous oxide emissions (efficient nutrient cycling and manure management, improved diet patterns of animals).

Technological and infrastructural solutions are directed to the use of biomass supply and anaerobic treatment of animal manure for renewable energy purposes.

Socio-economic and policy responses aim to diversify farm activities and develop climate agro-environment payment schemes and capacity building relating to Kyoto Protocol's Clean Development Mechanism (CDM) projects implementing and financing.

Implementation of the measures aiming at adaptation and mitigation of climate changes at the farm level usually results in an initial decrease in revenues, i.e. it requires some investments and time for pay-back of invested funds. If in the interim period there is no any government support, motivation of farmers for participation in the programs of adaptation and mitigation is being reduced. Subsidized loans for the purchase of equipment and inputs, subsidizing of the crop and livestock insurance, support for strengthening of the producers’ associations [57], as well as the solving important items in domain of land tenure [37], would greatly help the farmers to take care, in a new and better way, about conservation of natural resources in the conditions of climate changes.

An awareness of farmers that stewardship of natural resources is in their own interest, i.e. in the interest of preserving the conditions for sustainable development of agricultural production in the future, has existed for the centuries. Farmers have always cared about the land, water, plants and animals, on the farm and in close environment, and they have adapted to climate conditions. But, the changes become too complex and transition too exhausting, so it become necessary for the farmers the stronger institutional and financial support of the state, as well as the technical assistance of science and extension advisors.

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