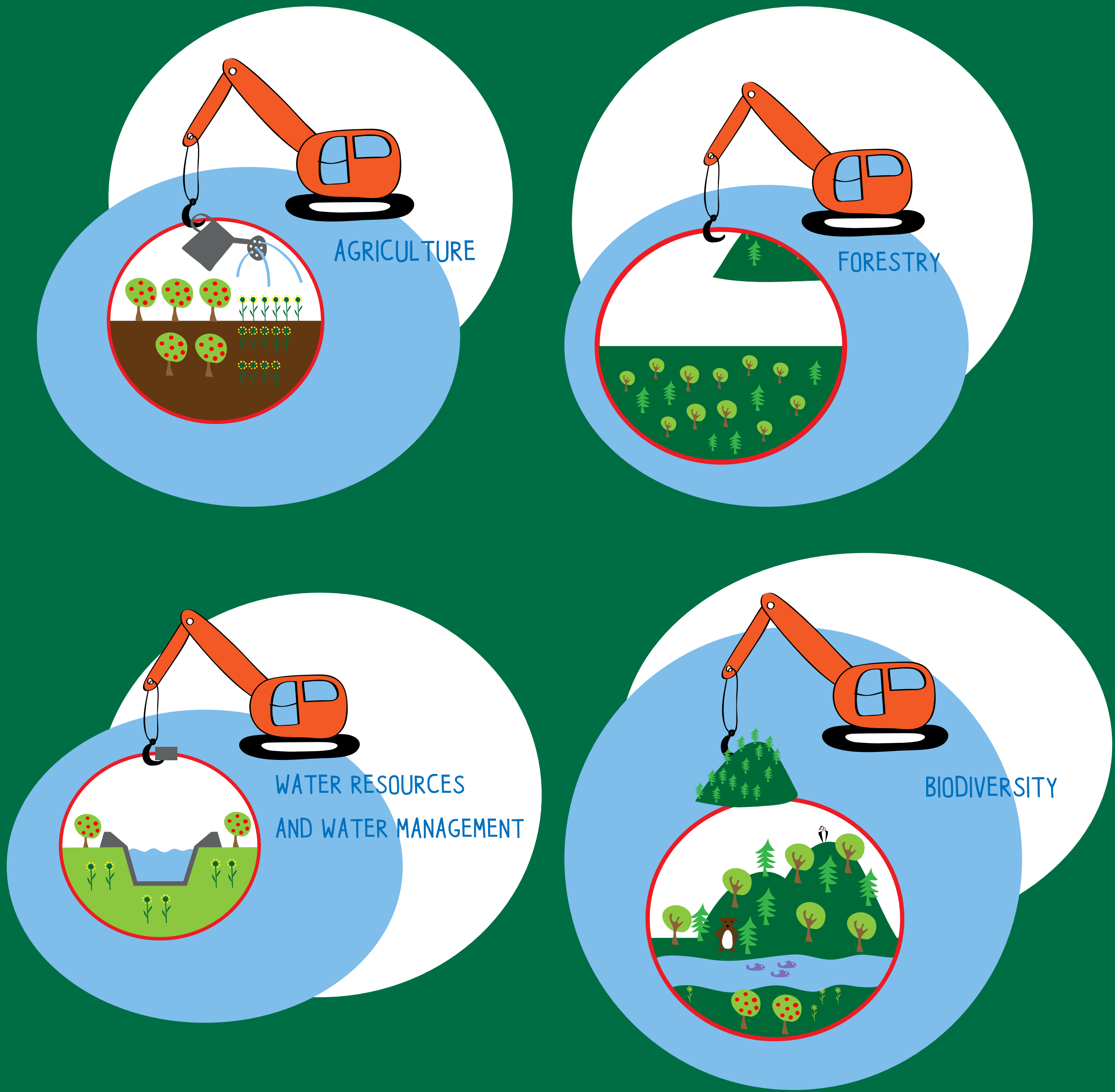

SERBIA'S FIRST NATIONAL ADAPTATION PLAN

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Introduction

Climate change as a consequence of anthropogenic activities, primarily by means of increasing the concentration of greenhouse gases in the atmosphere can now be unambiguously detected and quantified through measured changes in many aspects of the climate system. Based on numerous studies, analyzes and reports, it is clear that today broad agreement exists on the far-reaching consequences if the global community fails to achieve future changes within the limits necessary for continued development of our global society. The long-term goal of the international community is to limit the rise in mean global temperature to 2 ° C above pre-industrial levels by means of significant reduction in greenhouse gas emissions. Observed climate changes lead to changes in the environmental, social and economic indicators, i.e. to changes in the overall conditions in which contemporary society lives across the globe and also in Serbia. It is believed that if further changes remain within the limits which have been determined as the goal, the mitigation of negative consequences will be possible through the appropriate and timely measures of adaptation to changing climatic conditions. On the other hand, in the case of continued uncontrolled rise in global temperatures and changes in other elements of the climate system, the consequences will be on a significantly higher scale, while adaptation will require additional efforts and additional financial investments, which can significantly slow down and hamper the progressive development of society. The aim of adaptation is to reduce the potential negative effects of climate change via planned change in the natural and socio-economic systems and to maintain the functioning of the system, or if possible, to improve efforts where such potential exists.

The United Nations Framework Convention on Climate Change (UNFCCC) recommends the elaboration of National Adaptation Plans (NPA) as one of the efforts to plan for the adaptation to climate change. The process of developing an adaptation plan should ensure the assessments of vulnerability and risk in relation to future climate change and, based on those assessments, define possible options for adaptation and, in particular, identify measures related to medium and long-term needs. National Adaptation Plans should improve existing reporting on the process of formulating and implementing adaptation measures and contribute to integrate that adaptation into relevant social, economic and environmental policies and actions. The methodological preparation of the NPA will primarily follow the methodology defined by the instructions of the United Nations Convention on Climate Change.

General goals and objectives include:

- The synthetic analysis of future risks and vulnerabilities in selected sectors (water resources, agriculture, forestry and biodiversity), compared to scenarios of future climate, as outlined in the First and Second Report of the Republic of Serbia under the UNFCCC, which will allow the identification of priority adaptation measures, primarily those characterized as no-regret and low-regret measures. In the selection of adaptation measures, one of the criteria will also be ensuring synergies between the future development of the sector and proposed measures.
- A synthetic review of the proposed adaptation measures in sectors that have been identified as the most vulnerable, as well as the analysis of possible progress in the implementation of these measures which have been proposed in the First and Second National Report of the Republic of Serbia under the UNFCCC.
- The assessment of loss and damage as a result of long-term changes in climate conditions in Serbia, and as a result of weather and climate extremes, whose intensity and frequency can be associated with the observed climate change over the past decades. Estimates of the losses and damage will be based on documented events and published analyzes and reports.
- Proposal for priority adaptation measures and corresponding analysis of their successful implementation in the future. Analyses of individual adaptation options in addition to, if possible, the direct economic benefits, will be based on non-economic indicators (e.g. in the field of biodiversity) as well as the potential social benefits of their implementation.
- Identification of opportunities and constraints for the integration of adaptation measures in the applicable sectorial strategies, but also in other relevant national plans.

Observed Climate Change

During the period 1960-2012 in Serbia a significant increase in mean daily temperature was observed with an average temperature increase of 0.3° C per decade. The dominant trend of increase was recorded for the period June-July-August, at 0.57 ° C per decade. After 1990, in only four years the negative anomaly of mean annual temperature was reported, and eight out of ten warmest years were recorded after the year 2000. The statistically relevant trend of precipitation was recorded at just a few meteorological stations. On the annual level, most stations showed a positive trend (17 out of 25 analyzed stations), but only two stations recorded a significant positive trend, while the other stations showed a negative trend in precipitation. The average trend for the stations with positive values is 12.47 mm per decade, and the average trend for the stations with negative value trends is -6.8 mm per decade. Although there are no significant trends in the quantity of precipitation in Serbia, we must emphasize the fact that Serbia has faced several serious precipitation trends since 2000. The most prominent were those recorded in 2000, 2003, 2007, 2011 and 2012.

Analysis of climate extremes also shows that in recent decades there have been significant changes in the frequency and intensity of extreme events, particularly those extreme events which are the result of high temperatures. Concise conclusions of changes of extreme values in Serbia are:

- A significant increase: summer days on all stations with an average rate of 5 days per decade since 1960; tropical nights at most of the stations, an average of 1 day per decade; Monthly maximum values of daily maximum temperatures and monthly maximum values of daily minimum temperatures at a large number of stations; duration of heat waves, on average 4 days per decade;
- An increase at most stations, but not significantly, of the length of the vegetation period, on average 4.5 days per decade;

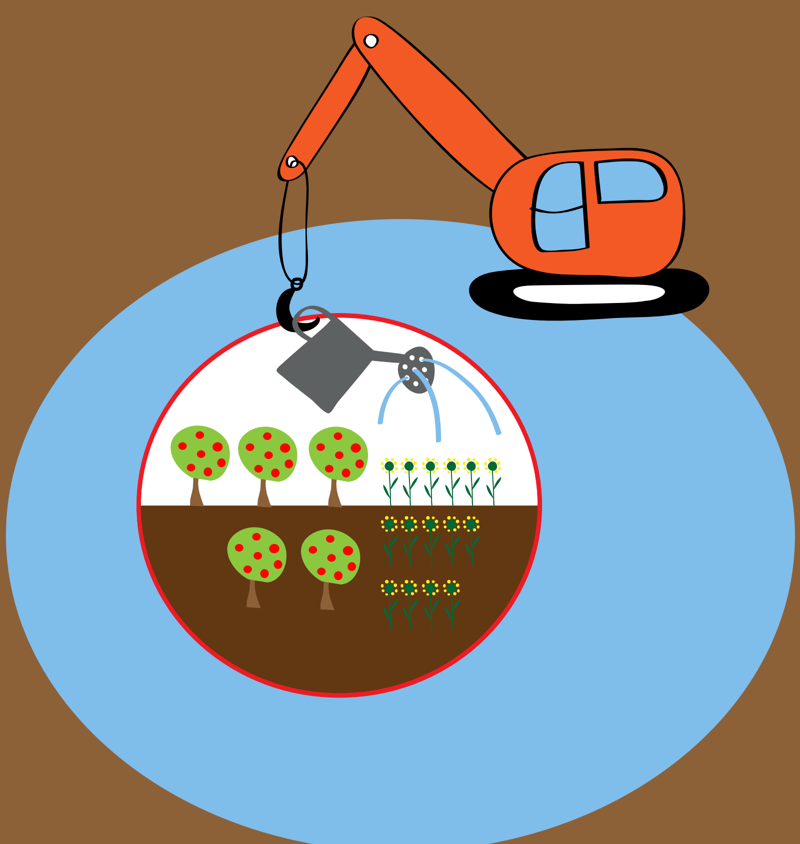
- A reduction at most stations, but not significantly, in the number of frosty and icy days, on average 2 days per decade for frosty days and 1 day per decade for icy days;
- An increase at the majority of stations, but statistically significant only at a few, of the indexes of strong and extreme precipitation: the number of days with an accumulation of more than 20 mm, and accumulated precipitation exceeding the 90th and 99th percentile, with an average of 0.3 days per decade, 10 mm per decade and 6.5 mm per decade, respectively.

Scenarios of climate change

According to both scenarios, A1B and A2 outlined in detail in the First and Second report of the Republic of Serbia under the UNFCCC that predict further increase in greenhouse gas concentrations in the atmosphere, which would be close to growth trends observed in recent years, by the end of this century, we can expect further rises in temperature. During the period 2011-2040 and 2041-2070 the increase in temperature is higher in the A1B scenario, 0.5-0.9 ° C and 1.8-2.0 ° C respectively, than according to the A2 scenario, 0.3-0.7 ° C and 1.6-2.0 ° C, but by the end of the century, (2071-2100) the change in temperature obtained by scenario A2 is in the range of 3.6-4.0 ° C and exceeds the value obtained by scenario A1B, which ranges from 3.2-3.6 ° C. Warming is the most pronounced during the summer and autumn seasons. The change in precipitation under both scenarios compared to the base period 1961-1990 was positive during the period 2011-2040 and is reduced according to negative values over the entire territory of Serbia by the end of the century. According to the A1B scenario, over the course of three periods, 2011-2040, 2041-2070, 2071-2100, changes in annual precipitation range from + 5% to -20% up to the end of the century. According to the A2 scenario, changes range from + 20% to -20%. The possible deficit is the most pronounced during the summer season. The precipitation deficit is higher in the A1B scenario during the period 2011-2070, while in the period 2071-2100 the climate is drier in the A2 scenario. These results fit in with the possible extent of changes in the territory of the Republic of Serbia, which was obtained on the basis of results from the database of the European project ENSEMBLES.[1]

[1] ensembles-eu.metoffice.com/docs/Ensembles_final_report_Nov09.pdf

AGRICULTURE



Agriculture

In the area of agricultural production, which accounts for about 10% of the total gross domestic product of the Republic of Serbia, the entire national economy is very sensitive to all factors that affect agriculture. According to statistical data from 2011, the Republic of Serbia has 5,096,000 hectares of utilized agricultural land and 3,294,000 hectares of arable land. Overall, agricultural production is concentrated in private households. Private farms process about 89% of agricultural land, or 80% of arable land. On the other hand, most important producers are large farms, which represent the foundation for large processing capacities. There is no doubt that climate change will affect the quality and quantity of yields of major crops in Serbia, as well as the variability of yield which will be more pronounced each year. Plant production in the area of the Republic of Serbia mainly takes place in conditions of natural water supply and the natural variability of weather conditions during the year (except for production in protected areas), which is most frequently the main cause of high variability (instability) of yields between individual years. According to climate change scenarios, which predict a further rise in greenhouse gas concentrations, we can expect more frequent occurrences of extreme weather conditions, drought and then reduction of the amount of summer precipitation in particular, the increased number of dry days and days with extreme temperatures in the individual sub-periods of vegetation (high spring and summer temperatures), warmer winters with a lower number of frostless days. In such conditions the most efficient adaptation measure would be irrigation; however, it is also the most complex of measures, which presupposes the existence of sufficient funds for investment in appropriate systems. Therefore, intensive studies are conducted and introduced in preventive and alternative ways in the production process to combat extreme weather conditions. Through customed agricultural techniques and the application of complex agro-technical measures, it is possible to mitigate, though not completely exclude the negative impacts of climate change on the yield of cultivated plants.

The impact of climate change

In recent years, agriculture in Serbia has suffered significant losses due to adverse weather conditions and distinctive climatic anomalies. The most important include the damage arising from the effects of drought, spring frosts, hale, storms and floods. Since 2000, Serbia went through several episodes of severe drought, which resulted in significant losses. Extreme droughts were recorded in the years 2000, 2003, 2007, 2011 and 2012. According to the data for 2007, by region, the damage from drought ranged from 10% in Bačka, Srem and Mačva, up to even 90% in Nišava, Toplica, Pirot, Jablanica and the Pčinja district. Although rarely characterized as drought, lack of precipitation in the period from October to February may also adversely affect the yield of winter crops, such as sugar beet, rapeseed and others. Furthermore, during the vegetation period high temperatures and the higher intensity of solar radiation also have significant adverse impacts. They cause damage to the fruits and leaves, but also to the trunk and the bark of trees. These changes were observed especially during 2007 and 2008.

On the other hand, the emergence of a very warm period during the late winter and early spring, followed by freezing temperatures and frosts, is especially dangerous for the early varieties of fruits as well as vine and some agricultural crops due to early start of the growing season, which becomes interrupted by low temperatures. Table P.1 shows the effects of devastating spring frosts in the last decade in the territory of Vojvodina. While in 2002 the greatest damage was suffered by apple tree, pear trees and vineyards, in 2003 the most vulnerable areas were sugar beet fields.

Table P.1 Damage from spring frosts in Vojvodina in 2002 and 2003 expressed in hectares of affected areas (Source: Provincial Secretariat for Agriculture, Water Management and Forestry).

Year	Apple	Pear	Apricot	Peach	Vine	Sugar beet	Cherry	Walnut	Plum	Quince	Total
2002	4236.12	772.0	897.70	1476	2091.8	1630	319.5	94	239.5	27	13785.6
2003	2160	320	125.4	547	1493.5	33669	87.5	79	75.5	24	40583.9

Impacts of possible future climate change to agricultural production in Serbia will be reflected in an increase in the length of the vegetation period and move the start of the growing season towards earlier dates even up to 20-30 days as we approach the year 2100, which will significantly affect the planning of production and time available to work in the field. Warming will affect the phenology of plants, leading to faster development. The consequence of this will be reflected in a reduction in yield, unless the varieties adapt to high temperature (change in maturity groups). Dry periods will have the greatest impact on the yield of spring crops that are not irrigated. In soils with low water capacity potential yield will be reduced. On the basis of studies that have been presented in the Second National Report on Climate Change expected changes in corn yield according to scenario A1B for the period 2001-2030 have a variable character depending on the region. Under the A2 scenario for the period 2071-2100, the expected reduction in corn yield ranges from -52 to -22%. The same survey showed that irrigation can reduce the loss of maize yield up to 31%. In addition, according to the A2 scenario for the period 2071-2100, changes are expected in the yield of winter wheat, and the greatest relative change of the yield is obtained in the central region with up to 6%, while a reduction in yield is expected only in the south of Serbia with up to -10%. In these altered climatic conditions, thermal stress and lack of precipitation can adversely affect the yield and quality of many agricultural crops, vegetable and fruit crops. This may be manifested through reduced soil fertility, the occurrence of pests and diseases, the occurrence of sunburns, water stress, etc. Certain changes in the areas and changes in time and intensity of diseases and pests are expected on the basis of anticipated climate changes in Serbia. A particular challenge for the protection of plants in the coming decades will be to fight against fungal diseases and pests, as well as the corresponding viral diseases. The effect of climate change increases the complexity of integrated pest management. In the case of small grains according to current scenarios, climate change could lead to the domination of the pathogens for the development of which higher temperatures are required or pathogens that can quickly adapt to drought conditions.

Adaptation measures to climate change in the agricultural sector

In the Second National Communication of the Republic of Serbia [1], a series of adaptation measures to changing climatic conditions was listed for the agriculture sector. This report will analyze in more detail the measures relating to the reduction of risks in the changed climatic conditions, as compared to the observed trends of the past decades, as well as in relation to the projections of future climate under various scenarios. The measures whose implementation will be analyzed are:

- Irrigation, through a general future development of irrigation;
- Drainage and maintenance of water management facilities;

- Adaptation of the technology of crop and seedling production (adjustment of agro-technical measures)
- The use of short-term, monthly and seasonal weather forecasting in agro-meteorology.

Analysis of the measures proposed

Irrigation

The position of agricultural land in terms of topographical and climatic features in Serbia have through the historical period created conditions for over moisturizing more than a problem of drought, so that the construction of a system for drainage has had a priority over irrigation. Crop production has developed undisturbed with a steady increase in the yield since the 1960s, not due to favorable climatic conditions, but due to the application of mineral fertilizers and plant protection products. However, the incidence of severe and extreme droughts in recent years in the territory of Serbia has been very common [2,3,4], so that irrigation is imposed as a measure to mitigate losses, in addition to the introduction of new hybrids and varieties tolerant to drought or by using other methodologies which help achieve a more efficient use of water.

Irrigation in the climatic conditions prevailing in our country is an optional measure, because crop production can take place relatively successfully with the available natural supply of water, especially when it comes to agricultural crops. Users are not obliged to use any or to pay expenses related to irrigation, even though they have that option. That problem can be twofold: the monetization of bringing water to the plot and the profitability of irrigation on the land if there are not enough interested farmers for irrigation. Previous studies [5, 6] have shown that irrigation can be profitable if at least 60% of the total number of owners/users use the irrigation system in the irrigated area. One of the potential problems is system management. In many countries the management of a single system of irrigation is accomplished through an association of water users. Unfortunately, in our country a Draft Law on Water Users Association is only in the process of public debate [7]. It is also thought that the price of water for irrigation in Serbia is low. The price of the raw water is low, but when the water has to be transported several kilometers and placed under pressure, in that case the price of water in Serbia ranges from 0.08 to 0.23 euro / m3 [8], which is more expensive than in Italy or Greece, our competitors in the fields of fruit and vegetable production where the price is 0.09 eur / m3 – and the price in case of case of pumping is 0.11 eur / m3 [9, 10]. The complexity of irrigation is also reflected in the fact that the method of irrigation must be adapted to the given topographical and soil conditions, as well as for the requirements of plants for water and crop rotation. The amount of water available for irrigation determines the potential irrigation area, and water must be of a certain quality to ensure the production of safe and healthy food and the long-term sustainability of soil quality. In addition to all the natural conditions, the requirement of economic profitability must also be met. Namely, the irrigation system provides an increased volume of production but requires increased investment of up to 30% [8]. For this reason, a detailed analysis of cost-effectiveness in specific areas is required, as well as an analysis of the existence of infrastructure for transporting raw materials to the production site and finished products from the site, as well as an analysis of the existing market that would be able to buy off and process the crops, which requires the analysis of the structure of registered agricultural producers, an analysis of plot size, analysis of plant production, and processing capacities.

The agricultural census of 2012 [11] found that in the Republic of Serbia:

- The total irrigated area amounts to 99,804ha;
- Most irrigated crops are vegetables, watermelons and strawberries (outdoor), whose irrigated area is 64% of the total area under these crops;
- 61% of users stated that the main source of water for irrigation is groundwater;
- Surface - gravity irrigation is applied by 65,303 households;
- Sprinkler systems irrigation is used by 13,174 farms and the drop by drop method (drip irrigation) is used by 29,323 households;

- The municipality with the highest share of irrigating households is the agricultural land Bosilegrad (73%).According to the census in all regions, the most watered crops are vegetables and after that fruit seedlings (Tables P.2 and P.3). The most watered field crops are sugar beet and cultures for seed production such as maize hybrids, soybean, sunflower, sugar beet, and watermelon. The highest percentage of irrigation is recorded in the Belgrade district, primarily because of the possibility to sell fruits and vegetables to a large market. Another reason is to facilitate access to professional staff, design companies, and a greater supply of irrigation equipment.

Table P.2 Irrigated areas (ha) in Serbia according to the 2012 census

Region	Total	Ploughland and gardens	Orchards	Vineyards	Meadows	Other seedlings	% out of the total area
Belgrade	6109	4581	1438	8	12	70	4.5
Vojvodina	58251	52907	5050	89	22	183	3.6
Šumadija and Western Serbia	21173	15031	5254	70	368	450	2.1
Southern and Eastern Serbia	14271	12339	1603	48	200	51	2.1
Total	99804	84858	13345	215	602	745	

Table.P.3 Percentage of cultures in the irrigated areas

Region /cultures	Agricultural and other cultures	Vegetables, melons, strawberries	Fruit seedlings	vinezards	Other
Belgrade	27.4	47.5	23.5	0.1	1.5
Vojvodina	31.0	59.8	8.7	0.2	0.3
Šumadija and Western Serbia	25.3	45.8	24.8	0.3	3.8
Southern and Eastern Serbia	36.1	50.6	11.2	0.3	1.8

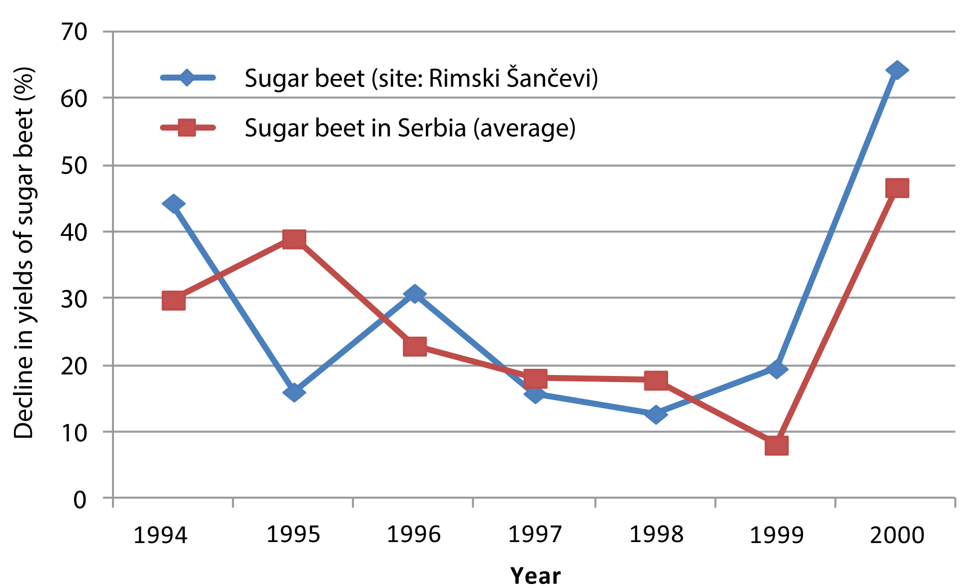
Damage Assessment

Based on the analysis of decline in yield for the period 1980 - 2000 using the CROPWAT model [12], it was determined that the soil reservoir plays a very important role in the produced yield, especially in rainless periods in Serbia. The assessment of decline in yield determined that the highest decline occurs on sugar beet and maize at

5 - 70%, and in extreme years up to 80%., which was confirmed by the data obtained in other surveys [13, 14, 15, 16, 17]. In the case of sunflower and soybeans, it is evident that these cultures are more tolerant of drought. Decline in yield of sunflower range from 0 - 40% and in soybeans from 5 - 50%. On the other hand, the impact of drought on fruit plantations has a double effect. Namely, the drought episode from one year has a predominant influence on the yield in the following year as well. However, due to other effects that can affect yield, such as the onset of late spring frosts and the emergence of strong winter frosts, it is not easy to determine the extent to which drought affects the drop in yield. By some estimates, the impact of drought on the reduction of fruit yields, for example in the Zajecar district, varies from 33 - 77% by [18]. We can state with great reliability that a high-quality yield cannot occur without irrigation in most parts of Serbia, nor the regular yield each year.

Based on this knowledge, the assessment of direct tangible losses due to drought was made for the entire territory of the Republic of Serbia for the period 1994-2014. The yield from 1991 was taken as a reference year as it was a very favourable year in hydrological terms [12, 14] when the highest yields of wheat, corn, sugar beets and soybeans were achieved, while the year 1986 was taken as the reference year for sunflowers for the same reason. Given that vegetables in our conditions cannot be cultivated without irrigation, only beans and potatoes were selected for analysis because they are the only crops that can grow without irrigation. 1986 was also taken as their reference year. In the analyzed period the estimated reduction in yield varied from year to year: for wheat from 1 - 40%, for maize from 1 - 60%, for sugar beet 1-47%, for soybeans 1-54% and for alfalfa and clover up to 35%. The values obtained were compared with estimates based on experimental studies [14, 15, 16, 17, 18]; the basic trends generally coincide, and the percentage of reduction in yield is slightly different. Figure P.1. shows the decline in sugar beet yield in the area of Rimski Šančevi compared to the estimated average for Serbia.

Fig. 5 Comparative trend of decline in yields of sugar beet in the area of Rimski Šančevi compared to the estimated average for Serbia



In some years, wheat showed a different trend compared to other cultures, because its vegetation period is much longer, so that the yields are also affected by autumn-winter and spring drought. In potato and beans a drastic reduction occurred with the increasing degree of drought. The yield of beans in the last decade decreased steadily from 55 - 70%, and the potato yield decreased over 40%. Such a drastic reduction in the yield of beans due to drought conditions was also reflected in a decrease in the market, which led to a constant rise in the price from 27 RSD in 1999 to 67 RSD in 2000, and from 136 of RSD in 2011 to 260 RSD in 2012. Finally, the total estimated annual direct losses were obtained as a product of the estimated annual decline in yields and total production value of each culture (total yield multiplied by the price per kilogram) for the corresponding year. The values of total production and average purchase prices for each crop per year are taken from the database of the Statistical Office. Final estimates are converted into USD based on the exchange rate movements during the observed period (Table P.4).

Table P.4. Assesed direct damage to major agricultural crops, potatoes and beans (in 1000 USD)

Year	Wheat	Maize	Soybeans	Sunflower	Sugar beet	Potato	Beans	Total
1994	66632	190636	9025	16032	25744	35627	9018	317105
1995	35161	82881	3977	12579	23665	9518	3052	161317
1996	97854	245027	11277	30387	26967	33682	11167	422684
1997	89977	115331	2611	28260	16230	13658	20187	272598
1998	52041	126593	9317	17242	9787	18999	15346	230327
1999	66461	158665	0	26569	6026	33398	29573	287296
2000	41340	125382	12134	8793	12335	36989	5233	205219
2001	53661	139934	4311	12509	3239	0	17726	231380
2002	75326	113792	4191	14683	6242	2282	20558	234792
2003	103997	221866	18864	22761	22157	46804	19753	409398
2004	14893	82291	0	6566	0	0	20034	226692
2005	31099	0	0	20272	0	0	13079	64450
2006	50733	0	0	15767	899	0	15991	83390
2007	89038	306793	27083	34114	14706	0	19492	491228
2008	33402	8577	12693	7333	0	0	19956	81961
2009	36829	0	12450	3768	0	0	15953	69001
2010	81404	0	0	21039	0	0	11771	114213
2011	43378	0	0	588	0	0	11679	55644

2012	71261	337345	69415	44384	26095	0	11921	560420
2013	29788	0	18805	0	0	0	21677	70270
2014	60264	0	0	0	0	0	18475	78739
Total	**1224541**	**2255114**	**216154**	**343647**	**194092**	**230957**	**331640**	**4668125**

Based on this analysis, the direct damage caused by low yield as a result of drought from1994 amounted to 4.6 billion USD, which can be considered a lower limit of estimates because the analyzed cultures are grown only on 43% of the total agricultural land. Certainly the most affected culture is maize with an assessment of direct losses of 2.2 billion USD. Also if we add the fact that the analyzed data for alfalfa, melons and legumes, which are also highly sensitive to drought s well as the fact that due to lack of data the damage to fruit plantations are excluded, it is clear that the direct damage is far greater than what the figures above show.

The need for irrigation under future climatic conditions

Studies of climate change impacts on the requirements of crop norms for water and irrigation for the coming period of 2010 - 2100 has not been extensively conducted in the area of the Republic of Serbia. Detailed analysis [20, 21] of the possible impact of climate change on the change in yield of several strategic cultures such as wheat, maize, soybeans and sugar beets are given in the Second Report of the Republic of Serbia to UNFCCC. As a complement to the results presented in the Second National Communication, we will here display the AquaCrop model for scenario A1B, A2 [22] which estimated the impact of climate change on yields and requirements of sugar beet for water during the periods 2010-2039, 2040-2069 and 2070- 2099. The research results clearly indicate that the areas of Vojvodina and Central Serbia in the first period there will be no decrease in yield under any scenario, but rather an increase can be expected. In the second period, the declines in yield are observed in both scenarios. Irrigation in all scenarios significantly increases yield, but the yield increase is more pronounced in Central Serbia. If the optimal irrigation norms are to be used, the yield could be increased from 57-97% in Vojvodina and from 77-285% in Central Serbia. Considering the fact that due to the drier climate a decline in the flow of the rivers can be expected, it will be necessary to apply the reduced irrigation norms. Under such conditions in the A2 scenario, on the territory of Central Serbia water could be saved, but it would lead to a decline in yield. To achieve high yields, it is necessary to provide from 300 to 500 mm of water per m2, and on the territory of Vojvodina from 300 to 420 mm / m2, with the possibility of saving about 20%. Under the A1B scenario it may be possible to save up to 80 mm / m2. The analysis of the Bijeljina area [23], which is by soil and climatic characteristics very similar to Mačva and Srem, shows that the required amounts of water under all scenarios will increase by 40-60%, while increasing yields by only up to 30%. However, in the absence of irrigation, the yield will be reduced as in the current drought conditions from 30-50%.

Recommendations for expansion

The state is indeed making efforts to create conditions for the smooth functioning of the irrigation system and the possible expansion of surfaces. In the last three years 65,548 hectares of the irrigation systems has been rehabilitated. [24] These are positive developments, but they are not enough, given the trend of climate change. The first recommended expansion of irrigated areas in the next 10 years (Table P.5) will certainly cover areas that grow vegetables, potatoes, legumes and berries. One of the reasons for the recommendation for an increase in these areas is that these cultures have shallow root systems and are grown in shallow hilly mountainous areas, so that every average dry year drastically affects the yields and quality of these crops. In addition, it is significant that potatoes and beans are basic foodstuffs and berries are a significant export resource with an existing market, so that the funds invested are repaid the quickest. No less important is the fact that households which are already using irrigation and grow these vegetables and fruits have experience in this type of production.

Table P.5. **Recommendation to increase the areas under irrigation (ha) in the next 10 years**

Region/cultures	Vegetables	Potato	Beans and legumes	Raspberries, blackberries, and other berries	Agricultural crops up to 20% of increase	Total new irrigation areas
Belgrade	2405	205	115	26	306	3061
Vojvodina	21269	3775	1925	106	1070	28145
Šumadija and Western Serbia	8417	15593	1479	13442	1230	40161
Southern and Eastern Serbia	6095	5559	1479	857	386	14380
Total	**38186**	**25132**	**4998**	**14431**	**2992**	**85747**

Although at first glance the recommended area of about 86,000 hectares for the construction of irrigation system over the next 10 years appears small, these areas are important from the aspect of the irrigation development trend in recent years. Namely, according to the data of the Agricultural Land Directorate of the Ministry of Agriculture and Environmental Protection, the increase in irrigated land is quite modest, amounting to 358 hectares in 2012, 226 ha in 2013 and 578 ha in 2014 [24]. In the course of three years, irrigation systems were constructed in a total of 1,162 hectares for 1,022 users, which means that every user is watering one hectare of land on average. An indicator that the estimates given are realistic is an example from that area, managed by the public entity Srbijavode. This planned irrigation development with public ownership of 1,550 hectares in 2015, and in the territory of Vodavojvodina is supported by the Arab Fund at 1,306,143,904 RSD [25], which according to estimates is sufficient for about 3,000 hectares. According to available data [26] the cost of the construction of irrigation systems varies from $2,626 to $11,489 / ha for gravity systems, and from $3,471 to $15,373 / ha for pressure systems, while estimated costs for the two project areas in Serbia range from 3000-5000 euro / ha [19]. The lower prices are certainly a result of using the already built infrastructure and not constructing major infrastructure facilities. Moreover, if it had been necessary to build a dam for water accumulation for irrigation, the cost would have been significantly higher. The analysis of 211 areas in Turkey where irrigation systems were constructed, shows that the average cost of construction of the irrigation system under pressure is $ 8293/ ha. Taking into consideration the topographic conditions, especially in Šumadija and South-eastern parts of Serbia, it is necessary to plan the construction of micro-accumulations and pressure systems, and in the lowland, combined systems, water inflow channels when and where it is possible, then the construction of pumping stations for water distribution and dispersal of water over the field under pressure.

If the recommendation to increase the area to 86,000 ha in the next ten years were implemented, the level of irrigation of about 5% of the total arable land would be reached. European countries which are more arid than Serbia such as Italy, Spain and Greece water about 20% of their total available agricultural land. Irrigation is an extremely complex measure, and its development is extremely slow. In addition, over the next few decades under scenarios of climate change a permanent precipitation deficit is not expected, and that would require further expansion of the system to mitigate the negative effects to the maximum. Therefore, a realistic long-term goal would be to develop an irrigation system for up to 10% of arable land.

Possible deficiencies and limitations

The main causes of the slow increase in areas that are irrigated are the following:

- Economic instability (volatility of product prices, high bank interest rates, lack of markets, reduction of livestock fund and of processing capacities)

- Inconsistency of the circumstances in agricultural policy management (frequent change of managerial staff)
- Poor infrastructure (inadequate road network and inability to plug in irrigation pumps and electricity valves)
- Available sources of water: insufficient water sources in the mountainous areas; remote waters flows - the channels in lowland areas; the problem of pumping water in real time with the already existing systems, low quantity of groundwater,
- Arranged drainage ditches (drainage of the field is a mandatory prerequisite for irrigation)
- Expert - advisory assistance,
- Supply of raw materials (high-yielding varieties and hybrids, mineral fertilizers, plant protection products, manure for the preservation of soil fertility),
- The age structure of the agricultural population.

Providing enough energy to operate the system can be a significant limitation for the current capacity of the entire energy system. Analysis of the capacity of installed pumps for irrigation in several locations and system operating hours, revealed the following assessments. It is necessary to provide engaged power of 0.64 KW/ ha i.e. for the new recommended 86,000 ha the total of 55mW (Table P. 6), which could be a significant limitation regarding the current capacity of the entire energy system.

Table P.6. **Estimated KW and KWh requirements, which should be provided for the operation of the newly constructed irrigation systems**

Size of irrigation plot (ha)	1	10	14	50	100	281	500	1400	2500	Total 4856
Flow Q (l/s)	1	10	6	40	85	180	330	770	1375	
Manometer measurement (m)	20	20	40	50	80	80	60	90	90	
System operation hours in the peak load period (h)	16	16	18	20	20	20	18	20	20	
Processing operation time in the irrigation season (h)	1250	1250	1480	1400	1400	1400	1300	1350	1350	
Pump aggregate power (kW)	0.2	2	6	20	75	150	180	1080	1600	3113
MWh	0.25	2.5	8.88	28	105	210	234	145.8	2160	420.663
Average engaged power per hectare (KW/ha)										**0.64**
Engaged power MW for 86000 ha										**55,135**

To address the requirements of irrigation from the ecological perspective, it is also necessary to provide for the intake of enough organic matter to maintain soil structure, which is the basic element of fertility. Through irrigation, the mineralization of the organic matter in the land is conducted more intensively so it is subject to impoverishment and conversion into deserts. To prevent this, it is necessary to ensure the application of manure. The optimal amount of manure per hectare is provided by 2 large cattle (ox, horse). The European average is 1 cap, while in Serbia it is only 0.3. So, preserving the land with irrigation use requires the development of animal husbandry, especially near irrigation fields.

Dewatering

The total agricultural area affected to a lesser or greater degree by internal waters is 3,000,000 hectares, which represents about 80% of arable land. Thus, almost the entire primary agricultural production depends on the performance of drainage systems.

According to data from the Water Master Plan [27] the constructed drainage systems cover an area of 2,010,882 hectares. According to the same document, in order to finalize all amelioration works, it is necessary to build additional drainage systems on 997,647 hectares. According to the preliminary version of the Strategy for water management in the territory of the Republic of Serbia [28] for a period of 20 years (2015-2034), the field of drainage improvement is foreseen to be achieved primarily through adequate effort to ensure the functionality of existing systems, primarily adequate regular and investment maintenance, followed by the rehabilitation and upgrading to the projected performance.New systems should be constructed primarily on Class 1 drainage land, approximately on 100,000 hectares, i.e. 20% of still vulnerable areas. Construction should be implemented together with measures for land consolidation. By bringing the drainage system to the designed state and by the construction of new systems on the priority areas that have been registered, the negative effects of the absence of these measures would be reduced to a minimum on one hand, and on some sections of the channels it would create the possibility of water abstraction for irrigation.

The costs to maintain inland drainage waterways across the territory of the Republic of Serbia for 2014 are given in Table P.7 as along with the necessary expenses to maintain internal waters to the extent to which the drainage systems are dimensioned [26, 29, 30, 31, 32]. According to the planned program of the public entity "Vode Vojvodine" in order to provide 100% of maintenance by the standards in 2015, the amount of 3.57 billion RSD is needed, and that will provide the statutory minimum of maintenance and protection from flooding from inland waterways (20,700 km) only if all ongoing maintenance activities are completed. According to the estimates of the revenue, only 59% of the required work will be completed [29].

Table P.7. **Invested and required resources for the maintenance of drainage systems in the Republic of Serbia**

Water area	Regular maintenance costs (RSD) 2014		Realized investment maintenance (RSD)	Required in 2015
	Realized	Required		
Srbijavode	206.378.316	880.600.868	94.917.066	897.993.721*
Vode Vojvodine	945.200.000	3.656.621.937	1.294.814.000	3.566.310.828
Beograd vode	125.860.591	500.000.000	-	2.000.000.000*

* Regular and investment maintenance

For the planned program of "Srbijavode" for 2015 [30] the estimated costs of regular and investment maintenance are not sufficient, so that despite the planned maintenance the overall functionality of drainage system will be reduced, because maintenance will only be carried out in places of absolute priority. Although this program does not include the estimate of the required scope of work and resources to place the system at a baseline condition, i.e. a state of design which would enable full functionality, in 2013 studies were conducted in which it was stated that it was necessary to provide 975,517,935 RSD, and the amount allocated in course of the period of three years (2013-2015) was only 482,409,227 RSD, i.e. the scope of work of 49.5% for the cleaning of 3,156 km of canal network and the maintenance of 26 pumping stations. From these figures, it is clear that the additional funding for regular maintenance of drainage systems is insufficient.

For the purpose of maintaining the drainage system managed by Beograd vode it is necessary to provide RSD 2 billion for the reconstruction of the canal network and pumping stations, and 500,000,000 RSD for regular maintenance. Unfortunately, the current plans envisage amounts of 235,000,000 RSD because it is expected that the volume of works will be realized to such an extent, i.e. in accordance with the inflow of money [31]. According to EU standards, the necessary funds for regular maintenance of pumping stations are around 40,000 euro / station 1000 Eur/facility and 1,500 Eur / km of canals. If we take into account that in Serbia we have 210 pumping stations, 24,000 km of canals and about 19,000 objects (sluices, culverts, bridges, siphons), the conclusion is that the regular maintenance of the entire drainage network within the Republic of Serbian requires 63 million euros a year, i.e. 7.61 billion dinars, without investments, which would restore derelict facilities and channels back to functional condition. This means that the stated funds of 6.5 billion dinars are below the EU standards which need to be ensured in order to achieve full functionality of the drainage systems on the entire territory of the Republic of Serbia.

If the existing system were to be maintained by the present system, it is assumed that there would be no further reduction in yields, if the quantity and intensity of precipitation remain within the limits according to which the systems were dimensioned, but it would not lead to the promotion and development of agriculture. When the management of drainage systems is conducted with competence, the only prerequisite for sound functioning is a well-implemented drainage fee. According to the previous experience of some EU countries, privatization has not yielded positive results, so it is proposed that management of dewatering systems should be in the ownership and supervision of the state.

Damage assessment

According to experts, the damage from the weak performance of drainage systems in temperate climatic conditions is difficult to determine directly. Claims are reflected in an indirect way:

- When over-moisturization occurs over a longer period (spring) agricultural production is disabled;
- Sowing is delayed, and therefore the plant may enter into the sensitive phenophase in the most unfavourable period (flowering and fruit formation), which has a negative impact on yield;
- The vulnerability of the lowest parts of the field (depression) where occasionally for a longer or shorter period water is retained. Due to the lack of air, plants suffocate and in those parts the yield decreases (Figure P.2);
- Use of irrigation is disabled, along with two sowings a year;
- Disabled sowing of perennial grasses sensitive to over-moisturization (alfalfa) and winter crops, although generally summer crops can be planted, which is undesirable from an environmental aspect along with the fact that they would be especially vulnerable in future climatic conditions due to further increases in temperatures and intensifying drought during the summer;
- Planting of perennial plants disabled;
- Over-moisturization near saline ponds creates an additional negative effect on yield.

Dewatering in the future climatic conditions and recommendations

Drainage systems may prove to be especially important if in future climatic conditions there is an increase in short-term episodes of intense precipitation which is indicated in the future climate change scenarios. Even though the analysis indicates that the climate will be warmer and drier, drainage channels should be maintained regularly, due to the reasons mentioned above and because in drier climates more intense precipitation can be expected with increased risk of flooding. In the coming period it is necessary to examine the drainage criteria in selected locations (e.g. Srem, Negotin plain, South Banat, Pomoravlje, Mačva), because in many places the water surpluses were calculated only from a period of 10 years during the seventies. By these criteria, only the previously calculated surplus of water is dewatered every ten years over the allotted time, which leads to plant suffocation. Unfortunately, to date the new conditions of intensive agricultural production have not been considered along with climate change, which necessitates the need to consider new drainage criteria, primarily a three-day water surplus during the growing season for a number of years, as well as ways of managing drainage systems. A good model could be that of the Dutch Government, which has reviewed the management of water resources due to climate change and established a new approach: instead of increasing the drainage capacity, to shift the focus to accepting the principle intake – to retain, and then dewater the excess water [32]. This approach not only reduces the peak flow, but also increases the amount of water retained in the soil profile to be used during the period of water deficit. In response to these newly created conditions, new practices should be introduced that make it possible to retain a certain amount of water for irrigation in the low-water period. The study [33] for the area of South Serbia has shown that it is only possible to retain water which can be used for a period of drought (July, August) by shutting off pumping stations for the evacuation of water, provided that the water is taken from the canal for irrigation. In the coming period, the Directorate for Water and Public Water management companies should review the drainage criteria which could be based on some of these new approach, whose results would be guidelines for the implementation of major investment.

The technology of growing crops and seedlings

The impact of adaptation measures in agricultural production, which belong to the cultural practices and changes in cultivation technology is specific to certain regions and crops, and also depends on the time of occurrence and the intensity of the manifestation of adverse weather factors that limit the amount of yield. Particularly important for the implementation of these measures will be disseminating information about them through various forms of education, training and training of producers, whose implementation should be organized through the cooperation of the Agricultural Faculties and the Institutes, competent experts of the Ministry of Agriculture and advisory and expert services. Adaptation to climate change in agriculture shall primarily include the following priority actions:

1. *Changes of plant species and assortments in the sowing structure of sowing in relation to the expected changes in the phenology of plants.* Maize can be taken as an example of these measures as a basic fodder, with a huge number of hybrids of different lengths of vegetation, which in part can be replaced with sorghum for grain, which is much more tolerant to stressful environmental conditions. Standard maize hybrids that are commonly grown in our conditions can also be replaced with the earlier hybrids in order to shorten the growing season, earlier anthesis and silking (flowering) and avoidance of drought conditions in the course of the three critical summer months.

2. *The adequate selection of assortment* under the conditions of climate change, with increasing annual fluctuations in weather conditions and more frequent extremes, suggest the cultivation of a larger number of varieties/hybrids of different lengths of vegetation on each farm. In that way, in case of an extreme event, the different varieties / hybrids will be located in different phenological phases and will react differently to stressful conditions, and shall mutually compensate for losses in yields. It is very important that the selection of hybrids and varieties comply with the soil and climatic conditions of the habitat. Regarding the selection of varieties

and hybrids in conditions with high frequency of dry years and in small grains and row crops, genotypes with shorter vegetation have an advantage, which on average can achieve 30-40% higher yield compared to medium late and late genotypes.

3. *Introduction and use of species and varieties/hybrids more tolerant to stressful conditions.* An example of these varieties of alternative types of grain: triticale, spelt, millet, sorghum and the like.

4. *Work on the selection, breeding and creation of tolerant genotypes.* This adaptation measure requires a longer period of time in the selection and breeding establishments. However, the findings are invaluable and enable the creation of varieties and hybrids of cultivated species with tolerance to stressful conditions, particularly drought, or genotypes with altered phenology, length of vegetation, etc., which for example could allow the cultivation of varieties/hybrids of earlier flowering or ripening in regions with extremely dry summers in conditions without irrigation.

5. *Increase the representation of growing winter crops.* Warmer winters with a fewer number of frostless days enable the successful cultivation of crops such as winter wheat, barley, oil seed rape, which are by their biological characteristics - growth and development more adjusted to tolerate lower temperatures, offer better utilization of winter moisture reserves and accelerated spring development, thereby avoiding spring-summer drought conditions. Also, in the expected changed climatic conditions earlier planting and obtaining two harvests per year, especially under irrigation conditions will be possible for these crops.

6. Adjus*ting crop rotatio*n In the anticipated changed climatic conditions, crop rotation will increasingly gain importance. It is especially important to emphasize a crop sequence with different water consumption rates. A typical example is the sunflower which as a preceding crop is mostly bad for small grains because it dries out the land with its very deep roots and complicates processing, preparation for seeding and seeding of wheat in October.

   In semi-arid and arid climates and in dry years limitations in the choice of crops occur, with certain crops impossible to grow. The intensification of plant production, especially the use of larger quantities of nitrogen fertilizers significantly increases the consumption of water for all crops, which reduces the water reserves in the soil, and therefore their preceding crop value. In dry conditions it is of special importance to what depth individual preceding crops dry out land to the permanent wilting point. Crops with shorter vegetation such as winter forage mixture, peas, and grain crops may dry up the land up to 100-120 cm, maize up to 180 cm, and sugar beet, sunflower and alfalfa even over 200 cm. Therefore, the difference in the content of pre-vegetation water reserves is very important. In dry years crop rotations with a higher share of small grains and other early preceding crops are more favorable.

7. *Adapting the basic treatment systems.* One of the main goals of treatment is to improve the water regime of land or a larger accumulation and conservation of moisture in it. In well-treated soil water more easily penetrates into the deeper layers and creates greater supplies of water for dry periods. Also, ameliorative treatment of hydromorphic soils improves vertical and horizontal drainage, which reduces the risk of over-moisturizing and creation of waterlogged areas in micro depressions. Properly and timely derived treatment measures can significantly reduce the evaporation of water from the soil. These measures include: peeling (shallow plowing), primary processing, surface treatment, treatment during vegetation, and conservation treatment.

8. *Conservation tillage of soil.* Change of tillage practices may be one of the most effective adaptation measures in agriculture and is already widely used in many regions of the world. This processing system may include any system that ensures that at least 30% of the land after sowing is covered by crop residues. The presence of plant residues on the soil surface softens erosion by wind and water, while during dry conditions significantly reduce evaporation and contribute to the preservation of soil moisture.

9. *Adequate rational fertilization.* It is known that water consumption is substantially reduced in conditions of optimum and harmonious mineral nutrition. In dry conditions the process of mineralization is slowed down which leads to a reduction in the amount of available forms of assimilates in the soil. At the same time it re-

duces the ascendant transport of approved feedstuffs, which worsens supply of above ground organs with mineral matters.

Nitrogen fertilization. The excessive and unilateral application of nitrogen can significantly increase water consumption in plants, which in dry years adversely affects the yield. Furthermore, excess nitrogen nutrition stimulates the growth of vegetative organs and increases leaf surface, causing intense transpiration in plants, and increases the transpiration coefficient. For these reasons, in drought conditions it is more effective to reduce the amount of nitrogen fertilizer. Phosphorus fertilization. A number of authors point out that in dry years the most efficient is phosphorus fertilization. Lack of phosphorus in drought conditions causes a decrease in root growth, it is harder to supply above-ground parts with water, chlorosis appears, as well as the extinction of secondary shoots and the thinning of crops, causing a decrease in yield.

Potassium fertilization. Potassium affects the water regime and transpiration of plants. The plants optimally supplied with potassium typically consume less water for the synthesis of organic matter and have a lower transpiration coefficient.

10. *Organic fertilization* – enriching the soil with organic matter and humus in order to increase the water-air regime of soil.

    Regular use of manure, compost, siderat and other forms of organic matter in the soil can very effectively alleviate the impact of drought. This measure has a positive effect on the balance of humus, the activity of microorganisms, the creation of stable structural aggregates, which is reflected in a number of physical properties of the soil, primarily on its water, air and thermal regime. In arid conditions the most important role of humus formed from the decomposition of organic matter is that it can absorb large quantities of water, which increases the power of keeping readily available water and its contents, which is very important to better supply plants with water in dry periods.

11. *Change and improvement of the treatment system with the aim of improved moisture conservation (application of reduced treatment systems)*. The systems of reduced and minimum treatment of soil without turning over the arable layer serves to reduce the deterioration of soil structure, humus degradation, reduction of soil compaction, improvement of water-air properties and increase of beneficial micro-fauna in the soil, as well as a reduction in hydro and wind erosion. These systems practically enable greater accumulation of water in the soil.

12. *Construction of windbreaks.* Construction of windbreaks improves efficiency of water by reducing non-productive evapotranspiration and reduces soil erosion especially in areas of the košava wind.

13. *Changes in time and sowing density.* Scenarios of possible future climate change enable earlier sowing and harvesting of crops, and greater participation of earlier varieties/hybrids in the sowing structure. Under the anticipated conditions of the increased trend in dry days for the period April-August, planting density should be reduced, especially in years with low levels of winter precipitation. Transpiration and water consumption per plant are higher in lower density crops, therefore by using the optimum density of plants, losses from evaporation can be reduced. The cause of decrease in yield in denser structures is a significantly bigger leaf area, higher transpiration and greater competition of plants for water. In dry conditions, the cultivation of maize in the denser structure can reduce the yield by 30-50%, while in sandy soils with low water holding power, root crops can be completely destroyed by drought (for e.g. in 2012).

14. *Monitoring and adapting to the new invasive thermophilic invasive pests and diseases (adapted to drought conditions)*. Great importance in this adaptation measure is placed on the customized improvement of forecasting and reporting services, whereby the importance of crop rotation will come to the fore.

In order to assess the effectiveness of the proposed measures to amend the technology of growing crops and seedlings, more criteria is provided in Table 8 in relation to what measures were assessed. Scores and categories of criteria are defined in relation to the capacity of measures to respond to the changed climate conditions, followed by the scope of applicability of the measures in relation to the number of cultures, the time needed for the measures to be implemented, the financial requirements for the implementation of the measures and the capacity of measures in relation to regional specificities.

Table 8. Categories and scores used in the analysis of agro-technical measures.

Criterion	Scores/categories for efficiency according to the given criterion
Temperature	Effect of measure through reducing vulnerability to temperature rise. Scores 2 measure significantly reduces vulnerability 1 measure reduces vulnerability 0 neutral -1 measure increases vulnerability
Precipitation	Effect of measure through reducing vulnerability to temperature drop. Same scores apply as for the criterion Temperature
Extreme weather conditions	Effect of measure through reducing vulnerability to extreme weather conditions (heat waves, storms, floods, frost, etc.); same scores apply as for the criterion Temperature
Cultures	Cultures which would benefit the most from implementation of measure
Implementation time	The time required to start with implementation of measure. Categories: immediately, 2-3, 5, 10 and more than 10 years.
Verification time	The time required in order to be able to quantify the first effects, and for the measure to be improved, complemented and so on. Categories: 2-3, 5 and 10 years.
Current situation	Trend of introducing measures as common practice. Categories: A - it was observed that the measure applies AL - it was observed that the measure applies but to a very limited extent NA – measure does not apply
Additional training	Required additional training of the manufacturers and other participants in the process to begin with the implementation. Categories: I - informing (one off relatively easily organized informing) T - training (courses, seminars, including more lecturers, requires a higher degree of organization in relation to information) S - specialization (maintenance of advanced courses or specialization for several months)
Long-term aspects	Does the measure, with further deterioration of climatic conditions (e.g. very unfavourable conditions beyond 2050) may lose on its adaptive capacity. Scores: -1 Measure loses capacity 0 capacity is not changed 1 capacity increases

Financial investments	Required financial investment in order to implement measures. Scores: 2 does not require funds 1 Requires funds but not significant 0 Requires significant funds
Financial support	Potential that some form of financial support (loans, grants, co-financing, etc.) can help improve the adaptive capacity of measures, while at the same time not jeopardizing the potential positive financial benefits of the measures. Scores: 2 Neutral 1 Would help 0 Would help significantly
Potential cost-effectiveness	The potential cost-effectiveness of measure. Scores: 2 Measure has the capacity to significantly increase profit 1 Measure has the capacity to increase profit 0 The measure has the capacity to sustain current profit and / or minimize potential losses, ie. measure reduces the risk of loss but does not increase the current profit/earnings
Region	Regional scope of measure. Categories: N - measure can be applied at national level NR+ - measures can be applied at national level or in some regions, positive effects can be significant R - measure has only a regional capacity (particularly advantageous for certain regions).

Table 9 shows the evaluation of certain measures in relation to the set criteria. Fields are highlighted in green towards yellow in accordance with the efficiency of measures in relation to a given criterion. Summing up the results in Table 9 through the weighted average of all displayed measures, the measures can be roughly divided into three groups:

1. Group of received measures with the highest marks for more than half of the criteria, and includes: Introduction and use of tolerant species and varieties / hybrids, changes in time and sowing density, proper fertilization - nitrogen and proper selection of varieties.
2. Group whose criteria scores are generally rated as the second-highest, and includes: modification of plant species and varieties (phenology), adaptation of crop rotation, proper fertilization - phosphorus, proper fertilization - potassium, organic fertilization, adapting the system of primary treatment, changes and improving the of system with the aim of better water conservation, monitoring pests and diseases, increase in the share of growing winter crops and conservation tillage.
3. Group of measures with potential limitations, most often as a result of additional financial investments and long implementation periods, and includes: selection, breeding and creating tolerant genotypes and construction of windbreaks.

Finally it should be noted that the vast majority of the measures proposed do not require large additional investments, but rather timely information and training which would allow the measure to be adequately implemented.

Use of short-term, monthly and seasonal weather forecasting in agro-meteorology

The quantity, quality and efficiency of agricultural production in terms of changing climate greatly depend on the weather conditions in each individual year, i.e. the production season. Therefore, knowledge of weather conditions in the future is important for timely efforts in the field in order to optimize agricultural production and reduce risks, as well as corresponding economic losses. In this sense, the weather forecast is crucially important not only short-term, but also long-term, that is, seasonally (from several weeks to several months). According to studies of climate change impacts, in the future the region of Central Europe can expect a more frequent occurrence of extreme weather conditions and unfavorable weather conditions. The operational use of seasonal weather forecasts can optimize operations in the field and apply scientific agro-technical measures and thus reduce the risk in plant and livestock production (e.g., the early announcements of droughts, heat waves or high intensity radiation).

In addition, the use of seasonal weather forecasts for meteorological input data in agro-meteorological models and models of plant production enables the forecast of plant development and yields several weeks or months in advance. In the case of solar radiation, the improved forecast of the intensity of radiation may help in the timely removal of leaves in a vineyard, taking cattle to pasture and provision of protection, as well as impact assessment on the growth and development of plants and planning measures to reduce the risk of leaf damage.

One example of the efficient use of monthly weather forecasts in agro-meteorology can be seen in the results presented in [34]. Table P.10 shows the results of the comparison of values of selected agro-meteorological parameters calculated on the basis of monthly forecasts for the March-July 2005 period, compared to the values calculated using the measured values of meteorological data.

Table P.10 Values of agro-meteorological parameters calculated using the observed values of meteorological elements and values obtained based on monthly weather forecasting.

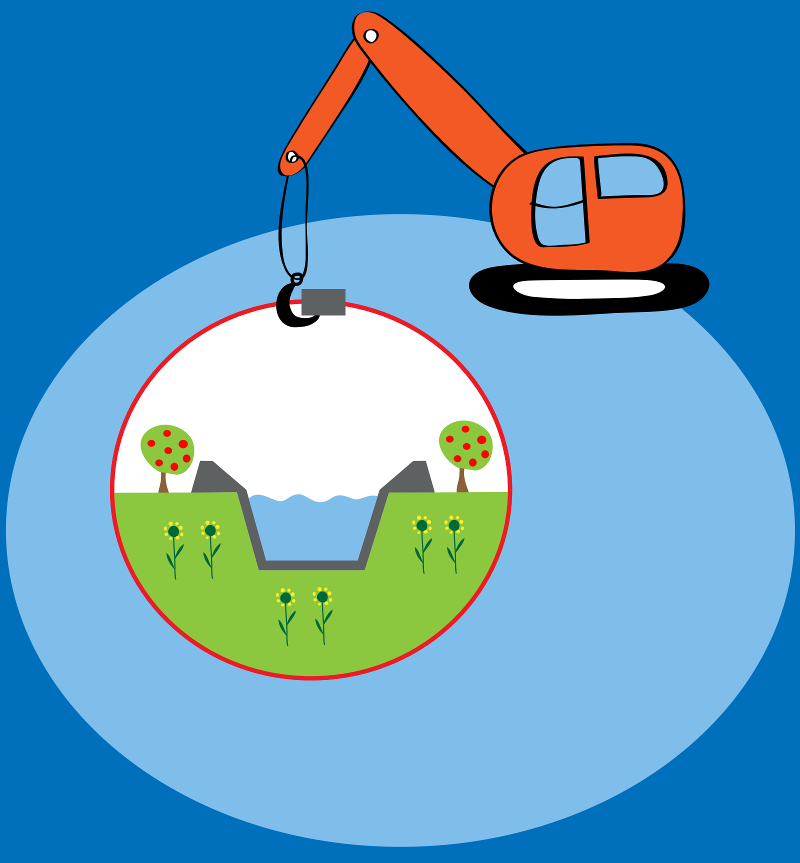
	ET (mm)	Max.def. (mm)	Date of flowering	Date of full ripening	Biomass (kg/ha)	Yield (kg/ha)
Novi Sad observed	425	136	139	181	14473	6006
Novi Sad simulated	379	143	139	179	14478	5920

The institution responsible for ensuring the short and long-term numerical weather forecasting for operational needs is the Republic Hydro-meteorological Service of Serbia. Operational use is preceded by the testing and evaluation of the efficiency of these forecasts in different fields of agriculture, especially in plant production and plant protection. Evaluation of the results could be the responsibility of the institutions that have a developed network of agro-meteorological stations and observers in the field, such as the forecasting and reporting services in plant protection of Serbia and Vojvodina. Also, the monitoring and evaluation of the application of short-term and long-term numerical weather forecasting in agriculture could include some better organized and equipped agricultural extension services and research institutes. One of the most pronounced weaknesses when it comes to the application of contemporary agro-technical measures and different products of numerical forecasts in agriculture lies in the lack of information of producers, as well as advisory and agricultural extension services about these methods and their importance. It is therefore essential that in terms of education, in addition to educational institutions, other actors whose influence in this regard is immeasurable should be involved.

Measure	Temperature	Precipitation	EBP	Cultures	Implementation time	Verification time	Current situation	Additional training	Long-term aspects	Financial investments	Financial support	Potential cost-effectiveness	Region	Note
Change of plant species and assortment (phenology)	1	1	1	Maize, soybeans, winter and spring small grains, sunflower, vegetable crops, fruit crops, fruit plantations, grass	Immediate *5 – 10 years	2-3 years *10 years	AL	T	1	2	2	1	N	* For fruit plantations
Introduction and use of tolerant species and varieties / hybrids	2	2	1	All cultures	Immediate	2-3 years *10 years	AL	I	1	2 0*	2	1	N	* For fruit plantations, vineyards
Selection, breeding and creation of tolerant genotypes	2	2	1	All cultures	5 years	10 years	AL	S	1	0	0	2	N	
Increasing the share of growing winter crops	1	2	1	winter crops, annual grass, oil rapeseed and other species in the crop rotation	Immediate	2-3 years	NA	I	1	1	1	0	NR+	
Proper selection of varieties	1	1	1	All cultures	Immediate	2-3 years	AL	I	1	2	2	0	N	
Adapting crop rotation	2	2	1	All cultures in crop rotation	2-3 years	5 years	NA	T	1	1	2	1	NR+	
Adapting the basic treatment system	1	2	1	All cultures	2-3 years	5 years	AL	T	1	1	2	1	NR+	areas with heavy-clay soil types or too light-sandy types
Conservation tillage	1	1	1	Maize, small grains, vegetables, fruit plantations	2-3 years	5 years	AL	T	1	1	1	1	NR+	land with unfavorable water-air and physical characteristics, hilly areas
Rational fertilization – Nitrogen	2	2	1	All cultures	Immediate	2-3 years	A	T	1	1	1	1	N	
Rational fertilization – Phosphorus	1	1	1	All cultures	Immediate	2-3 years	A	T	1	1	1	1	N	
Rational fertilization – Potassium	1	1	1	All cultures	Immediate	2-3 years	A	T	1	1	1	1	N	
Organic fertilization	2	2	1	All cultures	All cultures	Immediate	AL	T	1	1	1	1	NR+	
Changes and development of treatment system in the aim of better moisture Conservation	2	2	1	All cultures	All cultures	5 years	AL	T	1	0	1	2	NR+	land with unfavorable water-air and physical properties
Construction of windbreaks	1	0	1	All cultures	All cultures	10 years	AL	I	0	0	0	0	NR+	Vojvodina, especially Banat and other košava wind areas
Changes in time and sowing density	1	2	1	Immediate	Immediate	2-3 years	AL	I	1	2	2	1	N	
Monitoring of pests and diseases	1	1	1	All cultures	Immediate	2-3 years	A	T	1	1	0	1	N	

Table P.9 Multi-criteria scores for the changes of technology of breeding crops and seedlings.

WATER RESOURCES AND WATER MANAGEMENT



Water resources and water management

Water resources of Serbia mostly consist of transit waters of the Danube, the Sava, the Tisa and other rivers. Only 9% of water resources are made up the domestic waters of watercourses and mostly belong to the Danube basin, i.e. the Black Sea basin. The western and south-western and southern parts of Serbia are richer in water than the northern, central and eastern. In addition to spatial disparities, water regimes on the rivers in Serbia are generally characterized by seasonal unevenness with high waters in spring and low waters in the late summer, autumn and early winter.

Water management in Serbia is based on the Water Act (Official Gazette 30/10 and 93/12) and regulations that emanate from this law, and takes place in three main branches of water management: water use, protection against harmful effects of water and protection of water quality. The basic types of water use are supplying the population and industry with water, irrigation, hydropower, navigation, tourism and recreation and fish farming. National regulations in the field of water are partially harmonized with EU regulations. In institutional terms, the central role in water management is given to the Ministry of Agriculture and Environmental Protection, i.e. its Water Directorate. However, competences in the field of water significantly overlap between many state institutions, agencies and public enterprises, which often make water management ineffective.

The main strategic document in water management is the Water Management Plan of Serbia, and the one currently in effect was established in 2002 and is based on the existing situation from the 1990s. The drafting of a new water management plan has begun, while in the meantime a draft Water Management Strategy [V.1] was also prepared which is in the process of public debate. The third report on the impact of environmental protection in Serbia [V.2] provides an assessment that Serbia lacks an adequate framework for the water sector in which to achieve sustainable management of waters and wastewaters. It was also noted that there are neither programs for the efficient use of water that are being implemented, nor innovative solutions at the national level.

Three main potential impacts of climate change on water resources are related to the problems of water availability, water quality and the intensity and frequency of floods and droughts. Changes in the water regime with these three aspects would inevitably influence water management within all water management branches.

The impact of climate change

Studies of the impact of possible future climate change on water resources and water management in Serbia are scarce and limited. Despite the fact that the analysis of trends is not always sufficient to point to all aspects of change in complex systems such as the hydrological system, in the framework of the Second National Communication [V.3], from the results of the trend of mean annual flow at 18 hydrological stations, it was estimated that the flow of rivers in Serbia has had a negative trend since the mid-twentieth century, which is about -3% per decade, with spatial variability. The observed long-term trend for the Danube and Sava rivers in Serbia is also negative, but about 1% per decade.

The framework of the Second National Communication on Climate Change presented the results of several studies that used different projections of climate inputs for hydrological modeling. These studies included the basins of the rivers Sava, Kolubara, Toplica, Rашka and Mlava and groundwater resources in two alluvial and two karst springs. These results for surface waters show that by the mid-21st century significant changes in the amount of water are not expected (changes are less than ± 10%), while significant reductions are expected in the distant future, i.e. by the end of the 21st century, where these changes range from a few percent to about -30% in the case of Kolubara and Toplica [V.4]. The study [V.5] of the Sava river basin shows expectations for the near future of redistribution of its water over the course of the year. i.e. between seasons. However, on the annual level changes are expected which by significance do not exceed the potential uncertainty in measurements and modeling, in terms of increased water quantities at winter and reduction of spring water quantities, In the more distant future, a very significant reduction in the amount of water in the summer is expected. In the study [v.4] results are similar for Kolubara and Toplica.

Changes in extreme values of flow are much less explored than the mean flow i.e. from available water quantities. In the Second National Communication on Climate Change it was estimated that the maximum annual flow rates show a declining trend for almost all rivers (noting that the analysis did not include data from 2014), while the trend of the minimum annual one-day flows is variable. Study [v.4] did not show a significant increase in the maximum annual flow in the basins of Kolubara and Toplica in average rates, but higher variation at the upper end of the distribution has been observed. Study [V.5] shows a very small increase in the 100-year high waters in the river Sava near Sremska Mitrovica of a few percent by the end of the 21st century, while on the other hand this study shows the reduction of characteristic small waters (minimum mean monthly flow of 95%) at the same level of about 10% by 2070.

The impact of climate change on the quality of surface and ground waters in Serbia can be estimated at this time only through certain generalizations. The expected changes in air temperature would certainly adversely affect the water quality. The direct impact would be reflected in an increase in water temperature, and indirectly through increased concentrations of pollutants under the conditions of the reduced quantities of water, particularly in low flow periods.

Very few of the results relate to the impact of climate change on certain water management branches, but this influence is only indirectly assessed based on changes in the quantity of water.

Summing up the results of the analyzed reports and studies, as well as the potential negative impacts of climate change on the water sector in the Republic of Serbia, there are several primary ones: increased water shortages; increases in the intensity of drought and areas affected by drought; prolonged duration of small waters in the rivers; reduction of small waters in the river sections without upstream accumulations; direct and indirect increase in problems related to water quality; intensification of erosion processes, torrents and floods on small rivers; and the rise of high waters on large rivers.

From the limited results available, it can be concluded with significant uncertainty that all the impacts of climate change in the first half of the 21st century are relatively mild on average over the year, but with changes in intra-annual schedule and more pronounced differences between the low and high water periods. In the future, i.e. by the end of the 21st century, the problems significantly intensify in terms of the total available water resources, especially in the summer, i.e. the low-water period and in the case of unfavorable scenarios of greenhouse gas emissions, such as presented in the scenario A2.

Adaptation measures to climate change in the water sector

The basic objective of all measures in the field of water management, as well as adaptation measures, is integrated water resources management, which should be optimal from various aspects of water management (water protection, protection against harmful effects of water and water use), and from the standpoint of different users (e.g., conflicts between populations, industry, agriculture, hydro-energetics, etc.).

This report analyzes the measures that are defined in the Second national report as measures to reduce climate risks in three strategic areas:

- Use of water,
- Protection from the harmful effects of water,
- Water quality.

In the area of water use as the most important medium-term measure it was proposed to increase the efficiency of the water supply system, namely: (1) reduction of losses to the optimum level, (2) the introduction of an economic price for drinking water, (3) organizational optimization of the water utility. This measure has been described as a no-regret measure. Reducing the uncharged part of water in public water utility systems is one of the operational objectives in the draft Water Management Strategy [V.1]. Establishing the water pricing policy and the reform of public utilities also ranks among the medium-term priorities for the period 2017-2020 according to the Post-screening document [V.6].

In the field of protection against harmful effects of water flows, the necessity of an integral approach and harmonized activities of relevant institutions and organizations to improve protection in these activities include: making plans for flood protection, the construction of new buildings in flood zones, improvement of protection with large settlements and the inclusion of active protection measures (retention basins). In addition, the priority is the development of a system for forecasting and flood alert (according to a study WATCAP [V.5]), which should be part of the integrated approach to flood protection.

In the field of water protection the priority medium- and long-term adaptation measures include the construction of a wastewater treatment plant for all settlements with populations of more than 2,000 inhabitants and for industrial centers, the improvement of protection from diffuse pollution (mainly from agriculture), and an increase in prices of waste water treatment.

Analysis of the measures proposed

Use of waters - water supply

The percentage of households covered by the public water supply in Serbia is on average 80%, but there are significant regional differences. The population covered by the systems is mainly concentrated in areas with higher population density and the percentage of connected households is highest in Belgrade and in Vojvodina (90%), while in central Serbia it is significantly lower (it is the lowest in the Nisava and Toplica districts, below 60%) [V.7].

For public water supply about 680 million m3 of water is abstracted, about 70% from ground waters and approximately 30% directly from streams or accumulations. Although on average about one third of the capacity of groundwater is exploited [V.8], exploitation of ground waters in Vojvodina exceeds local capacity [V.1]. From the abstracted water, about two-thirds are delivered on average, while the rest are losses.

Water shortages were identified in Čačak, Požega, Gornji Milanovac, Bor, Požarevac, Veliko Gradište, Lučan, Lazarevac, while in Kikinda, Zrenjanin, Topola, Lajkovac, Kraljevo, Ćuprija and some other settlements lack of water is also accompanied by inadequate water quality [V.9]. Even some big cities in peripheral areas have the problem of water shortages in the summer period. It is also considered that many water sources are not sufficiently protected [V.1]. Besides the problem of quantity and quality of water, the water supply of the population follows the problem of large losses, i.e. high uncharged quantities of water. The price of water is low and in many cases does not cover the cost of system operation, and the degree of collection in smaller systems is not sufficient [V.1]. Poor human and technical organization and low efficiency of utility companies responsible for the public water supply are also observed as problems [V.9], [V.1].

The abstraction of water for industry tends to be on the decline, but this is attributed to the reduced volume of industrial production, rather than structural or technological measures for saving water [V.9]. In 2012, about 90 million m3 of water has been abstracted by industries, out of which about 50% from their own catchments from surface water, 30% from their own catchments from groundwater and 20% from the public water supply systems. In these systems, the losses amount to 2%. Some local water intakes for the industry are not registered, while some undertakings do not meet the statutory regulations of the systematic registration of water volumes abstracted in the course of exploitation and delivery of measurement data to the competent institutions. Also, the authorities have no effective regulation on water abstraction [V.1].

The impact of climate change on water supply

With the current state of the water supply and the degree of knowledge of potential impacts of climate change on water quantity, from the available results for the territory of Serbia we can conclude that in the future, escalation of the conflict between the requirements and the available water quantities is to be expected, considering that reduced amounts of water are anticipated during the summer period when water requirements are the greatest. Reduced amounts of water will be accompanied by worsening water quality, which in combination with high temperatures will aggravate the sanitary and hygienic conditions in the local systems [V.9]

An individual water supply, which is most common in rural areas, can be considered highly vulnerable to climate change. These systems are already characterized by inadequate operation and maintenance, which leads to a higher percentage of samples of drinking water that do not meet hygienic standards, and climate change would additionally aggravate this problem. In contrast, the cities' public water utility systems are more resistant to climate change because they have professional staffs and financial resources to invest in technology and infrastructure modernization. On the other hand, since demographic growth shows a negative trend in the near future, we expect only a slight increase in demand for water for the population.

The aggravation of problems in supplying industry with water in the future can also be expected in terms of the reduced amount of available water given that industry needs are conflicting with the needs for water supply of the population, but the depth of this conflict would be determined by the growth of industrial production.

Proposal for adaptation measures - reduction of losses in water supply Based on the information in the previous sections, it is evident that the increasing demand for water in the future is in conflict with the reduction of the available water supply under the influence of climate change. Providing additional quantities of water by expanding the capacity of existing water sources or creating new sources therefore does not seem a sustainable solution to the problems of water supply. On the other hand, the present state of water supply is characterized by inefficiency in terms of major losses in the systems, non-economic pricing of water and poor organization of public companies responsible for water supply.

In addition to the fact that they represent a sustainable solution, adaptation measures that would be based on a reduction of losses in water supply systems in the mid-term are more cost-effective than measures of constructing new systems. Water losses add to the loss of resources, are also direct energy losses and losses of chemicals consumed in water treatment. With the aging of infrastructure, losses are increasing, through the number of failures and intervention and repair costs of pipelines and other infrastructure (roads, streets), and renovation of building foundations. Leaking increases the risk of contamination of water in the pipes in the course of returning water to the pipes. Opening new sources increases the investment costs of water supply systems, increases the exploitation costs of pumping because water is usually distributed to more distant locations,and increases treatment costs because by then it is usually a lower quality of water. If you extend the groundwater sources with new wells, there will be a need for their regeneration, by limiting the use of soil in water protection zones.

According to [V.10], of 12 analyzed municipal water supply systems in Serbia, four are in the category in which the losses are at an acceptable level according to the Infrastructure Leakage Index ILI[2], two systems are in the category where it is possible to improve system performance with better management of the system, while six systems were classified into categories of very inefficient use of resources and for measures to be undertaken to reduce losses.

When it comes to the financial efficiency of the water supply system, it can be viewed through the ratio of the water quantity that does not generate revenue and water that does generate revenue. The water that does not generate revenue includes:

- The actual losses due to leakage,

[2] Infrastructure Leakage Index ILI is defined as the ratio of the amount of current and inevitable actual losses on the annual level. Actual losses are physical losses due to leakage and do not refer to unbilled water.

- Apparent (commercial) losses due to illegal connections and due to faulty consumption measurement,
- Unaccounted legally consumed water (unmetered and uncollected water).

Among the 20 systems that have been analyzed in [V.10] for the year 2009, the most favorable ratio of water that does not generate revenue was at 21% in the municipality of Knić, while the worst ratio of 258% was in Kosjerić. Only five systems had a ratio that was less than 50%, while the ratio in six systems was greater than 100%.

Losses in the water supply system of Pančevo in 2006 amounted to 31% of the total volume of total water abstracted, out of which the majority of actual losses was due to leakage (29% of total water abstracted). Water that does not generate revenue was as high as 61% of the total water abstracted (Table V.1) because the percentage of uncollected but registered water was high. The analysis in the study [V.10], which took into account the cost of water, showed that the financial loss for the amount water quantity amounted to 75% of the operating costs of water supply in the year under review.

Table V.1. Types of water losses in the water utilization system in Pančevo for 2006, in millions of m3 and in percentage, according to [V.10].

<table>
<tr><td rowspan="4">Total water entered into the system 13,08 (100%)</td><td rowspan="2">Registered consumption 9,07 (69,4%)</td><td>Charged registered consumption 5,08 (38,8%)</td><td>Water that generates revenue - 5,08 (38,8%)</td></tr>
<tr><td>Uncharged registered consumption 3,99 (30,5%)</td><td rowspan="3">Water that does not generate revenue - 8,00 (61,2%)</td></tr>
<tr><td rowspan="2">Water losses 4,01 (30,6%)</td><td>Apparent losses 0,18 (1,4%)</td></tr>
<tr><td>Actual losses 3,83 (29,3%)</td></tr>
</table>

Based on the trend of the water requirement projections presented in the Water Management Strategy [V.1] for the time periods of 2024 and 2034 of the South Banat district, for Pančevo it can be estimated that in 2034 it will be necessary to abstract 14.6 million m3 of water for the public water supply (with a reserve of 15%, which is the most pessimistic scenario). This estimate includes all the assumptions from the Strategy, and even the maintenance of the same level of losses in the system. As can be seen, according to such a projection it would be necessary to abstract 1.52 million m3 more than in 2006, which is less than half of the losses in that year. If only this change were accomplished (i.e. assuming the same needs, the same price of water and that nothing is done in terms of increasing the level of charge), the total abstracted water in this year would be reduced from 13.08 to 11.56 million m3 and operational costs would be reduced by about EUR 300,000 per annum.

According to the Water Management Strategy [V.1], it would be possible to assess the minimum annual savings in the water utility systems of Sombor and Pirot in a similar way. In Sombor, water that does not generate revenue accounts for 60% of the water entered into the system, and in Pirot 42%. Out of this, actual losses amount to 26% of the total water in Sombor and 41% in Pirot. Due to actual losses, the financial loss in Sombor is estimated on 26% of operating costs, and 41% in Pirot. Due to unpaid water services, estimated financial losses in Sombor are 44% of operating costs, and 15% in Pirot. Projected water needs in Sombor from the Strategy envisage a significant increase of abstraction in 2024 and 2034 that can neither be covered by reducing the actual losses, nor with an increased charge. Projected water needs in Pirot have a very low growth and additional water quantity up to 2034 amounts to about 0.8 million m3 with a decrease in losses from 2.8 to 2.0 million m3; this goal would be easier to accomplish by the rehabilitation of losses and redistribution of balance instead of additional abstraction.

Remediation costs of a single system are difficult to assess without access to the state of the system and the local conditions. One of the few available examples where it is possible to make a partial comparison of the costs of the reconstruction of the system is the example of the regional system in the Kolubara district which includes the systems of Valjevo, Lazarevac, Mionica, Ub and Lajkovac [V.11]. This project envisages the replacement of the excessive pumping of groundwater from local wells by abstracting from the future accumulation of Rovna. Besides the construction this system, the project has also included measures to reduce water that does not generate revenue in all five municipalities. The cost of this project is estimated at 12.5 million, of which EUR 1.5 million is intended for the program of non-structural measures to reduce losses (such as the management of operating pressure in the system, improved detection of leakage including a system zoning system and improvement of measurement, shortening the duration of leakage by better organization of repairs, mathematical system modeling, and maintaining updated databases). However, based on the data on projected future spending and a projected reduction of losses, from the information available for this project it can be concluded that even with the same price of water the results of the project would be such as to earn an additional revenue of 1.67 million euros per annum, due to savings from reduced losses and charges for new volumes of delivered water in the extended part of the system. Under this assumption, investment in the expansion of the network of 12.5 million would be feasible over a short period of about 8 years. It should be noted that the cost estimate of the project [V.11] did not cover the cost of construction of the accumulation in Rovna which will be ongoing for a number of years, and also did not consider maintenance and depreciation of the system. Such additional requirements would certainly extend the deadline of the project's cost-effectiveness, but the cost-effectiveness would contribute to the increased price of water, which is often pointed out as a necessary measure.

Protection against harmful water effects

The current state of flood protection in Serbia is not satisfactory: it is estimated that about 18% of the territory of Serbia is potentially vulnerable to floods, primarily in the coastal area of the Danube, the Tisa and the Sava, then the rivers Morava, Drina, Kolubara, and Timok where the population and economic activities are concentrated. The potential risk of flooding exists even in places where protective systems have been constructed [V.1]. This was confirmed by the flood in Obrenovac and other places in May 2014. In potential flood areas in Serbia there are more than 500 larger settlements, over 500 large commercial buildings, about 1,200 km of railway lines and more than 4,000 km of roads. Significant flood areas are identified in the Preliminary flood risk assessment [V.12].

Vulnerability to floods in Serbia is generally twofold. Flood waves on large rivers (the Danube, the Tisa, the Sava) are predominantly formed outside the borders of Serbia. On the other hand, a large number of smaller watercourses are characterized by the torrential character of the hydrological regime, i.e. the sudden advent and short duration of high water. The most serious threat to the lowland areas of Serbia is the simultaneous occurrence of high waters on the rivers Danube, Tisa and Sava, which could lead to catastrophic consequences [V.1]. An additional problem is that the accumulation of "Djerdap 1" has a relatively small capacity for receiving flood waves. The backwater of this accumulation that stretches upstream along the Danube to Novi Sad, and the Sava to Sremska Mitrovica, creates unfavorable conditions for the high waters of the tributaries of these rivers to flow away, which was demonstrated in a dramatic way in the case of the Kolubara in May 2014.

Dominating previous measures for flood protection in Serbia are infrastructural measures, the passive protection measures (embankments). Active protection measures (reserved areas for water retention, relief channels, rehabilitation of river ecosystems, protection of soil from erosion and restoration of forest ecosystems) are underrepresented. The state of infrastructure is described in detail in the draft Water Management Strategy [V.1]. The current level of protection is assessed as unsatisfactory in many locations, including the right bank of the Sava (from the mouth of the Drina to Šabac), the left bank of the Sava river near Sremska Mitrovica, the lower course of the Drina River (the area of Mačva), the Kolubara basin, the valley of the Timok (floods in Zaječar in 2010), on the Pčinja (flood in Targovište, 2010), on the South Banat watercourses (Karaš and Nera), and the Sava river (the floods in 1999, 2007, 2010 and 2014).

Only in the examples of the last two major floods in 2006 and 2014,has it been shown that most problems occur in cities and towns along the Danube and the Sava (Novi Sad, Belgrade, Smederevo, Pozarevac, Veliko Gradiste, Golubac, Sremska Mitrovica, Sabac, Obrenovac). The planned reconstruction of infrastructure after the floods of 2006 was only partially completed. Although the protection of Belgrade in planning documents is always at the first priority level in Serbia, the required level of protection is not provided, and the construction within potential flood zones continues.

Embankments and other infrastructure are generally sized at 100-year highwaters, but the actual level of protection is unknown considering that targeted waters were measured at various time intervals and with varying hydrological data. Therefore, the degree of protection is only assessed as satisfactory or not based on the experience from previous floods.

Reduced security and the level of protection against high waters is the result of multi-annual reduced investment in the maintenance of river beds and facilities, as well as the construction of new protection facilities. The worst situation is in the catchment areas of minor watercourses, where the existing protection is at a very low level and incomplete. Inefficient flood protection was also caused by unplanned urbanization in river valleys, changing conditions in the basin (deforestation, urbanization), construction of bridges and culverts of inadequate dimensions (without coordination with water management bodies), and neglect of the rivers with waste disposal in riverbeds. Reserved spaces for the reception of flood waves in existing accumulations today are reduced due to the deposition and decrease in their useful volume.

One study [V.5] also agreed that the current flood protection in the entire Sava River Basin is insufficient for effective flood management due to inadequate infrastructure, poor maintenance, and lack of coordination in the basin in terms of monitoring, forecasting and warning, which indicates the need for international cooperation with upstream countries for the large rivers in Serbia.

Serbia has initiated activities for the implementation of the EU Directive on the assessment and management of flood risks. Hazard maps and flood risk maps, which are the basis for the evaluation of real or potential harm and making plans for flood risk management, have been carried out for significant floodplains along the Danube and in the Morava River Basin, and in the future these maps will be made for other major floodplains, during the initial phase of the preparation of a plan for the management of flood risks [V.13].

The immediate flood protection in Serbia is regulated by the General Flood Defense Plan for the period 2012-2018, while each year the operational plan is made. Forecasts and an early warning system have a significant role in flood defense and in reducing flood damage. High waters on large lowland watercourses are characterized by a slow rise in waves of several days and long duration, so the possibilities for forecasting and implementation of defense measures on them are higher than in the watercourses of torrential character with a short duration of wave, high water velocities and large amounts of sediment.

Flood control on rivers (the outer waters flooding) is most often primary to flooding in urban areas which occur due to heavy precipitation and insufficient capacity of sewerage systems. However, due to the continuing increase in the value of urban infrastructure and property of citizens, the damage caused by this type of flooding (i.e. the flooding in inland waterways) may be a burden for the budgets of the local self-governments. In addition, the interaction of high waters and increase due to heavy rains can cause significant consequences and damages. An example is the floods in Belgrade in 2006 when there was only a minor spill of the Sava and Danube rivers from their river beds, but the sewerage system in the coastal parts of the city did not function due to high water and backwater in the sewerage system. In addition, floods often damage the public sewerage infrastructure, waste water treatment facilities and individual sanitation facilities and result in consequences with accompanying hygienic risks for the entire settlement and downstream residents [V.9].

There is no systematic review of damages caused by earlier floods in Serbia, which would relate the amount of damage caused with the space covered by the floods and other factors. The most recent memory is of the catastrophic floods of May 2014, in which the direct and indirect damage was estimated at approximately EUR 1.5 billion [V.14], but other small-scale events also caused major material damage such as the event from Zaječar in 2010 when the damage amounted to 4.5 million EUR. Implementation of direct flood defense also requires substantial resources. Successful operational flood defense on the rivers Danube, Tisa and other watercourses in 2006 cost about 10 million EUR.

Erosion is the second important aspect in the protection from harmful effects of water. About 56,000 km2 of the territory of the Republic of Serbia has been affected by erosion processes of different intensities, with an average annual production of layers of sediments close to 40 million m3 [V.1]. Erosion control activities and the maintenance of existing systems have decreased significantly in the last twenty years due to reduced budgetary funding for this area. As a consequence, in recent years across Serbia floods occur in torrential flows (Jadar 2005, Bjelica 2006 and 2013, Veternica and Vlasina 2007, Pčinja, 2010), while the floods from 2014 had disastrous consequences across a large territory of the state. It should be noted that for a certain number of torrential streams and their catchments general projects for the regulation of erosion and torrential areas exist, but their implementation is lacking.

In order for the protection from harmful water effect to be efficient, i.e. for the investments in a certain degree of protection to be balanced against potential damage, it is not enough to solve only individual problems. For effective protection it is necessary to apply an integrated approach and harmonized activities of all relevant institutions and organizations, as well as the support of the society as a whole.

The impact of climate change on flood protection

Major impacts on future flood protection are not only related to climate change, but also to future social and economic development. It is expected that climate change will contribute to increasing the threat of flooding through the occurrence of intense precipitation, as well as the frequent occurrence of high waters [V.15]. The occurrence of more intense precipitation would contribute not only to more extreme floods of the rivers, but also to the aggravation of the problem of flooding in cities, indicating the necessity to solve integrally the protection against high waters at the level of municipalities and regions.

The following study shows that [V.5] the impact of climate change on the increase of high waters in the Danube basin is somewhat larger than on the tributaries of the Sava River downstream in the Sava River valley, but at the same time one should not ignore the fact that dikes and other protective infrastructure in more upstream areas increase the risk to downstream sections. This was evident twice during the floods of May 2014: first, an enormous amount of water from tributaries caused breaches of embankments in Slavonija and Semberija, but this then reduced the risk on the sections of the river Sava through Serbia. For this reason, the existing retention areas in central Posavina are of great importance for the protection of downstream parts of the river Sava, but new retention areas are also necessary (whose sites should be protected from further construction). This also points to the importance of cooperation with upstream countries.

From this experience, it follows that the existing passive protection measures, in terms of increased natural vulnerability, increase the risk downstream, indicating a need for orientation on active measures with retention areas and the application of the principle of "more space for the rivers" So, if we do not improve the current state of infrastructure for flood control and if we don't stop the trend of river valley occupation with unplanned construction, flood risks may increase further in the future.

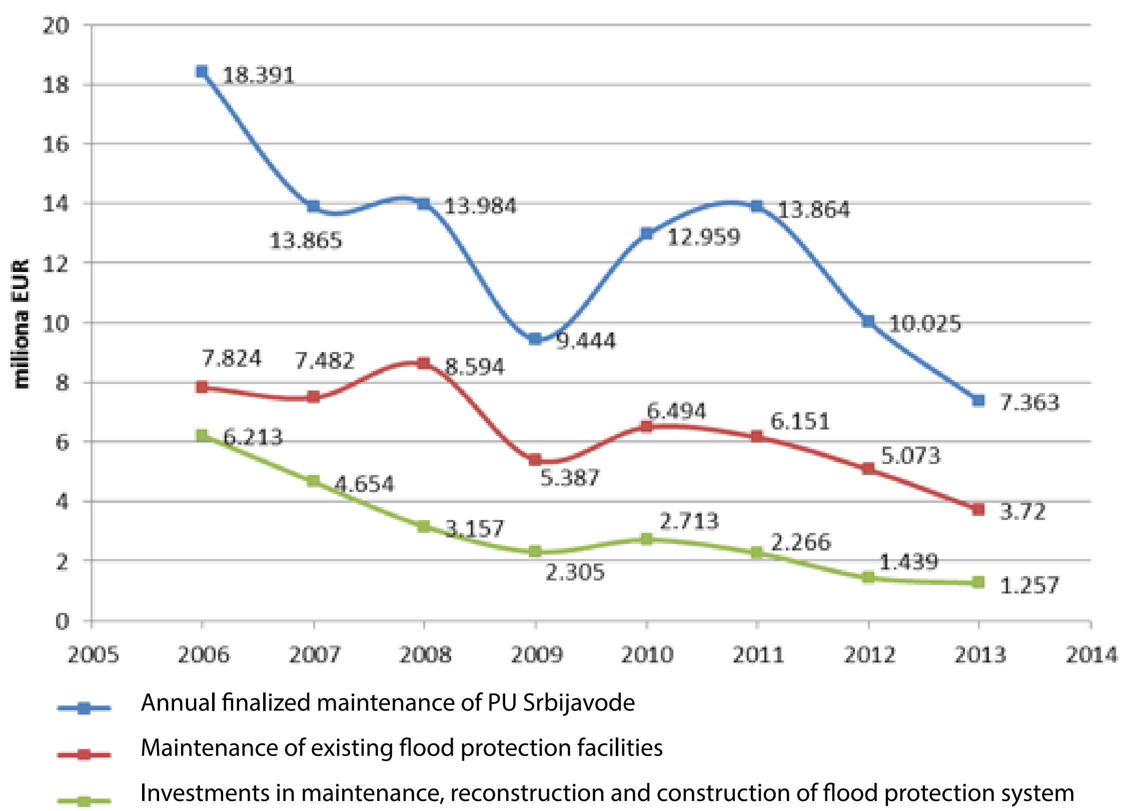
The migration of populations from rural to urban areas is a modern tendency, which is expected to continue in the future in terms of lower economic growth. Thus an increased vulnerability of cities and larger settlements in river valleys is expected, and their protection in the future should become a priority. This means that investments in flood protection should be increased in the future, perhaps at the expense of agricultural land if necessary [V.5]. As the biggest risks are expected in cities in river valleys, especially of the rivers Danube and Sava, this also points to the necessary cooperation with upstream countries and improving the system of early warnings and alerting.

In the future, flood protection will even more evidently overlap with land development, so that this area should with foresight carefully select adaptation measures involving other sectors, particularly the sector of urban and physical planning.

Improvement and adaptation

Only in the case of the catastrophic flood in May 2014 was it completely evident that the construction of facilities for flood protection is always cost-effective. According to data from the U.S.A. [V.16], for each invested monetary unit in flood protection there is a benefit of four monetary units in the form of avoided damage. Unfortunately, the flood protection system of Serbia was destroyed due to lack of maintenance, reconstruction and expansion of the system. This is evidenced by the data on financing activities of the public water enterprise "Srbijavode, as shown in the Figure V.1. As can be seen, in the period from 2006 to 2013 about EUR 50 million was invested in flood protection, which is only 1/30 of the total damage amount from the flood in May 2014.

Figure V.1. The decreasing trend of investments in maintenance, reconstruction and construction of flood protection facilities in the public water enterprise "Srbijavode" [V.17].



Improving the system for forecasting and early warning as a measure of protection is gaining importance in terms of the impact of climate change due to the expected increase in the frequency and intensity of high waters. In Serbia and in the region so far there have been several projects whose task was the development of such systems, while the costs of such projects range from about 0.5 to 2 million euros depending on the size of the basin. This cost is less than the registered flood damage in Serbia mentioned above, and even several times less than the cost of direct flood defense.

In conditions of reduced funding, measures whose implementation carries only administrative costs are proposed as priority, i.e. adoption of legislation that would suspend illegal construction in flood zones.

Water protection

Key sources of water pollution include untreated industrial and municipal wastewaters, drainage waters from agriculture, leachate waters from landfills, as well as pollution related to river navigation and the operation of power plants.

According to the construction of the wastewater infrastructure, Serbia belongs to the group of medium developed countries, while in regard to the treatment of waste water it is at the very bottom. About 55% of the population is connected to the sewerage system, while less than 10% of the population is covered by some form of wastewater treatment. Pre-treatment of industrial wastewater before discharge into the sewerage network or other recipients, includes only a small number of industries.

In settlements with more than 2,000 inhabitants, which are homes to nearly 75% of the population, the average percentage of connection to public sewer systems is about 72% and to individual (septic tanks) about 27%. In settlements with fewer than 2,000 inhabitants public sewerage systems are sporadically represented, so that in this group of settlements the connection is less than 5%. The condition of the construction of sewerage systems and wastewater treatment plants (WWTP) is low compared to European standards. Existing facilities which are in operation are serving approximately 600,000 inhabitants, i.e. less than 10% of the population.

Industrial capacities in the settlements are mostly connected to the public sewerage system. There are no reliable data on the types and quantities of industrial waste waters in the existing industrial facilities. The share of industrial wastewater in settlements is reduced due to the decline in production in the country and is estimated at less than 20% (in 1980s it was about 45%). The main problem in industrial wastewater is the general absence of their pre-treatment prior to discharge into the city sewerage system and recipients. Also, registration of industrial pollutants is not regular and complete.

Out of the total volume of wastewater discharged in 2013, 71% comes from households, 15% from industry and 14% from other sectors. Only 17% of the wastewater is treated in wastewater treatment facilities, out of which 2.4% with the primary treatment, 12% with the secondary treatment, and 2.5% with the tertiary treatment.

Dispersed source pollution from agricultural land, municipal landfills and the like should be quantified by targeted monitoring which has not been established in Serbia yet. Some landfills are located near watercourses and lakes, and some are less than 500 m from existing water sources. In addition, the share of illegal dumps in the total pressure of the solid waste is estimated at 50%.

The quality of water in watercourses is relatively good on the large rivers (Danube, Sava and Tisa) and some smaller rivers, while the situation is considerably worse in larger local rivers (primarily on the Velika Morava and rivers on which large cities are located).

Water quality has been systematically monitored at 140 stations covering 103 out of about 500 water bodies prescribed by law. Over 80% of monitored water bodies are classified at the II and III quality class, and less than 20% belong to the IV and V class. The curious phenomenon is that the water quality in the Danube on its flow through Serbia is improving.

The quality of drinking water is monitored by institutions/institutes for public health under the auspices of the Ministry of Health. In the period 2007-2012, microbiological and chemical conditions were not met at a rate of 4.9%, i.e. 15.4% of the samples from the water supply in urban areas, and 22.9% i.e. 50.5% of the samples from the water utility in rural areas [V.2]. The percentage of samples of drinking water in Serbia that does not meet the standards of hygienic validity is significantly higher in individual systems, than in the public water supply [V.9].

Climate change impacts

As discussed in previous chapters, the impact of climate change on the quality of surface and groundwater in Serbia can be at this time estimated only indirectly, through other indicators. The increase in air temperature will adversely affect water quality through an increase in water temperature as well as through an increase in the concentration of pollutants in the conditions of reduced water quantities. These effects are already visible in the basins of the rivers Velika Morava, South Morava, and West Morava [V.9].

Adaptation measures

According to the Second National Report on Climate Change, priority medium-term and long-term adaptation measures include:

- Construction of a wastewater treatment plant for all settlements with more than 2,000 inhabitants and industrial centers;
- The application of best available techniques for dispersed source pollution which originate mainly from agriculture;
- Increase in the price of wastewater treatment.

According to [V.6] strengthening the capacity of institutions in the water sector is a prerequisite for successful transposition and implementation of specific EU directives related to water quality (Water Framework Directive, Drinking Water Directive, Urban Waste Water Treatment Directive, Directive on the Protection of Groundwater Against Pollution and Deterioration, Bathing Water Directive, the Nitrates Directive, etc.). The most important prerequisite for the implementation of the Drinking Water Directive and the Urban Waste Water Treatment Directive is restructuring of public companies in accordance with the requirements of these directives, improving cost collection and dynamic alignment / increase in tariffs for the financing of developed infrastructure. Post-screening document [V.6] elaborates in detail on the priorities related to the transposition and implementation of the EU directives related to drinking water quality.

Integrating adaptation measures into existing plans and strategies

Adaptation to climate change in the light of integrated water management should look for solutions that will achieve multiple benefits in regard to water scarcity and risk management of floods and droughts, all through better alignment of planning and implementation activities at the basin level [V.18].

For the effective integration of adaptation measures to climate change into existing plans and strategies it is essential to ensure the preconditions related to the legal, institutional and economic framework of water management activities. These preconditions are most succinctly given through the following strategic objectives in the Draft Water Management Strategy [V.1]:

- The legal and institutional framework: completion of legal reforms of the water sector in accordance with the needs of adaptation to social conditions and requirements of the EU and the efficient organization of the water sector.
- Economic framework: to establish a system of sustainable, long-term financing of the water sector on the principle of self-financing, which implies stable sources of funding, the continuous inflow of funds and established mechanisms for covering costs.

Water management in Serbia can become sustainable only with these conditions, and sustainability will have the capacity to adapt to climate change.

Given that the Draft Law on Amendments to the Law on Water, as well as the Draft Water Management Strategy are currently in the process of public debate, further planning of the rehabilitation of water management and involvement of adaptation in this planning must take place immediately after the adoption of these documents.

The leading role in this process must have the Water Directorate as a state institution in charge of water management whose competence is water management. This institution must, by its nature, to be the coordinator for all other state institutions in activities related to strategic planning in relation to water management, and to establish clear distribution of jurisdiction in actions of implementation of strategic plans and documents, even when it comes to institutions of the same rank (other ministries such as the Ministry of Construction, Transport and Infrastructure, the Ministry of Mining and Energy, Ministry of Health, Ministry of the Interior, as well as other parts of the Ministry of Agriculture and Environmental Protection as the Environmental Protection Sector). Other institutions of importance are the Republic Hydro-meteorological Institute, the Environmental Protection Agency, the Office for assistance and rehabilitation of flooded areas, as well as similar institutions at the level of the Province of Vojvodina.

The territorial delineation of public water management companies according to the administrative division proved to be irrational and ineffective in practice; therefore, new legal solutions should envisage the division according to water areas. Cooperation with public companies in related fields, such as for example Electric Power Industry of Serbia, must be ensured through sustainable legal solutions.

Possible disadvantages and limitations

For a reasonable understanding of the effects of climate change on water resources the estimation of uncertainty is of great importance, especially in order to enable the implementation of no-regret and low-regret adaptation measures, i.e. those which will not lead to erroneous and non-refundable investment. The largest part of the uncertainty comes from the development of the society scenario and the concentration of greenhouse gases, climate modeling, hydrological modeling and other assumptions about changes in the future. The studies referred to in the Second National Report on Climate Change discussed mainly only one scenario of changes of greenhouse gases, the scenario A1B to the 4th report of IPCC, and the scenario A2 only in one case. The two studies used ensembles of climate models. In this way uncertainty was only partially analyzed, namely those stemming from climate modeling, while those derived from the change in estimate of the concentration of greenhouse gases cannot be assessed. Based on all the above, it can be concluded that the impact of climate change on the regimes of surface and ground waters in Serbia is not sufficiently investigated and that there are great uncertainties in terms of that impact in various parts of Serbia. When it comes to transit waters, the rivers Sava and Danube, at this moment we can use the results of other studies ([V.5], [V.15]) for the purpose of further analysis of the impact of climate change on certain water management branches and make recommendations for adaptation. On the other hand, when it comes to the domestic waters, further analysis is required which would help assess the impacts of climate change on hydrological regimes taking into account all the specific characteristics of individual basins, as well as the water management branches in certain parts of Serbia.

In the near future we expect results of analyses of climate change impacts on the hydrological regime for a number of catchments in Serbia as a result of the project TR 37005 from the Ministry of Education, Science and Technological Development, which will allow a better understanding of climate risks on the territory of Serbia.

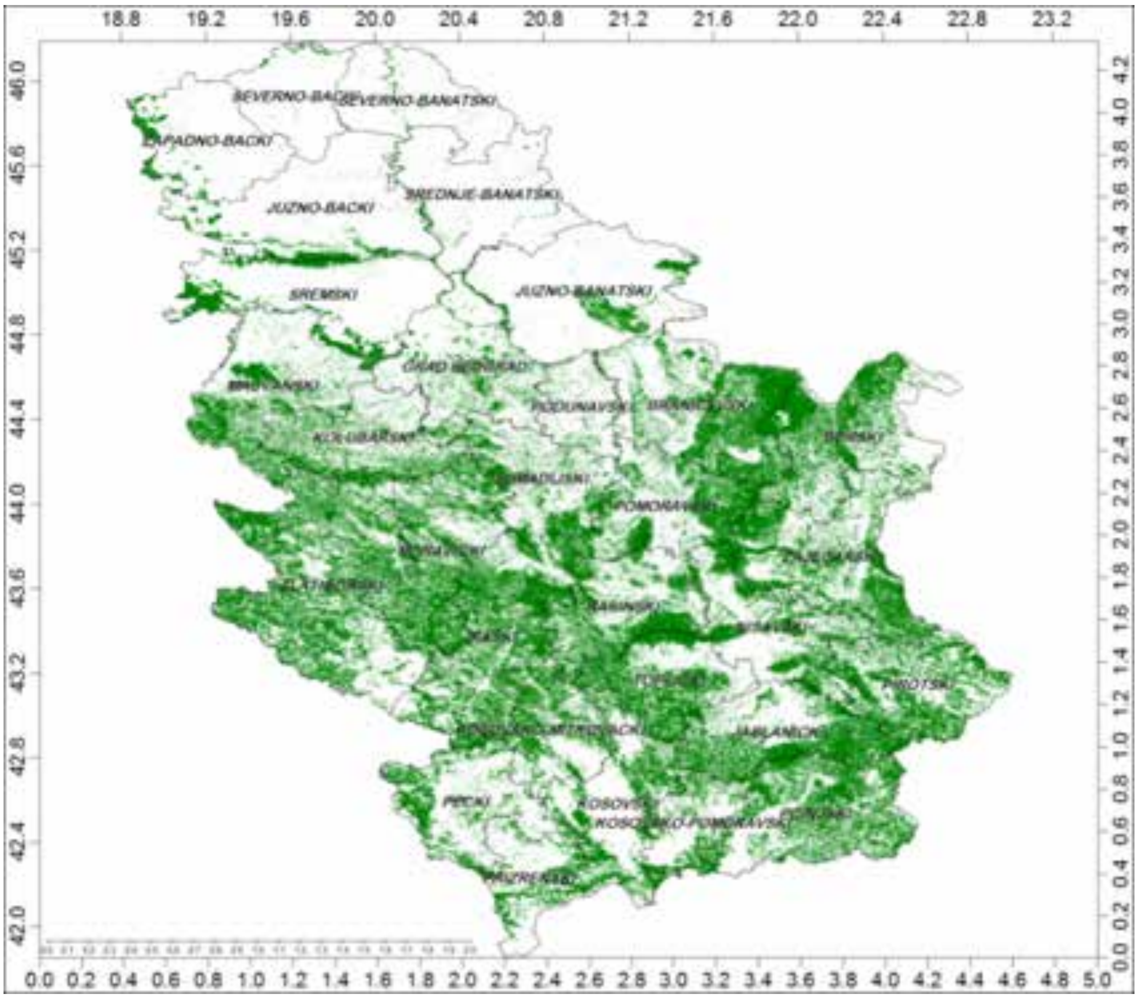
FORESTRY

Forestry

Based on the Spatial Plan of Serbia 2010-2020 [F.1]), the forest area of the Republic of Serbia amounts to 30.6% and the percentage of forest cover in central Serbia and Vojvodina is 29.1% (Figure F.1.). The national forest inventory of the Republic of Serbia [S.2] states that the total forest area in the Republic of Serbia (without data for the administrative province of Kosovo and Metohija) is 2,252,400 ha, 53% of the forest area being state-owned and 47% in private ownership. On the basis of the Regional Spatial Plan of Vojvodina [S.3] the forest area in Vojvodina is 144,388 ha. This document states that the production-protective forests are spread across 41.8% of the area, protective-regulatory woods across 8.5% of the area and protected natural goods across 49.6% of the area.

The main challenges that forestry has to face are related to the poor condition of forests (a large proportion of forest of coppice origin, a low volume increment, unfavorable age structure) uneven distribution of forest cover, poor road infrastructure essential for the use and protection of forests, and organizational problems in management related to the large number of private forest owners,. Based on these challenges, the increase of forest cover and its optimization is of great importance to forestry, and for the entire society. Increasing forest cover concerning the protective functions of forests is probably of greatest importance. Growing new forests and belts that will protect from wind and water erosion can simultaneously contribute to the adaptation of multiple sectors of society. Erecting windbreaks contributes to reducing the negative impact of winds on agricultural crops on the one hand, and on the other hand prevents backfilling canals for drainage and irrigation, while a the third advantage is that raises the share of the total forest cover, which is extremely low in some parts of Serbia. Overall, the newly erected forests bring new general useful and economic functions in regions where they are planted such as community development, development of hunting, rural and eco-tourism, environmental improvement, creating favorable conditions for people's health, favorable impact on the climate, and biodiversity conservation.

Figure F.1. Forest cover of the Republic of Serbia in 2000 with the highlighted administrative districts [F.4]

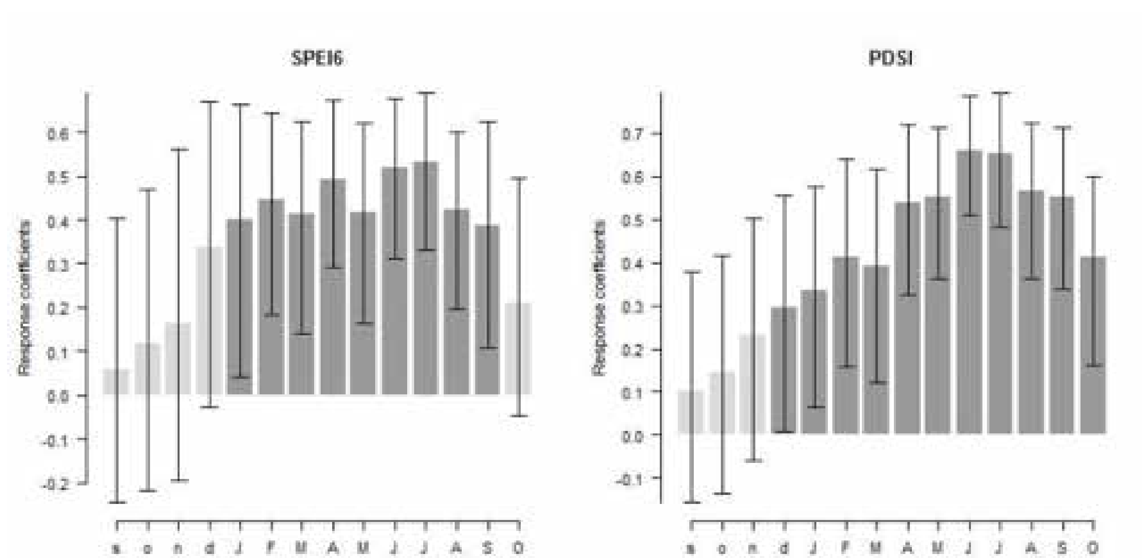


The impact of climate change

A spatial analysis of the potential impacts of climate change on the main tree species in Serbia shows that the expected impact will be different for different species. Previous research results suggest that the English oak will be the most exposed to the negative impacts of climate change. Its vulnerability stems from the fact that it is also dependent on groundwater which is subject to a general decline in recent decades in oak habitats in Serbia (data from the Republic Hydro-meteorological Service of Serbia). The distribution of the sessile oak, Turkey oak, fir, spruce, and beech is likely to change before the end of the 21st century based on calculations obtained by the drought index and the data for future climate; in the event of adverse scenarios of future climate it can be concluded that the least favorable conditions for forests in the 20th century will respond to the most favorable ones in the period 2071-2100. Black and white pine, as well as Downy oak, which are already present in arid areas, will be least affected by changing climate conditions [S.5].

New research suggests that in addition to long-term climate change, short-term climatic extremes such as longer periods of drought can have a significant negative impact on oaks in arid areas of our country [S.6]. Dendrochronology analysis of the effects of different climatic factors on Turkey oak (Quercus cerris) in Bačka shows that the accumulated precipitation summarized in SPEI6 (6-month Standardized Precipitation Evapotranspiration Index) or PDSI (Palmer Drought Severity Index) index correlate well with the increment in the period 1961-2010, especially during the summer months of June and July, when the tree trunks have the most intense metabolism and when they are most sensitive to drought [F.7]. (Figure F.2.). Given that these are lowland forests, which are particularly sensitive to climate change, the correlation between the accumulated precipitation, expressed through the indices, and the increment which has decreased in recent decades was expected. When it comes to beech and pine forests, the situation is much more complex in accordance with the change in climatic conditions. In the forests in western Serbia, where the amount of precipitation has increased in the past 30 years, a decline in increment was not recorded, but in some locations an increment was recorded.

Figure F.2. A simple Pearson correlation between the annual Turkey oak increment and average monthly values for the various indices in the period 1961-2010. Dark-gray peaks represent statistically significant correlation between increment and SPEI6 and PDSI indices.



Measures of adaptation to climate change in the forestry sector

Priority measures which contribute to the reduction of risk in relation to possible future changes in climate and that can provide the greatest effect in the sphere of forestry are:

- Establishment of new forests
- Construction of new forest roads
- Improving the quality of forests.

The establishment of new forests should achieve a number of different features. The emphasis should be on protective forests - windbreaks and forests that prevent soil erosion and torrents, simultaneously performing other beneficial functions.

The construction of new forest roads should be implemented with the aim of better prevention of the occurrence and spreading of fire and improvement of forest management in general.

Improving the quality of forests through conversion of coppice forest to high forest is important in terms of raising the adaptive capacity of forests. High forests as opposed to coppice forests provide both better environmental stability and better economic indicators.

Key documents and legal procedures relevant to the implementation of these measures are:

1. The Law on Forests [p.8]
2. Spatial Plan of Serbia 2010-2020 [F.1]
3. Regional Spatial Plan of Vojvodina [F.3]
4. National Forest Inventory of the Republic of Serbia [F.2]

Analysis of the measures proposed

The question of the rate of change of the degree of forest coverage is of great importance for the strategic planning in forestry as well as for adaptation and mitigation in relation to future climate change. Based on new research [F.4] forest coverage decreased in Vojvodina and Kosovo and Metohija in the period 2000-2013, while it increased in Central Serbia. A summary overview of changes in forest cover in Serbia is presented in theTable F.1. The largest relative decreases were recorded in the districts of Srem, Peć, West Bačka and Kosovo-Pomoravlje, while the largest increase was recorded in the Zlatibor, Raška, Pčinj and Morava districts.

Table F.1. Overview of area covered with forest trees and changes at the level of the Republic, regions and districts in the period 2000-2013. : Dark-green columns indicate the districts where the decrease of forest cover was registered.

District	District area (ha)	Forest cover 2000 (%)	Increase (2000-2013) (%)	Decrease (2000-2013) (%)	Summary of changes (2000-2013) (%)	Absolute change in forest cover (2000-2013) (ha)
BOR	351733	38,618	0,002	0,004	-0,002	-789
BRANIČEVO	386780	38,410	0,003	0,002	0,001	481
THE CITY OF BELGRADE	323713	16,612	0,004	0,006	-0,002	-796
ZAJEČAR	363255	39,293	0,002	0,003	0,000	-88
WESTERN BAČKA	248456	6,555	0,002	0,006	-0,004	-1031
ZLATIBOR	616114	43,389	0,011	0,002	0,008	5165

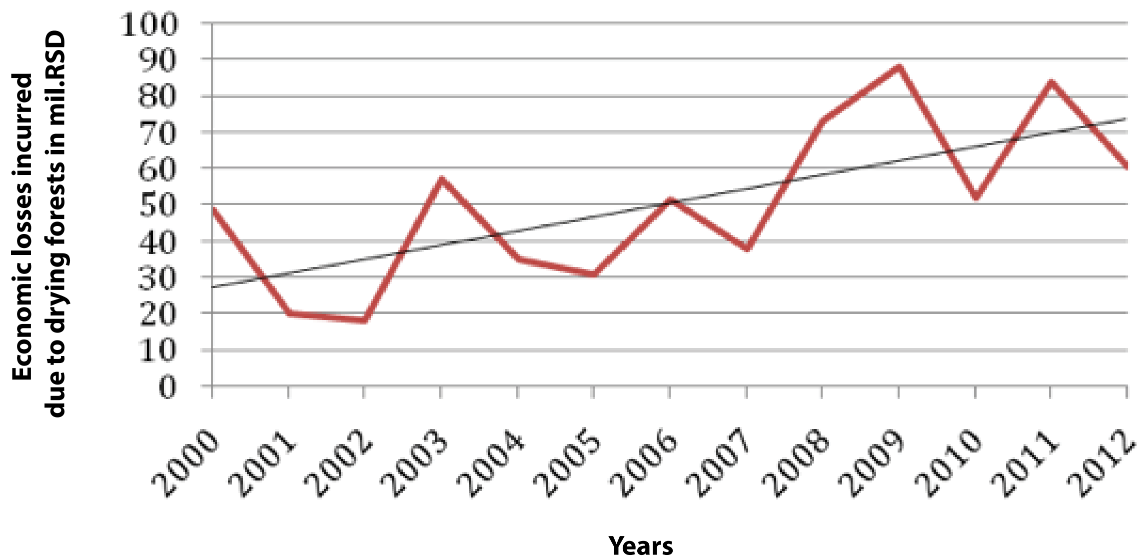
JABLANICA	276826	42,601	0,006	0,004	0,002	656
SOUTHERN BANAT	424254	8,009	0,003	0,003	-0,001	-293
SOUTHERN BAČKA	402448	6,957	0,003	0,006	-0,003	-1273
KOLUBARA	247463	29,777	0,002	0,002	0,000	-14
KOSOVO	312447	29,033	0,004	0,007	-0,003	-797
KOSOVO-MITROVAC	205430	35,979	0,006	0,005	0,001	192
KOSOVO-POMORA-VLJE	142930	26,562	0,009	0,012	-0,003	-484
MAČVA	326808	26,600	0,002	0,002	0,000	-22
MORAVA	302495	46,162	0,008	0,002	0,006	1798
NIŠAVA	273459	32,558	0,003	0,003	0,000	70
PEĆ	255971	22,962	0,006	0,010	-0,004	-1140
PIROT	276296	41,139	0,005	0,003	0,001	334
PODUNAVLJE	124187	9,569	0,001	0,000	0,001	89
POMORAVLJE	259805	37,019	0,002	0,002	0,001	152
PRIZREN	174889	21,568	0,002	0,004	-0,003	-442
PČINj	351215	41,404	0,013	0,007	0,006	2246
RASINA	266537	40,048	0,007	0,001	0,005	1431
RAŠKA	392680	48,732	0,011	0,003	0,008	3094
NORTHERN BANAT	233036	1,710	0,001	0,002	-0,001	-205
NORTHERN BAČKA	178148	1,790	0,001	0,001	0,000	-11

CENTRAL BANAT	326286	2,430	0,001	0,002	-0,001	-290
SREM	347827	15,011	0,003	0,009	-0,006	-2030
TOPLICA	220999	45,583	0,004	0,003	0,001	274
ŠUMADIJA	237925	28,843	0,001	0,001	0,000	-10
REPUBLIC OF SERBIA	8850414	28,454	0,005	0,004	0,001	6047
AUTONOMOUS PROVINCE OF VOJVODINA	2160456	6,718	0,002	0,005	-0,002	-5123
CENTRAL SERBIA	5598291	37,277	0,005	0,003	0,002	13959
AUTONOMOUS PROVINCE OF KOSOVO AND METOHIJA	1091667	27,411	0,005	0,008	-0,002	-2668

Damage assessment

Viewed from a general perspective, the Republic of Serbia has increased the forest area by 6,000 hectares. However, viewed in the context of the 2.5 million ha which is the extent of forest cover, the increase is only 0.001%. The fact that in 2/3 of the districts in our country a decrease in forest cover was recorded (gray fields in table Š.1), including all districts in the Autonomous Province of Vojvodina. One of the main causes of forest cover decrease is also the increased number of sanitary logging due to intensified drying. Drying of forests is associated with the occurrence of extreme events, primarily extreme drought (2000, 2003, 2007, 2011 and 2012), as well as windthrow, ice storm, fire and attacks by pests and diseases. Data on sanitary logging of "Srbijašume" show that the increased intensity of logging was occurring two to three years after major droughts. The decrease in forest cover is also affected by intense fires, especially the fires from 2007 and 2012, which were also years of great drought. In addition to drought conditions and fires, extensive damage to forests in Serbia and significant contrinution to the reduction of the vitality of forests and their subsequent drying was caused by a gypsy moth (Lymantria dispar L.). Widespread occurrence of the gypsy moth was recorded in 2004, as well as in 2013 and 2014. Finally, an example of economic losses due to drying of forests and other adverse impacts is the growing trend of operating losses of the public enterprise "Vojvodinašume" (Figure F.3) since 2000. Average annual losses in this period exceeded the amount of 50 million dinars. Estimated direct and indirect damage caused by fire in the public enterprise "Srbijašume" in the period 2000-2009 amounted to 36,454,762,406.56 dinars [s.9] . Considering that climate scenarios are the basis for predicting longer periods of drought and more frequent extreme events, it is to be expected that the processes related to the drying of forests will intensify in the future.

Figure F.3. The estimated economic losses incurred due to drying forests in the forests managed by "Vojvodinašume" in the period 2000-2012.



Previous investments in the sector for the purpose of raising adaptive capacity to climate change has been conducted in the area of new afforestation, forest tending, forest road construction, production of seeds and planting materials, research, forest protection and other activities. The Forest Directorate of the Ministry of Agriculture and Environmental Protection, subsidized the protection and improvement of forests with approximately 33 million EUR in the period 2004-2013 (Table S.2.).

Table F.2. Subsidies in forestry (funds for the protection and improvement of forests) in the period 2004 - 2013 (Source Forest Directorate)

Year	Afforestation on state land		Private afforestation		Maintenance		Construction of forest roads		Forest seeds production		Forest seedlings production		Scientific research	Protection	Other	TOTAL
	ha	€	ha	€	ha	€	km	€	kg	€	kom	€	€	€	€	€
2013	33	31,512	801	260,085	0	0	114	1,264,288	16,838	10,482	0	0	163,388	450,920	520,014	**2,700,689**
2012	297	282,018	407	117,963	1,904	434,356	167	1,656,510	7,037	29,631	3,628,955	192,343	235,049	176,523	307,602	**3,431,995**
2011	472	516,460	767	267,548	2,270	564,874	171	1,424,675	6,577	22,486	4,692,690	242,230	198,550	159,197	168,767	**3,564,787**
2010	921	586,314	1,155	258,112	2,053	476,716	157	963,996	283,234	88,805	2,937,177	174,750	176,095	189,468	183,938	**3,098,194**
2009	785	549,463	1,318	358,323	870	144,044	140	1,184,382	256,059	84,867	3,157,357	182,407	196,591	258,502	35,025	**2,993,604**
2008	485	349,007	749	277,070	2,909	527,978	161	1,580,500	7,410	51,988	6,914,800	312,649	256,638	709,162	458,322	**4,523,314**
2007	1,571	1,448,133	1,441	477,888	3,087	501,334	127	1,165,581	38,750	44,985	7,360,384	303,224	252,906	112,673	309,087	**4,615,811**
2006	1,010	431,757	1,043	220,918	3,060	266,340	59	319,580	126,599	79,702	4,941,079	131,177	188,231	960,829	223,531	**2,822,065**
2005	961	319,188	1,036	213,016	2,958	236,935	76	241,792	4,229	35,185	4,981,732	134,385	96,735	1,627,530	169,287	**3,074,053**
2004	1,418	285,435	1,263	297,333	3,883	307,416	57	192,232	24,760	37,385	8,047,500	167,110	124,575	621,256	224,840	**2,257,582**
∑∑	**7,951**	**4,799,287**	**9,981**	**2,748,256**	**22,994**	**3,459,993**	**1,230**	**9,993,536**	**771,493**	**485,516**	**46,661,674**	**1,840,275**	**1,888,758**	**5,266,060**	**2,600,413**	**33,082,094**

Regional prioritization of the measures proposed

The increase in temperature and change of frequency and intensity of precipitation will have a direct or indirect impact on all segments of society in Serbia and also on the forestry sector. However, certain regions in Serbia may find themselves under increasing pressure caused not only by the projected future climate change. The main objective of the analysis of the proposed measures was a more efficient adaptation to climate change through the assessment of regional peculiarities within the territory of Serbia. The analysis of the effectiveness of measures is focused on the choice of the region in relation to the criteria according to which the regions are ranked by the degree of vulnerability from the aspect of forestry. Criteria are selected in order to comprehend the broader context of vulnerability, in addition to the possible future threats of climate change, through the assessment of the current state of forests, economic and demographic characteristics, as well as additional benefits in other sectors such as agriculture, water resources and protection of nature, and in relation to the proposed adaptation measures. Ten criteria based on which the prioritization of the region was conducted are given in table F.3. Each of the proposed criteria was associated with the geo-referenced map that quantifies the given criterion, whether representing current values or projected values for the future.

Table F.3. The criteria for determining the priority regions for the implementation of adaptation measures in Serbia

	Criteria	Adequate geo-referenced map for the territory of the Republic of Serbia
1.	Forest area	State based on [F.4]
2.	Forest quality (conversion of coppice forests to high forests)	State based on National Forest Inventory (State based on F.2])
3.	Road infrastructure	Current situation (road network based on Digital map of Serbia in vector format 1: 300000 of the Military Geographical Institute)
4.	District population	State based on the Population and Housing Census in the Republic of Serbia from 2011
5.	Unemployment rate	Current state
6.	Average income	Current state
7.	Budget surplus / deficit	Current state
8.	The change of climate (temperature and precipitation)	Projected values
9.	Erosion (water and eolian)	Map was not available
10.	Nature conservation (ecological network)	Current state

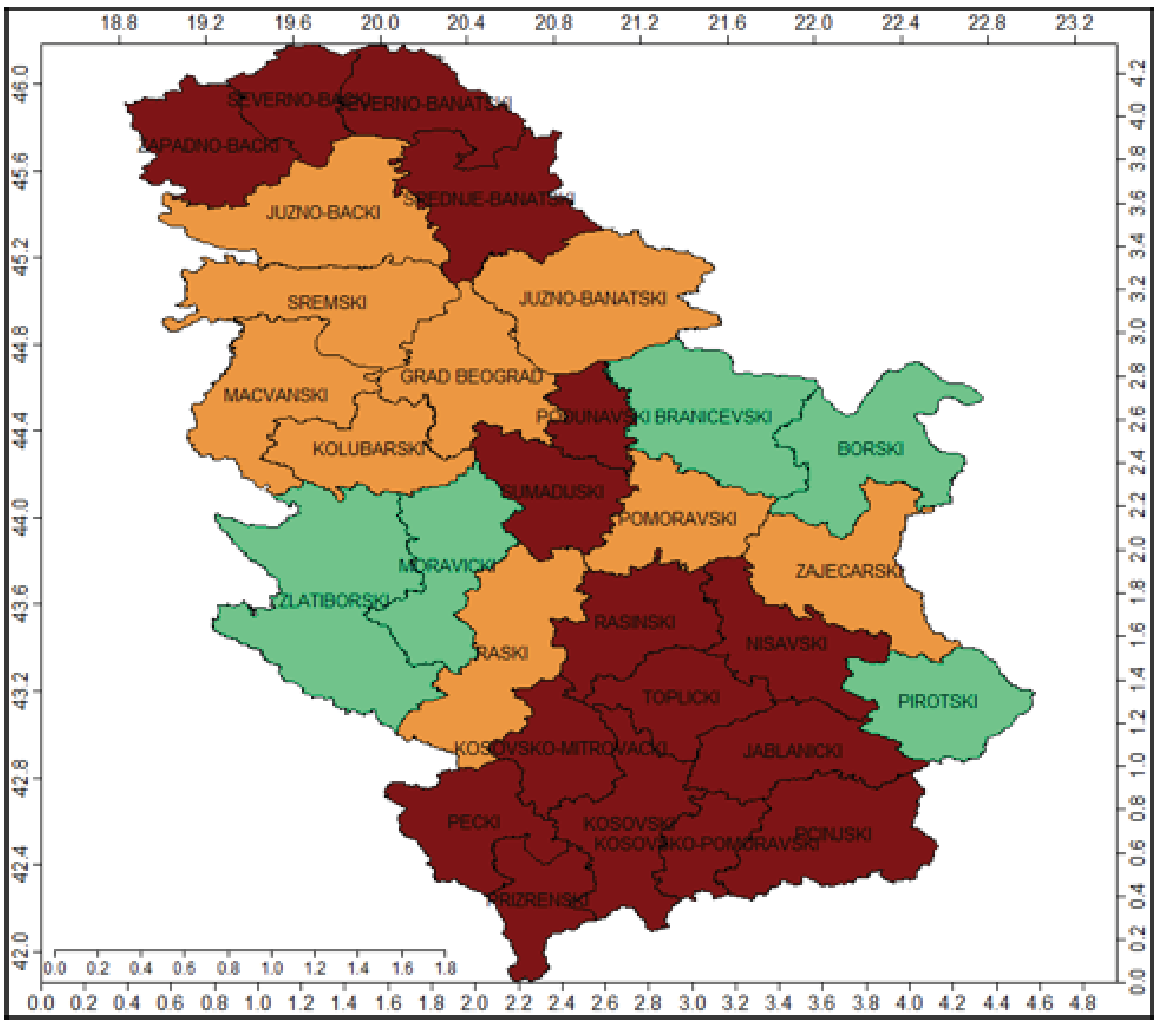
Each of the criteria was assessed in relation to their immediate impact on the general situation in the forestry sector or through its influence on the adaptive capacity of the proposed measures with respect to future climate change. In order to achieve robust results, the criteria were assessed by experts from different fields (climatology, forestry, economics, agriculture, water management and nature protection) and different organizations (ministries, institutes, public enterprises, faculties, and research institutes) and the final ranking was performed using the methods of analytical and hierarchy processes [S.10, S.11]. The result of the final ranking is given in Table F.4.

Table F.4. Ranked criteria by experts on the importance of regional adaptation to climate change

Criteria	Rank	Values
Climate change (temperature and precipitation)	1	14,9%
Nature protection (ecological network)	2	11,8%
Unemployment rate	3	11,3%
Erosion (water and eolian)	4	10,1%
Average income	5	9,9%
Budget surplus / deficit	6	9,7%
The area under forests	7	9,2%
District population	8	8,7%
The quality of forest (conversion coppice forests to high forests)	9	8,4%
Road infrastructure	10	6,0%

As the final result we obtained the map of vulnerability of certain regions as the compounded average of prepared maps, using the weights obtained by previous criteria rankings. Based on these results, we can conclude that the most vulnerable regions are the: Western and North Bačka, North Banat, Central Banat, Podunavlje, Šumadija, Rasina, Nišava, Toplica, Jablanica and Pčinja district (Figure S.4.). Although shown on the map, most of the data for the districts in AP of Kosovo and Metohija were not available.

Figure F.4. Vulnerability of regions in the Republic of Serbia, based on nine criteria: area covered by forests, the quality of forests, road infrastructure, the population of the district, unemployment rate, average income, the budget surplus / deficit, climate change, size of the protected goods. First ranked as the most vulnerable - dark red, the second-ranked orange, third-ranked green.



The most vulnerable areas to the impact of climate change according to the presented methodology are those which were by multiple criteria denoted as endangered. The greatest expected change in climate, together with poor economic indicators that were crucial to highlight were the 11 districts marked dark red. The population of the district was considered in terms of the number of inhabitants, since the higher number of inhabitants, the higher the vulnerability. However, the maximum weight of influence in this selection criteria was climate change and economic indicators. The assumption was that economically developed districts, as well as citizens who have more money have more options for adaptation and mitigation of negative affects of climate. Also, given that forests have beneficial effects on the microclimate, it was concluded that the regions with more forests and better quality forests are in a more favorable position than those that are lagging behind in this regard.

It is also important that the areas in which it is expected for climate changes to be the most pronounced are already endangered in terms of forestation and realizing the benefits of ecosystem services that forests can provide. Therefore, an increase in forest cover and its optimization in terms of reforestation of deforestated areas and planting protective forests should be a priority in the adaptation of the entire society to climate change. Increased activity related to the establishment of new forests and improvement of existing ones will lead to an increase in economic activity in the affected areas.

Anticipated future climate change will affect the forests in Serbia. At higher altitudes, the impact can be even more positive; however, in the lowlands, where there the largest part of the population lives and where the largest part of economic and social activities take place, the expected changes are negative.

Recommendations for the implementation of measures

Analysis of past financing for the improvement of the situation of state of forests in relation to adaptation to climate change has shown that certain activities, such as the construction of forest roads have been adequately funded and promoted over the course of the last ten years (Table F.2., The data of the Forestry Directorate). However, improvement of the quality of forests, which includes the conversion of forests is not sufficiently represented. The most critical situation is in the area of distribution of forests in Serbia and increased forest cover. Although financing exists, and although in the period 2004-2013 under the program of using the funds of the budget fund for forests of the Republic of Serbia 18,000 ha of forests was financed with approximately 7.5 million euros, this surface did not significantly improve the situation in areas such as the Northern Bačka, Northern Banat and Central Banat districts, whose forest cover is about 2%. Measures to strengthen the adaptive capacity of forest ecosystems and their expansion can be implemented through an annual program of utilization of funds from the Budget Fund for Forests of the Republic of Serbia and the annual program of utilization of funds from the Budget Fund for Forests of AP Vojvodina.

The establishment of new forests should be a more significant item in the annual programs. In the Republic of Serbia in the period 2004-2013, planting of new forests on public land and on land owned by individuals was financed with 23% of fund assets. It is recommended that at least 40% of the annual program of funds from the Budget Fund in the Republic of Serbia and AP Vojvodina in 2016 and the coming years should be used for subsidied planting of new forests on state and private land. A minimum of one third of the funds for financing reforestation should be allocated into districts that have forest coverage below 10% and at least one third into protective forests. The total target area should amount to 6,000 hectares per annum, which is in line with the Programme of forestry development within the territory of the Republic of Serbia for the period from 2011 to 2020 [S.12]. The establishment of new forests will contribute to the economic empowerment of local communities, the improvement of human health, the reduction of the harmful effects of wind and water erosion and enhancement of the conservation of biodiversity.

Construction of new forest roads is regularly performed by programs using the funds of the Budget Fund for Forests, both in the Republic of Serbia and in the Province of Vojvodina. Further financing of the improvement of road infrastructure in the forests should continue in its present scope with the aim of prevention and more effective mitigation of potential fires and improvement of forest management. The total length of newly built roads should be 234 km per annum on the basis of the Programme of forestry development in the territory of the Republic of Serbia for the period from 2011 to 2020 [F.12].

Improving the quality of forests through the conversion of coppice forests to high forests is an important aspect of strenghtening forest ecosystems and increasing adaptive capacity. Regular subsidizing of efforts to convert coppice forests to high forest should be included in the program of the Budget Fund for Forests. The target surface to be improved at the national level through direct conversion of devastated coppice forests is 6,321 hectares per year and indirect conversion of coppice forests on the area of 65,984 ha per year based on the Programme of forestry development in the territory of the Republic of Serbia for the period from 2011 to 2020 [F. 12]

BIODIVERSITY

Biodiversity

From the climatic, pedological and vegetation-ecosystem perspective, Serbia is unique due to the fact that at a relatively small area almost all types of biomes of Europe are inter-changing, i.e. their modifications [B.1]. According to the climatic zoning of Serbia and based on the classification of geo-biosfere zonobiomes, the territory of Serbia is characterized by two main zonobiomes: in the moderate climate conditions with short periods of frost and brown and gray forest soils, represented mainly by oak and beech forests, the zonobiome of deciduous (broadleaf) forests dominates; in the arid conditions of the moderate-continental type climate with cold winters, with chernozem as zonal soil and steppe vegetation, a steppe zonobiome is predominant. In addition, the mountainous terrain conditions altitudinal zoning and the appearance of an orobiome type, which in Serbia has led to the differentiation of two basic types of orobiomes, which are somewhat equivalent to the zonobiomes of the northern Holarctic regions: in the conditions of cold temperate climate on podzolic soils, prevalent in the subalpine zone, in the conditions of the mountain climate of the continental part of the country, there is the zonobiome (orobiome) of coniferous boreal forests, while the initial soil conditions in the Alpine climate of the highest mountains in Serbia extends to a zonobiome (orobiome) of high-mountain "tundra". Taking into account abiogenic and biogenic factors of biodiversity, Serbia is a country which has a very rich natural and cultural heritage and is one of the important centers of biological and geological diversity in Europe.

The Biodiversity Strategy of the Republic of Serbia with the Action Plan for the period 2011-2018. ("Official Gazette" no. 13/2011), defines the objectives relating to climate change, which refer to the development of a national strategy and mechanisms so that the possible impact of climate change on biodiversity is understood, planned and reduced to a minimum. Following on that is the aim to increase the capacity of institutions responsible for the monitoring and prediction of climate change impacts on biodiversity and the evaluation of the effectiveness of strategies and adaptation measures, as well as to raise awareness among all sectors and the general public about the impacts of climate change and preparation of adaptation strategy. One of the primary activities is the development and implementation of the National Action Plan for Biodiversity and Climate Change and creating the assessment of vulnerability of biodiversity to climate change in Serbia. In addition, the Strategy of biodiversity underlines the need to develop specific strategies for adapting protected areas to climate change. Following the analysis of the assessment of progress in the implementation of the Strategy of biodiversity in relation to the set objectives, for the purpose of preparation of the Fifth National Report under the United Nations Convention on Biological Diversity, it was determined that the strategic goal related to climate change has been accomplished to a very low extent [B.2].

The National Strategy for Sustainable Use of Natural Goods and Resources ("Official Gazette" no. 33/2012) as one of the specific objectives for the sustainable management of protected areas, biodiversity, geo-diversity and landscape diversity, emphasizes the need to carry out national analyzes of sensitivity to climate change and development and the implementation of strategies for adapting the management of protected areas. In addition, based on the national analysis of shortcomings in the system of protected areas and the sensitivity analysis to climate change, this Strategy envisages the development of a national plan to expand the system of protected areas. The National Strategy of Sustainable Use of Natural Goods and Resources also envisages the implementation of a national analysis of sensitivity to climate change and the establishment of the monitoring of the impact of climate change on biodiversity.

Although in the strategy documents the problem of climate change within this sector has been recognized as important, very little has been done to date, especially on the issue of systematic and institutional engagement. There is still a significant lack of information relating to:

- Identified impacts in response to current climate trends;
- Understanding of the factors that influence the distribution and abundance of species;
- Analysis of species, ecosystems and regions that are most vulnerable due to the impact of climate change;

- Comprehensive evaluation of available adaptation options, including modifications needed for the existing planning and protection practice;
- Analysis of current and future social and economic costs of climate change impacts on biodiversity;
- Understanding of the factors that determine the resilience and adaptive capacity of ecosystems

The impact of climate change

Over the past decades the reduction of biodiversity, among other things, is attributed also to a significant loss of natural habitat as a result of the expansion of agricultural land (especially in the Pannonian Plain), drainage of wetlands and marshes and irrigation of steppes for the purpose of growing agricultural crops, as well as the degradation and loss of forest cover. The complete destruction of natural habitats and their replacement by artificial habitats has created inadequate conditions for the survival of many plant and animal species. The colonization of habitats by invasive species and the introduction of exotic species in natural habitats leads to increased competition for resources and adversely affects the survival and productivity of autochtonous species. Possible future climate changes represent additional pressure on biodiversity in terms of reducing further loss.

However, the direct impact of these observed changes and the impact of potential future climate change on biodiversity and ecosystem services in Serbia are very little studied, primarily as part of the activities under scientific research projects, and also in the framework of projects of international organizations which referred to the broader impacts of climate change, including biodiversity, to some degree. Thus, for instance, in a project that dealt with the impact of climate change on biodiversity in South-East Europe [B.3], the general assessment of the possible consequences were given, according to which changes are expected in habitat conditions, in the distribution of species and increasing problems with invasive species. Denoted as the most vulnerable areas in Serbia are high mountain landscapes, pastures, forests, riverbanks, wet and steppe habitats. The relatively high sensitivity of the ecosystem is due to the fact that they are already largely disrupted, fragmented and exposed to anthropogenic pressures, making them generally more vulnerable to climate change. Particularly emphasized is the sensitivity of species related to the high mountain habitats, where the appropriate ecological area will be significantly reduced by global warming. Table B.1 provides an overview of projects that have dealt with the influence of climate change and adaptation in the wider context and/or the region and in which, among other sectors, impacts on biodiversity were analyzed.

Table B.1 Overview of projects

Project, implementation period, the institution-leader	Web address
Overview study on the impacts of and adaptation to climate change in the Danube-Carpathian region 2008, CEU	http://www.ceu.edu/project/overview-study-impacts-and-adaptation-climate-change-danube-carpathian-region
Climate Change Framework Action Plan for Adaptation for South East Europe (CCFAP), 2008, REC	http://www.rec.org/project_reference_EU-.php?id=130 http://www.seevccc.rs/CCFAP-A/CCFAP-A.pdf
The First Report of the Republic of Serbia under the United Nations Framework Convention on Climate Change, 2010, the Ministry of Physical Planning and Environmental Protection	www.klimatskepromene.rs

CarpathCC Climate Change Framework Project, 2011-2013, REC	http://carpathcc.eu/node/35 http://carpathcc.eu/sites/default/files/carpathcc_zerdelyi_presentation.pdf
OrientGate, 2012 -2014, Euro-Mediterranean center for Climate Change	http://www.orientgateproject.org http://www.southeast-europe.net/en/projects/approved_projects/?id=163
Climate change, impacts and vulnerability in Europe 2012, 2012, ЕУ	http://www.eea.europa.eu/publications/climate-impacts-and-vulnerability-2012
The Second Report of the Republic of Serbia under the United Nations Framework Convention on Climate Change, 2013-2014, the Ministry of Agriculture and Environmental Protection	www.klimatskepromene.rs

The results of these projects have shown that climate change in Serbia can lead to the following changes in relation to biodiversity:

- Phenological changes (changes in the phases of the life cycle of plants, animals and fungi that affect the migration, reproductive cycles and hibernation of sensitive species); it should be borne in mind that individual populations are likely to be more specialized and have a more limited environmental tolerance and adaptive potential than species considered in its entirety. Increasing temperatures will change the life cycle and stimulate an early appearance in the spring of various biological phenomena, such as the spring phytoplankton bloom, pure water phase, the first day of flight of aquatic insects and fish spawning time. The extension of the growing season can have a major impact on the species.
- Changes in morphology, physiology and behavior of species; the possibility is foreseen that there will be an increase in the biomass of representatives in certain populations of species.
- The loss of existing habitats and emergence of new modified conditions to which species are not adjusted; even small changes or losses of favored areas and habitats can result in the loss of local populations, especially those who have limited possibilities of spread [B.4].
- Changes in the abundance and distribution of species; based on the results obtained by analyzing the presence and distribution of 856 plant species, in the conditions of the anticipated increase in global temperature of 3 ° C by 2100, it was found that unless measures to mitigate climate change are taken, in the region of Southeast Europe there may occur an increase in the number of new species by 20-30%, and that about 25% of the species that are now present will disappear by that period [B.5].
- Increasing the number of pests and diseases; this possible scenario particularly envisages that due to elevated temperatures to species which were brought in (foreign, invasive, pests) it will enable the adequate conditions in areas where the microclimate has changed; such species in the new environments, due to the lack of predators and natural diseases can become more competitive compared to domestic species [B.6].
- Genetic changes, followed by the extinction of species unable to adapt to changes in natural habitats caused by climate change; in the analysis of populations of mammals in Europe, including the territory of Serbia, it was found that endemic species will be under higher influence of climate change, primarily due to limited distribution and a reduced potential to adapt to changing conditions [B.7].

Measures of adaptation to climate change

Within the First National Report of the Republic of Serbia under the UN Framework Convention on Climate Change, estimates were given of vulnerabilities in the sector of biodiversity as well as a proposal of adaptation measures. We identified four strategic areas: risk reduction, policy and institutional framework, monitoring and research, capacity building and awareness raising. In this report, we will analyze first of all the measures that should reduce risks in relation to changed climate conditions:

- Increase the area under protection
- Development of a functional ecological network
- Protection and improvement of forest and aquatic ecosystems
- Monitoring of species used for commercial purposes and planning their sustainable use
- Monitoring of invasive species and control of their spread

Increasing the area under protection

Natural, preserved ecosystems have a greater ability to adapt to changes, and in protected areas, with a special protection regime, one can preserve the adaptive potential of the ecosystem. Protected areas are part of the global response to climate change and impact the mitigation of climate change in terms of reducing emissions of greenhouse gases. In protected areas, the effect of preventing the loss of carbon that is already present in vegetation and soil is increased; protected areas absorb the remaining carbon dioxide from the atmosphere in natural ecosystems.

The development of functional ecological networks Ecological networks are one of the concepts of nature protection that has been developed in order to ensure the functional connections of the ecosystem in the wider areas; the Ecological Network represents one of the steps in the establishment of the Natura 2000 network in accordance with the Habitats Directive and the Birds Directive of the European Union. The development of ecological networks increases the surface area under protection, which in addition to its primary function of protecting species, habitats, ecosystems and landscape, according to its characteristics and purpose of existence, also have a role in mitigating climate change.

Protection and improvment the condition of forests and water ecosystems

Forest ecosystems are of great importance in the process of adaptation to climate change. Together with the forestry sector it is necessary to develop programs and plans for the protection and improvement of existing forest ecosystems, as well as plans to expand forest areas in accordance to the needs of protection and conservation of biodiversity. Water ecosystems are of particular importance for the conservation of biodiversity, taking into account the richness of wildlife and the importance that these resources have for human well-being; water resources are one of the most sensitive natural ecosystems; it is necessary to protect the preserved natural ecosystems, but also work on the revitalization of degraded aquatic ecosystems.

Development of monitoring of species used for commercial purposes and planning their sustainable use Medicinal and edible plants, fungi, snails, frogs, leeches and poisonous snakes, which are used to prepare serum are species from nature which are extensively used for various commercial purposes. If the collection is not controlled, it can pose a serious threat to their survival. Threats to populations of these species can be significantly increased also by the adverse effect of climate change, so it is therefore necessary to reinforce the control of their collection from nature, especially by developing the system of monitoring the state of populations of species that are collected in order to be able to plan their sustainable use.

Monitoring of invasive species and control their spread

The spread of invasive species impacts the reduction of biodiversity, invasive species are often more competitive than indigenous species, they do not have enemies on the area of their expansion who otherwise exercise control in their natural systems. It is necessary to do an inventory of invasive species in Serbia, to develop a system for monitoring the occurrence and distribution of species with invasive characteristics, make plans for controlling the spread of these species and their harmful effects on native species which are of importance to agriculture, forestry and fisheries.

Analysis of the measures proposed

Increasing the area under protection and the development of ecological networks

Protection of biodiversity in Serbia is accomplished by the implementation of measures to protect and improve the species, their populations, natural habitats and ecosystems, through the system of protection of natural resources: protected areas, protected species and mobile protected natural documents (Law on Nature Protection, "Off. Gazette of RS, no. 36/2009 and 88/2010"). Categories of protected areas in Serbia at the national level are: strict nature reserves, special nature reserves, national parks, natural monuments, protected habitats, landscape of outstanding features and nature parks. National parks are regulated by a special law.

The Institute for Nature Conservation of Serbia prepares protection studies as professional documentation for the protection of certain areas, which contain information about the borders, protection zones and cadastral municipalities they include, information about their natural features and values, including geographical, geomorphological, geological, hydrogeological, and climatological characteristics (but without special emphasis on solving the problem of climate change, which could possibly be taken into consideration), data about the present wild species of plants, animals and fungi, information on cultural heritage, opportunities for the development and promotion of tourism, but also including the basic data referring to the socio-economic and other aspects. The study of protection includes protection regimes, the proposed protection measures and the proposed control of a manager of a natural resource. Prioritization in the protection of areas is carried out on the basis of secondary legislation, such as the "Code on the content and manner of keeping the register of a protected natural area" ("Official Gazette "no. 81/2010); "Code on the categorization of protected natural areas" ("Official Gazette of RS" no. 103/2013); "Decree on the protection regimes" ("Official Gazette of RS" no. 31/2012), "Code on criteria for determining the habitat types, on habitat types, vulnerable, endangered, rare, and habitat types of priority for protection and safety measures for their conservation" ("Official Gazette of RS" no. 35/2010). According to the Law on Nature Protection, the wild species that are threatened or may become threatened, that have special significance to the genetic, ecological, ecosystem, scientific, health, economic and other aspects, are protected as strictly protected species or protected wild species.

The medium-term program of the Institute for Nature Conservation of Serbia, for the period 2010-2020 contains a list of goods that will be protected over this period. To date, the procedure of protection has been long and it often happened that the areas which were officially being declared as protected had lost their previous status of importance for the protection or change. According to the new amendments to the Law on Nature Protection, which is in process, as soon as the Institute sends the Study of protection to the competent state authority or local self-government, they are obliged to publish on their websites the information about the arrival of studies, so that from the date of publication on the website the area is categorized under that specific recommended level of protection.

The number of protected areas in Serbia is 474. The total area under the protection is 564,063 hectares, which represents 6.38% of the total territory. According to the Spatial Plan of Serbia ("Off. Gazette of RS", no. 88/10) by 2021 12% of the territory should be protected. Increasing the area under protection is one of Serbia's requirements as a signatory of the Convention on Biological Diversity, bearing in mind that the achievement of the strategic (Aichi) target relating to the improvement of biodiversity through the preservation of diversity at all levels (ecosystem, species and genetic diversity), particularly areas of particular importance for biodiversity and ecosystem services, are conserved through effecient management by means of ecologically representative and a well connected system of protected areas and with other efficient conservation measures, which should facilitate the integration of protected areas into wider landscapes. In Serbia there are also 1760 strictly protected species and 853 protected species of plants, animals and fungi ("Law on Nature Protection", "Off. Gazette of RS", no. 36/2009, 88/2010 and 91/2010) and "Code on declaration and protection of strictly protected and protected wild species of plants, animals and fungi" ("Off. Gazette of RS", no. 5/2011, 47/2011 and 69/11). A special type of protection refers to species that may be endangered due to excessive and unregulated collection from nature. However there is no list of species that may potentially be affected by climate change.

Protected areas according to their function and purpose represent unique areas from the standpoint of adaptation to climate change and in terms of preventing the loss of biodiversity and mitigating the effects of climate change on biodiversity. Furthemore, protected areas provide ecosystem services that are vital to the survival of local communities.

Recommendations for implementation

In order for the protected areas to perform their functions, it is necessary in the following period, at the national level to plan and develop activities in two directions - ensure the financial sustainability of the existing system of protected areas and expand the area under protection, in accordance with the principles of establishing a European Network Natura 2000 and the national system of protected areas. Sustainable use of natural goods and resources, including the possibility of extending the area under protection, depending on the system's financing and management of protected areas. The Law on Environmental Protection ("Official Gazette", no. 135/2004 and 36/2009), stipulates that the Republic of Serbia, autonomous province, i.e. local self-government, within its competence provide funding and achieving environmental objectives while the funds for environmental protection may provide through grants, loans, funds of international aid, foreign investments earmarked for environmental protection, funding from instruments funds and programs of the UN, the EU and other international organizations. This Law on Environmental Protection defines economic instruments, such as charges for the use of natural resources, fees for pollution of the environment, areas of special interest, fees for the protection and improvement of the environment, budget funds and international financial aid, and economic incentive measures. Of all the instruments and mechanisms, the state budget is an important component of the financing of protected areas in Serbia, regardless of the fact that the budget funds allocated for the financing of the system of protected areas is very small (in 2012 only 20% of the budget of protected areas originated from government sources). Therefore, the system of protected areas in Serbia should be improved in order to ensure sustainability after the expansion of areas under protection. For the functioning of public enterprises established for the management of the category of a national park (according to financial statements shown in the Information Bulletin of the public enterprise National Park Tara and public enterprise Fruska Gora, 2015), it is necessary to allocate almost 3 million euros per year.

Financial mechanisms for sustainable financing were considered in order to ensure stable financing mechanisms of protected areas, based on realistic assessments of needs and available resources [B.8]. In the context of adaptation to climate change, the investment required for the expansion of protected areas is much smaller in comparison to the damage due to the effects of climate change. Other factors threatening biodiversity can lead to loss of habitat, species and disrupting the balance of the ecosystem.

Preparation of the Study of protection is entirely financed from the budget funds and involves hiring researchers to collect data, field work, procurement of equipment and other direct and indirect costs. It is estimated that the production of a Study on this protection annually costs about 30,000 EUR (Based on the financial statements of the Institute for Nature Conservation of Serbia, the Report on Operation of the Institute for Nature Conservation of Serbia, August 2015). For the preparation of the Study of protection the required optimal period is two years of monitoring the situation in the field. According to the Medium-term Programme of protecion of natural resources for the period 2011-2020 (Institute for Nature Conservation of Serbia, 2011), for this ten-year period 165 protection studies are planned for development, out of which 37 relate to the individual trees. Taking these plans into account, for the period until 2020 it will be necessary to allocate 7,680,000 million EUR in order to implement the plan.

Once the balanced processes of nature are disrupted, it is very difficult or impossible for them to return to normal, the processes are more lengthy, require constant investment and the renewal percentage is never complete. Some experiences of other countries show that in the case of restoration of areas where under the influence of climate change or other factors and pressures biodiversity was decreased or lost, to return to the previous state takes from a few hundred to a few thousand USD per ha [B.9, B.10]. The establishment of the ecological network through the restoration of degraded areas, especially if there is the degradation occurred by intensive land use for agriculture or forestry purposes is not cost-effective for the community. Therefore, the evaluation of ecosystem services in such areas is performed and on the basis of cost-benefit analysis evidence is obtained that the current values of ecosystem services are higher than short-term profit, which arises from agricultural or forestry activities.

Possible disadvantages and limitations

On the basis of the analysis of the system of protected areas in Serbia [B.11], it was found that the existing regulations and strategic documents do not incude a clearly defined vision and plans that would ensure stable and long-term financing of protected areas in Serbia. On the basis of the available financial data of the Institute for Nature Conservation of Serbia and Provincial Institute for Nature Protection, the institutions that are responsible for the preparation of studies and partial monitoring of the situation in the protected areas, on the basis of information of the protected area managers, who have the most responsibility for the sustainable use of resources and protected area management, it is estimated that Serbia lacks 50% of the necessary funds for the financing of protected areas in Serbia [B.8], i.e. USD 8.7 million for basic expenses and USD 24.7 million for the optimum consumption (75% of funds). Due to such a large deficit, managers of protected areas have been forced to exploit natural resources, in order to survive, which often leads to a situation contrary to the concept of biodiversity conservation. According to available data, the direct financing of protected areas by the ministry responsible for environmental protection amounts to USD 2-3 million per year, and in protected areas managers through other mechanisms and sources (taxes, fees, permits, tourism ...) provide an additional USD 5-6 million. The total amount specified (USD 7-9 million a year) represent only 25% of the necessary funding to ensure optimal and efficient management, i.e. represents 50% for the minimum level of functioning. A very important source of income for protected areas is forest exploitation, worth over US $ 8 million per year, which represents an additional source of financing. Taking into account the plan of expansion of protected areas from the current 6.38% of the territory of Serbia to 12% by 2020, the additional problem of financing will occur if the designated funding remains at the current level, or even decreases, and if a more stable and sustainable system of financing of protected areas is not established. A large role in this is strengthening the capacity of managers, which should additionally be encouraged and supported by the state. On the other hand, investments in nature protection are currently much lower than the damages that may result from the application of inadequate measures.

The protection and improvement of forest and aquatic ecosystems

Forest ecosystems are of great importance in the process of adaptation to climate change and it is therefore necessary to pay great attention to their protection. Based on the National Forest Inventory of the Republic of Serbia [B.12] and the Spatial Plan of Serbia 2010-2020 ("Official Gazette of RS", no. 88/10), the forest area of the Republic of Serbia amounted to 30.6% and the percentage of forest cover of central Serbia and Vojvodina is 29.1%. The indicator of naturalness is an important indicator of bio-ecological stability and preserved biodiversity in evaluated areas. The highest percentage of forests in Serbia are semi-natural (92.1%), plantations are represented with 7.8%, with only 0.1% of the forests without human intervention. From the standpoint of biodiversity and ecosystem services, the most significant are the high-elevation natural stands, in which 38 tree species were registered, two of which are non-autochtonous. The most abundant species is the beech with 57.1% of the total volume. Other species participate in the forest fund individually with less than 10%, with only 10 species present with more than 1%. The total area of preserved forests in Serbia, whose density is 1,222 trees per hectare, is 70.6%. However, one of the main problems of high-elevation forests in Serbia is a medium level of preservation, primarily expressed in relation to the degree of stocking of stands. In the high-elevation forests a moderate condition of reservation of forests was recorded, and the preserved high-elevated stands cover 54.3% of the total covered surface.

A significant indicator of the state of forests and attitude towards the principle of sustainable forest management is the amount of dead wood in the forests of Serbia. The total volume of dead wood in the forests of Serbia amounts to 16,260,414 m3. The average volume of dry trees amounts to 4.05 m3 per hectare and dry fallen trees 3.17 m3 per hectare, i.e. the total concentration of dead wood in forests in Serbia is 7.22 m3 per ha and is even higher in Vojvodina (7.75 m3 per hectare) and in Central Serbia (7.18 m3 per hectare). The required norm is 2-3 m3 per hectare. This amount of dead wood enables sustainability of habitat stability, which is especially important for entomofauna and ornitofauna inhabiting forests and whose habitat are small pieces of dead wood of certain species. At the same time, the disposal of a portion of the yield in the forest is an important renewable resource in relation to the need to preserve the production potential of the habitat as a whole.

Forest ecosystems provide a number of services. Along with land, forest ecosystems have a great capacity to accumulate and release carbon. Climate change impacts forest ecosystems, in terms of an imbalance of carbon. The reserves of carbon in wood volume of forest ecosystems in Serbia depend on the origin of the forest. The amount of carbon left in the forest ecosystems is caused by many factors, but the most important are those that affect the growth of biomass, such as: changes in forest areas, commercial logging, forest fires, temperature extremes, air pollution, changing conditions in the soil, erosion, the presence and abundance of pests and so on. Conservation of the accumulated carbon in existing forests and reduction of emissions are the basic principles of modern forest management, in order to mitigate the effects of climate change at the local level.

Aquatic ecosystems are distinguished by their abundance of wildlife, but at the same time they are one of the most sensitive natural ecosystems. Preservation of aquatic ecosystems does not only contribute to the preservation of biodiversity, but also contributes to the conservation of water resources and other natural resources that are of great importance for human society. In addition to protecting the preserved, natural ecosystems it is necessary to develop plans for the revitalization of degraded aquatic ecosystems. According to the data specified in the Fifth national report under the Convention on Biological Diversity, in the waters of all three basins of Serbia aquatic life amounts to a total of 98 species of fish and kolousta (4 Cephalaspidomorphs species and 94 species of fish) from 23 families, which is about one third of the total number of freshwater fish species in Europe (10 species of Cephalaspidomorphs and 306 species of fish from 33 families). Of the total number of species living in the waters of Serbia, about 50 species are subject to commercial and recreational fishing. From the standpoint of commercial fishing, 29 fish species have a greater or lesser economic importance, out of which 12 species represent a target group of most of the fishing activities. Other species represent accompanying and sporadic catch and are of secondary economic importance. Recreational fishing covers about 45 species, but in this case approximately 50% of that number represents the target group.

Sustainable management of water resources, especially the fishery fund, is one more of the commitments made by Serbia as a signatory to the Convention on Biological Diversity, in line with the strategic objective relating to the reduction of direct pressures on biodiversity and promotion of sustainable use. The Aichi targets related to the sustainable use of invertebrates, fish and aquatic plants by 2020, legally and based on applied ecology, so that excessive fishing is avoided; plans and measures for recovery of all impoverished species are applied; fishing has no negative impact on endangered species and vulnerable ecosystems, and the effect of harvesting fish must fall within the environmental limits. the fish fund management in fishing waters, which includes the protection and sustainable use of the fishery fund as a natural resource of common interest is regulated by the Law on Protection and Sustainable Use of the Fishery Fund ("Off. Gazette of RS", no. 36/2009).

Development of monitoring of species used for commercial purposes and planning their sustainable use

Collecting medicinal herbs and berries in Serbia is one of the traditional ways of securing funds for households in rural, hilly and mountainous areas of eastern, southern and western Serbia. Areas cultivated in medicinal plants are located mainly in Vojvodina, while funghi can be found in the whole territory of Serbia. Table B.2 presents the key endangered species of medicinal plants in Serbia and endangering factors. In addition to uncontrolled collection, a change of conditions and/or loss of habitat is a very important factor compromising this natural resource.

Table B.2 Key endangered species of medicinal plants in Serbia and compromising factors (Source: FAO Second National Report on the state of plant genetic resources for food and agriculture in Serbia, 2009; SEEDNET report for 2012, the South East European Development Network for Plant Genetic Resources)

Latin name	English name	Endangering factors
Gentiana lutea subsp symphiandra	Yellow gentian	Uncontrolled collection, change of conditions and loss of habitat
Gentiana punctata	Dotted-Flowered Gentian	Change of conditions and loss of habitat, rare species
Salvia officinalis	Sage	Uncontrolled collection
Leontopodium alpinum	Edelweiss	rare species, uncontrolled collection
Drosera rotundifolia	Sundew	Change of conditions and loss of habitat, rare species
Arctostaphylos uva-ursi	Bearberry	Uncontrolled collection
Acorus calamus	Calamus	Uncontrolled collection, change of conditions and loss of habitat
Helychrysum arenarium	Immortelle	Uncontrolled collection, change of conditions and loss of habitat
Glycyrrhiza glabra	Licorice	Uncontrolled collection, change of conditions and loss of habitat
Gypsophila paniculata	Baby's-breath	Uncontrolled collection, change of conditions and loss of habitat
Angelica archangelica	Garden Angelica	Uncontrolled collection, change of conditions and loss of habitat
Ruta graveolens	The Common Rue	Uncontrolled collection, change of conditions and loss of habitat
Prunus laurocerasus	Cherry Laurel	Uncontrolled collection, change of conditions and loss of habitat
Castanea sativa	Sweet Chestnut	Uncontrolled collection, change of conditions and loss of habitat
Daphne alpina	Alpine Daphne	Uncontrolled collection, change of conditions and loss of habitat
Daphne blagayana	Blagay's Daphne	Uncontrolled collection, change of conditions and loss of habitat
Hyssopus officinalis	Herb Hyssop	Uncontrolled collection, change of conditions and loss of habitat

Juglans regia	**Walnut**	Uncontrolled collection, change of conditions and loss of habitat
Adonis vernalis	**Sweet Vernal**	Uncontrolled collection, change of conditions and loss of habitat
Veratrum nigrum	**False Helleborine**	Rare species
Menyanthes trifoliata	**Buckbean**	Change of conditions and loss of habitat, rare species
Pinus mugo	**Mugo Pine**	Change of conditions and loss of habitat, rare species
Vaccinium vitis idaea	**Lingonberry**	Uncontrolled collection, change of conditions and loss of habitat
Lycopodium clavatum	**Clubmoss**	Change of conditions and loss of habitat, rare species, uncontrolled collection
Fam. Orchidaceae	**Orchids**	Uncontrolled collection, change of conditions and loss of habitat

According to data of the Serbian Chamber of Commerce, in 2012 in Serbia the trade in medicinal and aromatic plants amounted to over USD 24.5 million, out of which income from exports was USD 19 million. However, herbs are dominant in the export of plants with about 2/3 of plants exported, while income from exports of medicinal plants in the narrow sense was USD 5.8 million. The largest importers of plants from Serbia are the European Union (62%) and CEFTA countries (35%). However, the assessment of vulnerability of these species in particular from climate change has not been prepared in detail for species that have economic significance for Serbia.

Monitoring of invasive species and the planning of measures to combat their spread

In order to prevent the uncontrolled spread of alien species it is necessary to develop a system for monitoring the occurrence and spreading of species with invasive characteristics, which would enable the planning of measures to mitigate the spread of these species and their harmful effects on native species, but also on agriculture, forestry and fisheries. One of the Aichi targets of the Convention on Biological Diversity refers to invasive species; it is stated that by 2020, invasive species and the routes of spreading must be identified and prioritized. Priority invasive species must be under control or eradicated, and clear and defined measures of protection from further spreading must be defined .

The Strategy on Biological Diversity and especially the Action Plan identified the administrative, scientific and technical activities, which include the identification of indicators for monitoring the status of introduced alien species and their impact on biodiversity; development of biological and other methods for the control and eradication of introduced alien species; establishing control over breeding centers of exotic species, animal labeling and prohibiting the import of exotic species that may become invasive; establishing a warning system for alien species brought into the country and procedures for responding to threats caused by these species. According to Article 82 of the Law on Nature Protection, the introduction of alien invasive species into the territory of Serbia is prohibited.

The mapping of alien and invasive species in the Republic of Serbia was initiated by the Ministry of Agriculture, Forestry and Water Management within the framework of the project "Mapping and monitoring of invasive species in agro-ecosystems" and the Institute for Nature Conservation, which conducts the mapping of habitats of certain invasive species, mostly plants. The proposed list of invasive species in the Republic of Serbia and measures of control and mitigation has been prepared, and the Department of Biology and Ecology of the Faculty of Science, University of Novi Sad produced it in 2010-2011. The database is named the "List of invasive species in the Autonomous Province of Vojvodina" with basic information on the biology, ecology and distribution[3].

As a consequence of the impact of climate change, the conditions of elevated CO2 concentration leads to increased bioproduction of allergenic plants, as well as increased production of their pollen. It is believed that the increased production of pollen of allergenic plants, due to climate change, contributes to the increased possibility of asthma and other allergic respiratory diseases [B.13]. Based on a large study which referred to the assessment and measures to control the spread of Ambrosia artemisifolia in Europe, conducted by a group of institutions in 2010, some economic parameters were identified using the cost benefit analysis [B.14]. For the territory of the European Union at the time it was estimated that for measures to monitor and control the spread of this species it was required for each EU member state to allocate about 445,000 EUR per year, while for an independent early warning system it was estimated that it would take an average of approximately 1:35 million per year per EU Member. However, the costs incurred by the application of measures to overcome consequences caused by the spread of this invasive species in agriculture (including measures of treatment with herbicides against this species), or to human health (costs of treatment and medicines), are estimated on the population at between 0.42 and 2.09 million people in the amount of between 143 and 714,000,000 EUR per year.

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