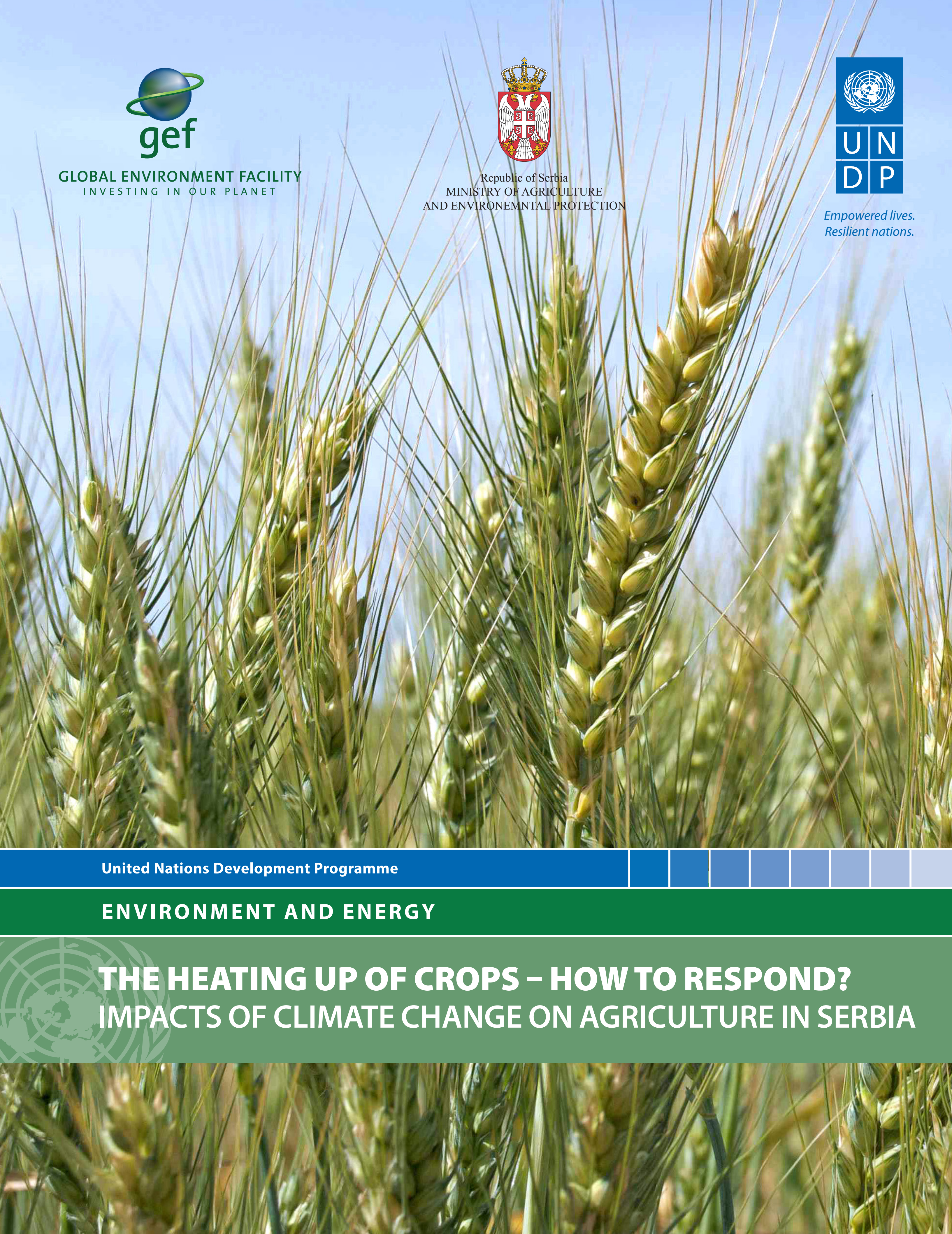

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ENVIRONMENT AND ENERGY

THE HEATING UP OF CROPS – HOW TO RESPOND?
IMPACTS OF CLIMATE CHANGE ON AGRICULTURE IN SERBIA

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Climate change is one of the greatest global challenges of our time. The consequences of this change are potentially so far-reaching and serious that every country must do its part to help stabilise our planet's climate. As a signatory of the United Nations Framework Convention on Climate Change (UNFCCC), its accompanying Kyoto Protocol, and other international treaties in this area, the Republic of Serbia has thus undertaken a number of measures designed to reduce greenhouse gas emissions.

We wish to be not only a nation whose laws comply with international requirements in this field, but also one that serves as an example of timely action to the region. Let us note that Serbia was one of the first ten countries to present greenhouse gas emission reduction targets under its Intended Nationally Determined Contributions (INDCs).

Therefore, the Republic of Serbia has been acting as a responsible member of the international community in this regard. As we have done every year to date, in December 2015 we will again take part in the Conference of the Parties to the Convention (UNFCCC – COP 21); this year we are also planning to enact a Law on Reducing Greenhouse Gas Emissions. Our engagement on the international stage, however, also matters for an additional reason – one that this report will describe.

Serbia derives 11.4 percent of its gross domestic product (GDP) from agriculture. This industry is all the more important given our national traditions and way of life. As this report will show, if we fail to prepare adequately, climate change can have a wide-ranging impact on the cultivation of our staple crops. It is thus of exceptional strategic significance for us to understand what we can do immediately to ensure a competitive future for our agriculture.

The findings of this document are based on an expert report entitled 'Vulnerability assessment and adaptation measures for agriculture in Serbia.' This publication aims primarily at identifying likely problems and suggesting options for their resolution to inform timely and appropriate reaction. The message of both that report and this publication to all those who work in this field, but also to the broadest public, is eminently clear: we must continue working globally to reach an effective agreement to cut emissions, whilst at the same time implementing a number of measures to adapt to climate change. These measures entail not only educating and training agricultural workers and stimulating stakeholders to apply adaptation and damage mitigation measures, but also introducing technology initiatives to improve irrigation systems and erosion control measures, as well as improving land use efficiency.

Finally, for these measures to truly become effective, public discourse in this area must also improve, which is one of the aims of this publication. The latest scientific knowledge, presented by the expert team that drafted the report, leads us to conclude that action in this area is urgently needed. The Government of the Republic of Serbia is unanimous in its resolve to involve Serbia in international initiatives in this area as a regional leader whilst at the same time adapting to the new conditions. The broadest public ought to support this plan, not only for the sake of this generation, but also for those yet to come.

Professor Snežana Bogosavljević Bošković , PhD
Minister of Agriculture and Environmental Protection

SUMMARY

This report on the impact of climate change on agricultural production in Serbia is intended for use by agricultural extension services, agricultural workers, farmers, and the broadest interested public. It is based on 'Vulnerability assessment and adaptation measures for agriculture in Serbia,' a report commissioned from an expert team for the purpose of drafting the Second National Communication of the Republic of Serbia under the UN Framework Convention on Climate Change.

The primary objective of this report is, above all, to identify likely problems and suggest options for their resolution so as to inform timely and appropriate reaction, with the ultimate aim of ensuring a competitive future for agriculture.

The findings of the report are as follows:

- An increase in temperature of between 0.5 and 1.5 degrees Celsius can be expected in the territory of Serbia to 2030. Over the final decades of the 21st century, temperatures will rise by between 4.0 and 4.3ºC if global greenhouse gas emissions continue at current levels. Precipitation trends are more difficult to forecast, especially in the first half of the 21st century. One scenario indicates a possible increase in precipitation of between three and ten percent to 2030, whilst all findings point to the likelihood of a major decrease in precipitation, of between ten and 19 percent, from 2050 to the end of the century.
- Climate change and greater climate variability will in the future affect agriculture in Serbia. Rising temperatures and more frequent extreme weather events may lead to declining yields and greater year-on-year yield fluctuations if appropriate adaptation measures are not undertaken in time.
- Maize yields will be hardest hit by climate change. In the absence of adaptation measures, a drop in maize production of 58 percent can be expected to 2030.
- The potential decline in wheat yields will amount to up to 16 percent to 2030, depending on region.
- A decline is also expected in sugar production per hectare of sugar beet; soybean and grapevine production are also expected to diminish by 2100.
- Rising temperatures induced by climate change will extend vegetation periods and move growth seasons forward (on average by between 20 and 30 days to 2100), which will affect the timing of farm operations.
- Climate change has already brought about change in the appearance of diseases and pests and is expected to cause additional changes. Fungal diseases and pests (and associated viral diseases) will pose a challenge that future crop protection measures will have to address.
- Long-term effects of extreme weather events can reduce yield potential of some types of soil and damage their key functions. Erosion due to heavy precipitation in combination with bare soils on hill slopes deserves particular consideration.
- However, timely adaptation measures, crucially greater irrigation capacity, may actually increase yields and allow for a second harvest of some crops, especially when irrigated (to 2100).
- In principle, although these impacts have not been explored in detail in this report, it should be borne in mind that rising temperatures adversely affect yield potentials of some crops and health conditions and production of animals. In addition, sanitary conditions for the production of milk and meat can also be affected negatively.

Given that agricultural production accounts for 11.4 percent of Serbia's GDP, the country's economy as a whole is exceptionally sensitive to changes affecting agriculture. This is why this industry is a key area for the Initial and Second National Communication under the United Nations Framework Convention on Climate Change (UNFCCC).

Moreover, Serbia has ever since 2000 been facing periods of extreme climate conditions and extreme weather events that have been causing major physical damage and financial losses. Even if no further climate change were to occur, the urgent need for adaptation is eminently clear. The drought of 2012 and flooding of 2014 were probably the two most significant extreme weather events.

Total damage caused by the 2014 flooding has been estimated at over 1.5 billion euros, of which damage to agriculture accounts for some 120 million euros. On the other hand, greatest losses have in all likelihood been caused by the droughts that struck Serbia over the past several years. The 2012 drought was particularly severe, and led to a decline in yields of some crops of about 50 percent, which caused about two billion euros in losses to agriculture in total.

Changes to climatic conditions and their greater variability will impact agriculture in Serbia. By *changes to climatic conditions* we mean primarily an increase in the average temperature and changes to precipitation patternsacross the territory of the Republic of Serbia. *Greater variability* entails more frequent and severe extreme weather events, such as heat waves, droughts, and heavy precipitation events. Extreme weather events – and in particular drought, or increased numbers of dry days and days with extreme temperatures – will play a dominant role in future climatic conditions.

There is no doubt that climate change will influence the quantity and quality of yields of staple crops in Serbia, both in terms of mean crop yield levels and year-on-year yield fluctuations.

All of the above bear out the urgent need for adaptation.

1. IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION AND VULNERABILITY IN SERBIA

Vulnerability of agricultural production to climate change was analysed using data from a number of locations and collected over a number of periods (months) crucial for agricultural production. Expected vulnerability of agricultural production to climate change was, in fact, considered for ten locations (Table 1) uniformly distributed across Serbia.

Table 1. Locations throughout Serbia subject to analysis of climate change on agriculture

Location (short name)	Longitude (°E)	Latitude (°N)	Altitude (m)	Dominant soil type
Sombor (SOM)	19,1	45,7	88,0	Chernozem
Novi Sad (NOV)	19,8	45,2	80,0	Chernozem
Požarevac (POZ)	20,0	43,8	310,0	Cambisol
Kraljevo (KRA)	20,7	43,7	215,0	Cambisol
Kruševac (KRU)	21,3	43,5	166,0	Fluvisol
Ćuprija (CUP)	21,3	43,9	123,0	Fluvisol
Niš (NIS)	21,9	43,3	201,0	Fluvisol
Zaječar (ZAJ)	22,2	44,8	144,0	Cambisol
Dimitrovgrad (DIM)	22,7	43,0	450,0	Fluvisol
Vranje (VRA)	21,9	42,4	432,0	Fluvisol

1.1. Trends and frequency of extreme weather events – parameters significant for plant growth

Impact of climate change was analysed on the basis of daily meteorological data obtained using a regional climate model. The 1961-1990 model climatology provided the reference data.

According to climate change scenarios, temperatures will increase in Serbia to 2030 relative to the reference period by between 0.5 and 1.5°C, whilst the increase for the final decades of the 21st century is expected to amount to between 4.0 and 4.3°C. On the other hand, different scenarios indicate different precipitation trends. According to one scenario, an increase in precipitation of between three and ten percent can be expected to 2030, followed by a major decline of between ten and 19 percent to 2100. A second scenario indicates a possible decrease in precipitation of between two and nine percent to 2030.

Apart from rising temperatures and changes to precipitation regimes, greater frequency of extreme weather events will be a key effect of climate change in Serbia. This prompted us to analyse the regional distributions of:

a) Number of frost days in March and April (minimum temperature below 0°C);

b) Number of summer days between May and September (maximum temperature above 25°C);

c) Number of tropical days between May and September (maximum temperature above 30°C).

The results were as follows:

a) There will be a significant decrease in the average number of frost days in March by the end of the 21st century.

b) By 2030, the number of summer and tropical days will increase by three to four days in August and September. For the period to 2100, these changes are far more serious and entail an increase of between seven days in May to 12 days in September.

At the same time, analyses of temperature, precipitation, and water balance for the periods of **April-May-June** and **June-July-August** to 2030 and 2100, as well as of parameters significant for plant growth, have led to the following conclusion:

Average temperatures will increase by between 0.5 and 0.7°C to 2030, which will be accompanied by a slight increase in average springtime temperatures (for the **April-May-June** period) of between 0.2 and 0.5°C. However, average summertime temperatures (**June-July-August**) will increase by between 0.6 and 0.9°C. The amount of precipitation will vary from -5 to 5 percent to 2030, whilst an increase in precipitation across all regions is envisaged in the summer. Accordingly, the water balance will fluctuate between slightly positive and slightly negative values.

Under scenarios that envisage continuing increases in global atmospheric concentrations of greenhouse gasses, further increases in temperature and declines in precipitation are also expected for the period to 2100. Summers are expected to see temperatures increase by between 4.2 and 4.7°C, whilst springtime temperatures may rise by between 3.2 and 3.7°C. Precipitation will decline by between ten and 23 percent in the spring, and by between 20 and 34 percent in the summer.

1.2. Impact of climate change on plant growth dynamics (crop phenology)

Due to warmer winters and fewer frost days in February and March, flowering should occur earlier, as should maturity, owing to higher temperatures in April-May-June. This shift is nearly negligible to 2030, but may bring the entire vegetation cycle forward by about 20 days to 2100.

Detailed analysis of the impact of such temperature changes on physiological and biochemical processes (that determine plant growth dynamics) have shown that climate change will bring the crop growth season forward by about 20 days to 2100. These changes in phenology can affect yields and the timing of farming operations, but may also produce a second harvest.

Interestingly, maize and soybean exhibit no difference in flowering times to 2030. Maize is expected to mature some seven to 13 days earlier, whilst no significant change is expected for soybean. However, maize and soybean may be expected to flower two or more weeks earlier by 2100. Maturity of maize will shift nearly two months ahead, whereas soybean will mature about two weeks earlier. In other words, a much shorter vegetation period can be expected, which will affect both the quantity and quality of yields.

Moreover, analyses show that climate change will have a moderate impact on winter wheat phenology to 2030, but, by 2100,it will have affected yields and will also have moved farming operations ahead.

Earlier sowing can have a beneficialeffect on the adjustment of most crops to expected climate changes.

1.3. Impact of climate change on yields and year-on-year yield fluctuations

Extreme weather events, especially drought and greater numbers of dry days (which do not necessarily always have to lead to drought), as well as days with extreme temperatures, will exert a decisive influenceon the yields of key crops under climate change conditions.There is no doubt that climate change will influence mean crop yield levels and year-on-year yield fluctuations. In other words, all of Serbia will be affected by changes to agro-climatic conditions, in particular rising temperatures and lower summer precipitation levels, which will reduce crop yields in the absence of adaptation measures.

The impact of extreme weather events on crop yields is briefly summarised below.

Winter wheat. Expected changes in winter wheat yields in Serbia vary from about -16 percent in the northwest and north of the country to 21 percent in the southeast. At the same time, expected relative yield changes to 2100 stand at six percent in Central Serbia and -10 percent in the south of the country. Analyses show that the most significant reduction in yields can be expected to take place in south-western and south-eastern parts of Vojvodina.

Maize. Earlier studies had revealed that, under rain-fed conditions, maize yields could be expected to drop by 58 percent to 2030 and by 40 percent to 2050. Use of irrigation mayreduce the rate of decline to 20 percent to 2030 and 31 percent to 2050. Estimates show that changes to corn yields under rain-fed conditions to 2100 range between -52 and -22 percent, with greater decline expected in the north and west than in the south and east of the country.

Sugar beet. Production of sugar beet may face serious difficulties by 2030, given the trends of increasing temperatures and declining precipitation. These trends will assuredly lead to a drop in sugar beet yields and sugar production per hectare. Additional irrigation will become increasingly necessary to stabilise yields. Traditional planting, which starts in March, may seriously jeopardise or hinder the germination process under conditions of typical rainfall deficits. Unfavourable germination following sowing in March, or development of recently sprouted seedlings, can also occur due to rising numbers of summer days, with temperatures greater than 25^0C starting in March. The increasing number of tropical nights, with minimum temperatures equal to or greater than 20^0C until September may reducethe sugar content in the root.

Soybean. According to estimates for the last three decades of the 21st century, assuming irrigation, yield changes would range from -14.1 to 20.3 percent.

Grape. In view of temperature and precipitation trends, significant disturbances in yields can be expected late in the 21st century. A warmer and prolonged growing season,coupled with greater heat accumulation and longer frost-free periods with a decline in frost frequency, will in all likelihood affect yields and ripening potential of grapes, and induce shifts in varietal suitability and wine styles. This may force additional vineyard irrigation, but also open up the possibility of marginal and elevated areas, previously too cool for cultivation of grapevines, becoming climatically suited for viticulture. In addition, increasing soil erosion under hill slope conditions in vineyards may become a particular risk if protection measures against soil erosion are not applied.

Other crops cultivated in hilly areas also face the risk of soil water erosion; this is a particularly major hazard for row crops such as maize and other broad row crops.

In addition, all rain-fed crops in the regions of Novi Sad, Kruševac, Ćuprija, Zaječar, and, crucially, Vranje and Niš, can be expected to become particularly vulnerable to summer droughts to 2100.

1.4. Impact of climate change on the appearance of pests and diseases

Climate change increases the complexity of the integrated plant management system by promoting uncertainty in the plant-pest-environment triangle. Studies have shown that, in our region,thermophile insects are expected to shift to higher altitudes and increase their number of generations. A movement of these species' ranges northwards is also to be expected. Estimates to 2055 indicate northward shifts of between 3°in the case of *Ostrinianubilalis*(European corn borer) to 11°for*Lobesiabotrana* (European grapevine moth). All crops (both winter and summer ones) will be affected by changing patterns of pests and disease driven by increasing temperatures and changing precipitation regimes, which will particularly increase vulnerability to pests (thermophile insects). Vulnerability of each particular crop and region depends primarily on the relevant crop acreage in each region, crop management, and crop rotation (e.g. these changes will particularly affect maize in Vojvodina and Mačva, sugar beet in Vojvodina, and orchards in the Kruševac region, Vojvodina, and elsewhere in Serbia, excepting mountainous regions).

Expected impacts of climate change on the appearance of pests and disease for key crops in Serbia are summarised below.

Small grains. Studies indicate that, in addition to the impact of commonly analysed parameters, such as temperature and humidity, on the appearance of small grain pests and disease, ozone and CO_2 should also be taken into account. Climate change may cause dominance of pathogens that require higher temperatures for development or are better able to adapt to drought conditions. This is why fungi of the genus *Septoria*spp. have already assumed a dominant role, causing significant damage.

Sugar beet. Under the assumed temperature and precipitation trends, sugar beet production to 2030 may increasingly face the adverse effects of attacks by harmful organisms favoured by the warmer environmental conditions (especially pests). The very start of the vegetation process presents an opportunity for the appearance of wireworms (*Agriotes* spp.) in sugar beet, as well as for a slight increase in the numbers of sugar beet weevils (*Bothynoderespunctiventris*). Germination, slow and protracted due to unfavorable rainfall, can mean that sugar beet seed is exposed to *Agriotes* spp. for longer. Wireworm larvae move from deeper soil layers to warmer and more ones, there damaging the seedlings and roots of young sugar beet plants. In conditions with no rainfall and high temperatures in the second part of the growing season, root aphids (*Pemphigus fuscicornis* Koch) and sugar beet moth (*Scrobipalpaocellatella* Boyd) can cause significant damage to this crop. In conditions ofincreased temperatures and rainfall deficits, sugar beet crops will face the substantial destructive effects of pathogenic fungi. Firstly, there will be an increase in the incidence of agents causing powdery mildew of sugar beet (*Erysphebetae*) and leaf spot of sugar beet (*Cercosporabeticola*Sacc.), both very destructive fungi causing leaf decay andsecondary leaf growth, and also lowersbeet root yield and sugar content. In the second part of the growing season, lower precipitation will promote the appearance of *Macrophomina-phaseolina* (as a stage of conidioma of *Sclerotiniabataticola*Taub. Butl.), which causes root rot. Given the projected conditions, *Scrobipalpaocelatella*, *Cercosporabeticola* and *Pemphicusfuscicornis* are expected to proliferate in the regions of Novi Sad and Sombor. Increased temperatures and precipitation levels at the mid-point of vegetation are expected to promote the appearance of causal agents of root rot (*Rhizoctoniasolani*) and aphids (*Aphididae)*.

Maize. A moderate increase in the frequency of cicada phytoplasm vectors (*Cicadelidae*), aphids (*Aphididae*), *Fusarium*spp., and western corn rootworm (*Diabroticavirgifera)*is expected to 2030. Some regional fluctuation with regard to this trend is also to be expected in this period for the European corn borer (*Ostrinianubilallis*; Novi Sad – moderate, Sombor – significant), cotton bollworm (*Helicoverpaarmigera*)and *Aspergillus*spp. (Novi Sad and Sombor – moderate). All analysed pests and diseases are expected to increase in frequency to 2050, albeit with major regional variations, particularly in the cases of *Ostrinianubilallis* and*Helicoverpaarmigera*.

Apple. The coddling moth (*Carpocapsapomonella*) is expected to see a moderate increase across the country to 2030, whilst no changes are envisaged in the intensity of attacks by *Venturiainaequalis* over the same period. A moderate increase in the incidence of the causal agent of powdery mildew, *Podospheraleucotricha*,andmites, *Acarinae* (except in Ćuprija, Niš,and Zaječar), whereas after 2030 they are expected to proliferate across Serbia.A slight increase in the number of aphids, *Aphididae*, can be expected to 2030, followed by a moderate increase to 2050, except in the south of the country (with Vranje seeing a moderate increase, followed by a substantial escalation, in these pests).

Grape. A slight drop in the frequency of the causal agent of grapevine downy mildew, *Plasmoparaviticola*, as well as a moderate increase in the numbers of cicadas (*Cicadelidae*) and mites (*Acarinae*) can be expected across Serbia to 2030. Aphids (*Aphididae*) are likely to see a moderate increase in southern Serbia, in contrast to the rest of the country, where a slightincrease in their numbers is expected. Some regional variation is likely in the appearance of the causal agent of powdery mildew of grape, *Uncinulanecator*, and the European grapevine moth, *Lobesiabotrana*: (i) Novi Sad, Sombor, Požega, Kraljevo i Ćuprija are expected to seeslight increase;whilst (ii) Kruševac, Niš, Dimitrovgrad and Vranje can expect a moderate increase. As effects of climate change are set to become more pronounced in the period to 2050, its impact on the increase of pests and disease can be expected to worsenby an order of magnitude.

Potato. Expected climate change should reduce the overall sensitivity of potato production to *Phytophtorainfestans*, the fungus that causes potato blight, one of the most serious diseases of the potato plant. *Leptinotarsadecemlineata*, the Colorado potato beetle, is expected to become slightly more common in northern Serbia, and moderately more so in the rest of the country. From the middle of the 21st century this effect is expected to increase by an order of magnitude. Aphids (*Aphididae*) and *Alternaria*, the causal agent of early potato blight, are expected to proliferate in southern Serbia (Vranje) and became slightly more common in the rest of the country. Aphid numberswill likely remain elevated; the severity of infestation will increase by one order of magnitude around the middle of the next century, whilst Kraljevo, Kruševac, Niš, Zaječar,and Dimitrovgrad can be expected to become more vulnerable to *Alternaria* over the same period. A moderate to serious increase in numbers of thepotato tuber moth is envisaged to 2030, with major regional variations. However, to 2050 these fluctuations should recede, with the incidence of this pest remaining moderate in the Sombor region, and high elsewhere in Serbia. Finally, a slight increase in the incidence of *Fusarium*spp. is expected in the period observed in northern and central regions, accompanied by a moderate increase in the south and east.

Tomato. This crop is expected to become less sensitive to *Phytophtorainfestans*, the causal agent of potato blight,to 2030. In addition, slightly reduced incidence of *Alternariasolani*, the fungal pathogen that causes early blight is also likely to 2030, followedby a moderate to substantial increase in the occurrence of this pathogen to 2050, with major regional fluctuations. The entire period is expected to witness a major increase in the occurrence of the tomato leafminer, *Tutaabsoluta*, and the cotton bollworm, *Helicoverpaarmigera*, again with regional fluctuations. Harmful nematodes are expected to proliferate in the Novi Sad and Sombor regions.

Pepper (capsicum). The cotton bollworm (*Helicoverpaarmigera*), European corn borer (*Ostrinianubilalis),* aphids (*Aphididae)*and thrips (*Thysanoptera*)have been recognised as the major pests of the pepper crop;sensitivity to these pests is expected to increase over the periods to 2030 and 2050. The regions of Novi Sad, Sombor, and Vranje will be particularly at risk from the European corn borer and aphids, whilst Dimitrovgrad will see increased exposure to the cotton bollworm. On the other hand, significant regional fluctuations can be observed in the case of thrips.

Cabbage. Sensitivity to the causal agent of downy mildew, *Peronosporaparasitica*, shouldsee a decline throughout Serbia, whilst sensitivity to the cabbage whitefly, *Aleyrodesproletella,* diamondback moth, *Plutellamaculipenis*,and cabbage fly, *Delia radicum*,should increase in time, with major fluctuations by region. A slight increase in the incidence of these pests is expected to 2030 in the regions of Ćuprija, Požega, and Kraljevo, along with a moderate increase in the areas of Novi Sad, Sombor, and Vranje.

Onion. Given current agro-climatic trends, *Peronospora destructor*, which causes downy mildew, jumping plant louse, *Bactericeriatremblayi*, and thrips have been identified as the major pests of the onion crop. The entire period to 2100 is expected to see a slight decrease in sensitivity to *Peronospora destructor*throughout Serbia. Estimated future conditions should favour the proliferation of *Bactericeriatremblayi*, and especially of thrips (*Thripstabaci*).The jumping plant louse will in all likelihood become slightly more common in all regions excepting the extreme north and south parts of the country, where more marked infestation can be expected around the middle of the century. Over the next several decades, theNovi Sad, Sombor, Kruševac, Niš and Vranje regionswill be exposed to greater incidence of thrips than the rest of Serbia.

2. ADAPTATION MEASURES

Expected climate change in Serbia will impact each region differently, but all areas will experience an increase in temperature, greater fluctuations in precipitation, and regional heterogeneity in precipitation distribution (across all periods). In addition, it should be borne in mind that extreme weather events are set to become more frequent, which will be the primary hallmark of climate change in Serbia. This will have a tremendous impact on crop yields and their sensitivity to climate change, which requires both identification and planning of adaptation measures.

Adaptation measures must, first and foremost, be aimed at improving 'physiological conditions' of plants in general through fertilisation, irrigation, use of hail nets, weed control, and permanent shoot cutting. Furthermore, for mostcrops adaptation will also have to entail the development of new genotypes able to adapt to both abiotic (e.g. soil composition, weather, climatic conditions) and biotic factors (such as other plants and animals), or the adaptation of existing genotypes to these changes. If these traits are to be obtained, germplasm from geographically distant areas – where such desirable traits are dominant – needs to be used. This germplasm will, however, also contain undesirable traits, most often susceptibility to pathogens. The newly developed crop species or cultivar is then adapted to the growing conditions resulting from climatic changes and begins to interact with the pathogen population. Because of this, detailed risk assessment must be made, based on meteorological and biological observations in the broader region, to prevent disease outbreaks in a given area.

Some of the already identified measures of adaptation to changed climatic conditions are given below, by culture, for both the national (Table 2) and the regional levels (Table 3). Additional analyses are certainly required for adaptation measures for specific production regions, as well as various farm structures and types.

Small grains. For this crop, it is of crucial importance to develop new genotypes able to adapt to abiotic and biotic factors, as well as to ensure that existing genotypes are able to adapt to changing climate conditions.

Maize. Measures that may reduce the sensitivity of corn production to expected climate changes include: changing sowing dates (moving planting forward); selecting more tolerant hybrids; and growing crops under irrigation. To reduce production risks, irrigation will have to cover greater areas than to date.

As longer growth periods can be expected, a switch to cultivars that ripen later should be recommended. Increased heat stress requires hybrids tolerant to higher temperatures. The expected increase in pest and disease incidence can be mitigated by crop rotation. Pest and disease monitoring and forecasting will increase efficiency of protection and reduce the risk of crop failure.

Sugar beet. Problems with germination that occur due to lack of precipitation in March may be addressed by moving sowing forward to February. The case for earlier sowing is also supported by the fact that soil still contains residual winter moisture at this earlier time; in addition, farmers can rely on early high temperatures in March, and the number of days with temperatures below zero or frost will decline between January and April.

The adverse impact of increasing numbers of tropical nights during sugar synthesis can be alleviated by delaying root extraction, which will lengthen production and exposure to outdoor conditions by at least another month. This measure will likely have a limited effect on sugar beet production, so additional efforts are needed, primarily in terms of irrigation. It is necessary to bring water to sugar beet fields,which will alleviate problems starting with germination, through growth, to the end of the vegetation season. However, given the temperatures that have been forecast, irrigation may promote the growth of pathogenic fungi, particularly *Cercosporabeticola*Sacc., the causal agent of leaf spot of sugar beet, and *Rhizoctoniasolani*, the fungus that causes root rot. The most efficient means of protecting sugar beet from leaf spot are treating seeds with fungicides and using tolerant hybrids. Root rot in June also causes major problems with sugar beet production; infection can be linked to precipitation between May and July. Sugar beet can be produced without the root of the plant rotting away only if the beet is sown in fields where the inoculum is absent from the soil, which is very difficult to achieve as there are few regions suitable for sugar beet cultivation where inoculum is not already present in the soil. Thus the most important measures for Serbia are selecting tolerant hybrids and testing favourable conditions for growth, including all marginal environments where yield loss can still be avoided.

Grape and fruits.'Physiological conditions' of plants in general must be improved through fertilisation, irrigation, use of hail nets, weed control, and permanent shoot cutting. As oospores can winter in plant debris, its removal will reduce the presence of inoculum in vineyards, which will in turn limit the potential for infection in the next growing season. For orchards and vineyards it is important to take into account expected agro-climatic conditions and address the potentially favourable environment for intensive development of harmful organisms.

Table 2. Proposed adaptation measures at the national level. Time required for implementation: ST – short term, MT – medium term, LT – long term

Strategic Area	Adaptation measure

Risk Reduction	• Change timing of field operations (ST)
	• Optimal soil cultivation time and sowing time, especially inBačka and northern Banat (ST)
	• Optimise plant density per unit of area unit, especially inBačka, northern Banat, and Srem (ST)
	• Introduce minimum tillage or reduced soil cultivation (ST)
	• Introduce and breedof drought and heat resistant cultivars (MT)
	• Introduce Earlier ripening cultivars in areas prone to summer drought without irrigation, particularly in the surroundings of Vranje, Niš, Zaječar, Ćuprija, Kragujevac, and Novi Sad (MT)
	• Introduce more productive cultivars (such as C-4 plant types) (MT)
	• Increase percentage of winter crops (MT)
	• Wide use of varieties of grasses in crop rotation system, including alfalfa (MT)
	• More crops per crop rotation due to increasing length of the vegetation period (MT)
	• Rational and effective use of fertilisers, optimised fertilisation (ST)
	• Enhanceorganic contentof soils, especially in northern parts of Vojvodina and the Subotica-Horgoš region (ST)
	• Optimised alternative use of residues by partial introduction of crop residues, particularly in the regions of Bačka and northern Banat (ST)
	• Plant residues incorporation combined with nitrogen application to provide better and faster decomposition of crop residues, especially in southern Vojvodina(ST)
	• Improve effective water management, including water harvesting methods (MT)
	• Improve irrigation water use efficiency and crop water productivity by optimising irrigation techniques and methods (MT)
	    • Improve bench border irrigation (MT)
	    • Irrigate of sandy soils (MT)
	    • Implement/extend local irrigation systems (MT)
	    • Improve basin check irrigation, fertiliser irrigation, and channel irrigation (MT)
	• Use more hail nets (MT)
	• Adapt to integrated fruits production, particularly in the regions of Fruškagora and Bela Crkva (MT)
	• Introduce alternative, earlier species and table cultivars, particularly in western Serbia (MT)
	• More effectively apply the techniques to protect grapevine against early autumn and late spring frosts (MT)
	• Introduce protective belt systems in the crop areas; improve snow-arresting tree belts, especially in areas influenced by the košava wind (MT)
	• Ensure effective snow hedge application, especially in areas influenced by the košava wind (MT)
	• Slope terracing (MT)
	• Improve practice for water erosion protection particularly in mountainous regions, improve practices for water accumulation in soil (MT)
	• Improve afforestation to protect against soil erosion (MT)

Strategic Area	Adaptation measure
Policy	• Enact a legislative framework to implement adaptation and mitigation measures in agriculture and harmonise national laws with EU acquis (LT) • Strengthen institutional measures for a successful information chain between stakeholders and experts, i.e. provide necessary capacities in agricultural research and extension services, establish monitoring and warning systems for agriculture (MT) • Provide subsidies where these can force implementation of adaptation/mitigation measures, i.e. as part of environmental programmes such as timing of fertilisation (MT) • Implement adapted legislative measures to address specific environmental problems i.e. protection of quality of surface and drinking water resources through limitations on fertiliser use or land usage restrictions(MT) • Support training and education of farmers (ST)
Monitoring and Research	• Monitoring: capacity-building for adaptation; cost-effectiveness of applied adaptation measures; changes to insurance policy; farmer awareness; education of people involved in implementation of adaptation measures; time and place of appearance of harmful organisms; activities of agricultural advisory services • Development of monitoring system for extreme weather (drought, heat waves, hail, storm, flood, frost) and diseases and pests. • Research: Development of varieties more resistant to stress and drought; development of procedures to minimise evapotranspiration and save soil water; more efficient use of numerical weather forecasts of different scales and advanced agricultural tools in providing crucial information for farmers
Capacity-Building and Public Awareness	• Provide training and education to farmers in production technologies and farm management options • Provide support and advice for direct marketing options for farmers • Ensure extension services are available for all farmers/farming systems • Provide attractive education possibilities for a younger generation of farmers • Aggregate overly small farms into medium and large ones; build co-operatives where applicable • Take permanent care to strikea balance between crop and livestock production in farming systems to avoid increase in GHG emissions

Table 3. Proposed adaptation measures at the regional level(ADAGIO Project)

Type of farming	Region	National name of region	Observed trends of adaptations to climate change (distinguish between farm level, regional level, national level)	Recommended feasible adaptation options to climate change	Identified limitations forthe named adaptation options	Uncertainties, cost/benefits, risks (including economic risks), opportunities of adaptation options	Mitigation and other effects (assessment)
Orchards	Fruška gora	Fruškogorski rejon	Farm: more hail nets (shade benefits) Regional: need for more irrigation systems	Apply integrated fruit production; use more hail nets	Expensive to introduce Additional irrigation expensive	Lower costs for plant protection, nutrition, added value Reduced production risks, more machinery needed	Environmental benefits, less water used (increased water use efficiency)
	Bela Crkva	Belocrkvanski rejon	As above	As above	As above	As above	As above
	Subotica	Subotičko-horgoški rejon	Farm: more hail nets (shade benefits) Regional: bare soil system in orchards, moving orchards to less light soils	Apply Integrated Fruits Production; using more hail nets Farms (>2008): enhancement of organic contents in soils	High introducing costs Manure needed	Less costs for plant protection, nutrition, added value Benefits only in case of optimal application date	Environmental benefits, less water used Negative: higher N2O emissions Positive: More stable sand light soils
	Arilje	Arilje	Regional: no response to climatic changes	Alternatives, earlier species and table cultivars	Under-developed market	Higher fruit processing costs	More intensive cultivation

Type of farming	Region	National name of region	Observed trends of adaptations to climate change (distinguish between farm level, regional level, national level)	Recommended feasible adaptation options to climate change	Identified limitations forthe named adaptation options	Uncertainties, cost/ benefits, risks (including economic risks), opportunities of adaptation options	Mitigation and other effects (assessment)
Crop farming dominated by cereals	Northern Vojvodina	Northern Bačka, Nortern Banat	Decreased acreage of wheat and increased land under barley and triticale; Increased farmer interest in climatic changes; Increased farmer interest in expert advice; Insufficient support by government; Greater involvement of experts and extension services	Optimal soil cultivation time; Optimal sowing time; Optimal plant density per area unit; Judicious use of NPK fertilisers; Maintenance of good plant health; Incorporation of plant residues into soil	Farmer income; Unfavourable bank loans; No subsidies for plant production; High cereal price fluctuations; Unfinished privatisation of food industry; Lack of national adaptation strategy; Many farms not covered byextension service programs; Lagging farm investments/old machinery	Cost of suggested adaptation options; Application of these measures would increase production stability; Farmers do not have influence on prices of inputs or outputs;Farmer associations very slow to form; Crisis in animal production is also a problem	Adaptation measures should improve soil fertility; Judicious fertilising of cereals will decrease soil, water and food pollution
Crop farming dominated by maize	Southern Vojvodina	Southern Bačka and Srem	Greater percentage of early cultivars in sowing structure; Increase plant density per unit area; Quicker adjustment of large farms to adaptation measures; Enhanced farmer interest in expert advice; Insufficient support by government	Optimise plant rotation (example: maize sown after cereals); Incorporate plant residue with nitrogen application; Decrease plant density per unit area in dry plant growing systems; Judicious use of NPK fertilisers; Optimal time and quality of seedbed preparation and sowing	Farmer income; Lack of subsidies for plant production; excessively high density of weeds on arable land; old machinery reduces soil cultivation quality; scarce advice and information for farmers	Crisis in animal production decreases local corn prices; Great variation of income increases economic risks; Corn crop more frequently devastated by summer drought or hail	More frequent inter-row cultivation expedites organic matter mineralization, meaning organic matter should be incorporated under maize; Use of corn for ethanol production will change growing technology; Farmer co-operation at very low level; Negative aspects: burning of organic matter on fields (increasing CO_2 concentration, soil erosion risk etc.)

Type of farming	Region	National name of region	Observed trends of adaptations to climate change (distinguish between farm level, regional level, national level)	Recommended feasible adaptation options to climate change	Identified limitations forthe named adaptation options	Uncertainties, cost/ benefits, risks (including economic risks), opportunities of adaptation options	Mitigation and other effects (assessment)
Crop farming dominated by vegetables	Southern Vojvodina	Southern Bačka, Southern Banat	Increased farmer interest in climatic changes; Rapid construction and application of irrigation systems; Introduction of new plant cultivars; Improvement of farm technologies; Application of modern pesticides	Introduce alternative species into production; Greater use of organic fertilisers; Judicious use of NPK fertilisers (nitrogen control); Maintain good health of plants; Effective water management	Unreliable incomes; Under-developed refining industry; Chaotic market conditions; Great number of small farms, low production intensity; lack of special machinery; insufficient production of manure	Uncertain placement of agricultural products on market (cabbage, potato); Uncontrolled import of vegetables; High farmer dependence on trade sector	Vegetable production is the most intensive production with highest accumulation and financial effects; Raised temperatures and irrigation will enhance quality of many vegetable products (tomato, pepper, onion, etc.)
Animal production	All regions			Apply heat protection measures in animal production; Increase sanitary standards; Increase storage capacities for fodder	Cooling systems for closed stables expensive; Storage capacities expensive	Uncertain market conditions and price fluctuations	Lower animal losses, higher production efficiency and security

It should be borne in mind that results on the ground show that some farmers have already begun to implement adaptation measures in the form of altering the timing of farm operations and optimising plant density per unit of area, and introducing and growing drought- and heat-resistant cultivars and earlier maturing varieties. Figures 2a to 2c show the results of a stakeholder survey with regard to selected adaptation measures that have already been applied and their respective priority and feasibility. Respondents' answers clearly show that the most frequent measure and the greatest priority in all regions is investment into irrigation systems. However, other possible adaptation measures are also seen as important. For crop production (Figure 2a), the measures most cited are Change of crops and cultivars (3); Reducing soil cultivation and improving soil structure (4); Increasing plant resistance with optimised fertilising schemes (7); Introduction of resistant varieties (13) and Increasing use of winter crops (14). For fruit production (Figure 2b), the survey shows a similar situation and priorities such as Frost protection and irrigation systems (1); Hail protection (2); Optimised fertilising schemes (5); and Improved irrigation (6).

For animal production (Fig. 2c), measures against heat stress and increased fodder storage capacities are seen as the greatest priorities. Nevertheless, regional variations are apparent in these findings as well.

A. CROP PRODUCTION

A – Feasible

B – Priority

C – Already applied

V – Vojvodina

SWS – Šumadija and Western Serbia

SES – Southern and Eastern Serbia

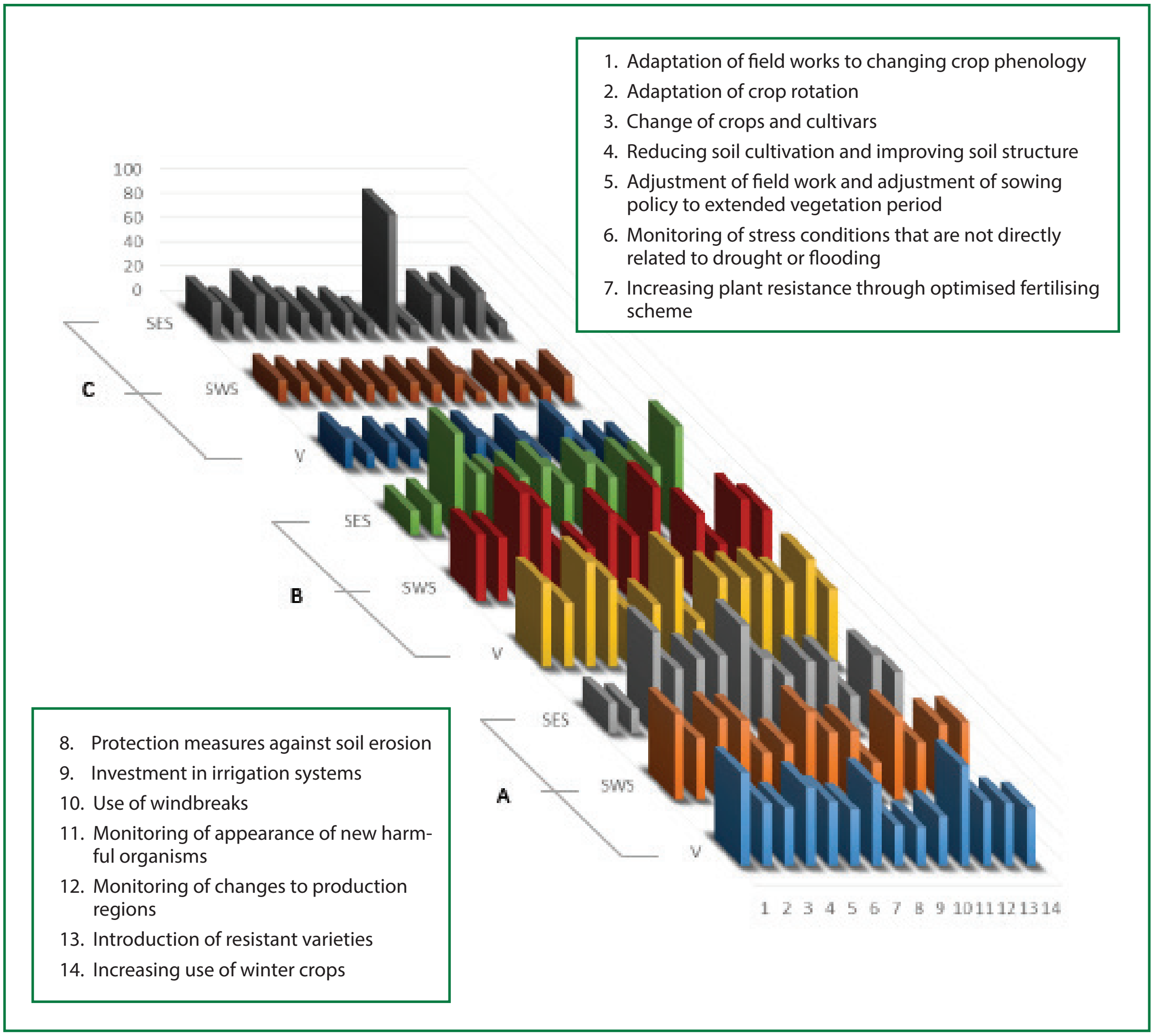

Figure 2a. Results ofa survey of farmers' perceptions and local experts' assessments of the regional importance and relevance of adaptation options to climate change for crop production

B. FRUIT PRODUCTION

A – Feasible

B – Priority

C – Already applied

V – Vojvodina

SWS – Šumadija and Western Serbia

SES – Southern and Eastern Serbia

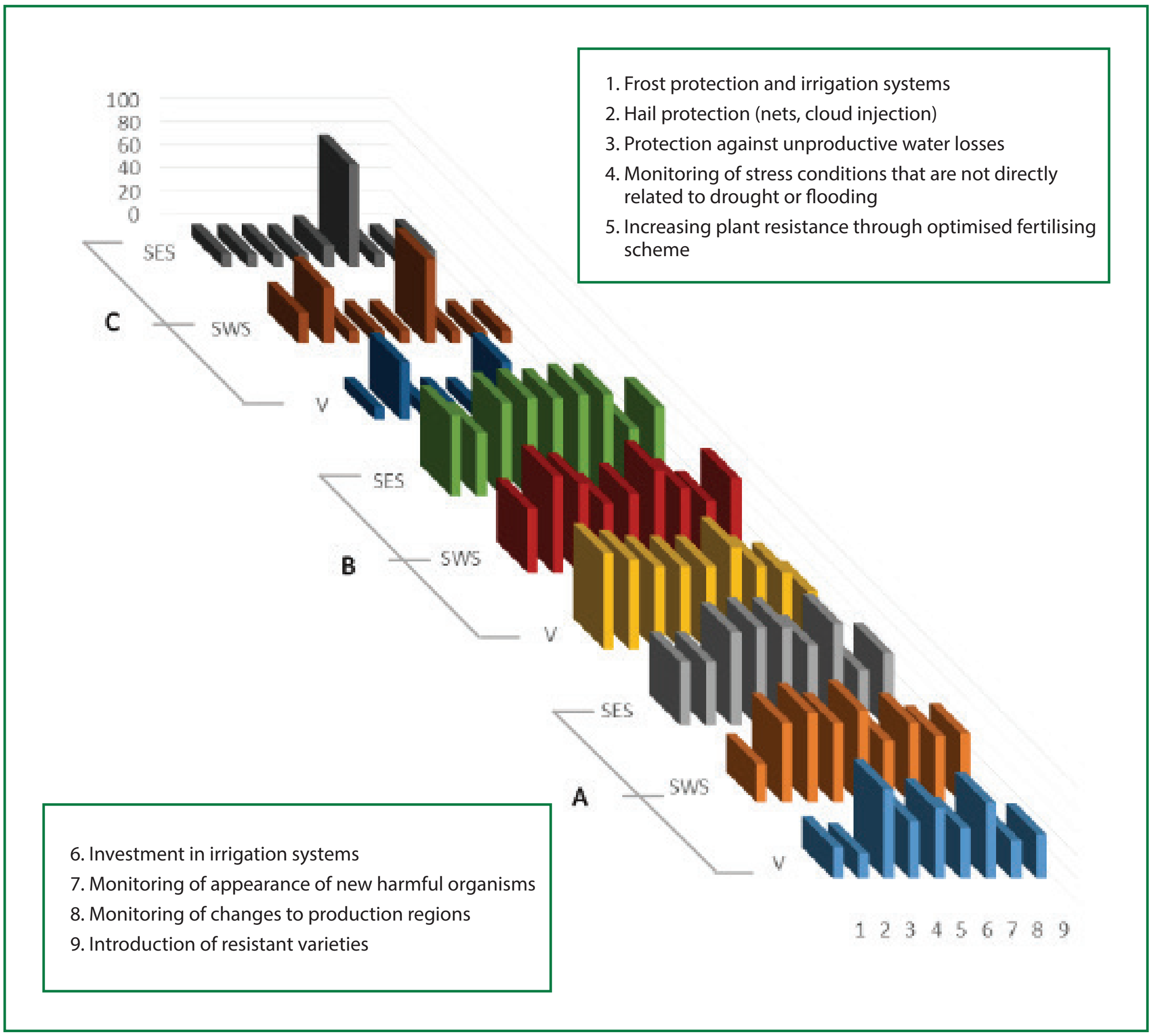

Figure 2b. Results ofa survey of farmers' perceptions and local experts' assessments of the regional importance and relevance of adaptation options to climate change for fruit production

C. LIVESTOCK PRODUCTION

A – Feasible
B – Priority
C – Already applied
V – Vojvodina
SWS – Šumadija and Western Serbia
SES – Southern and Eastern Serbia
0 - no response

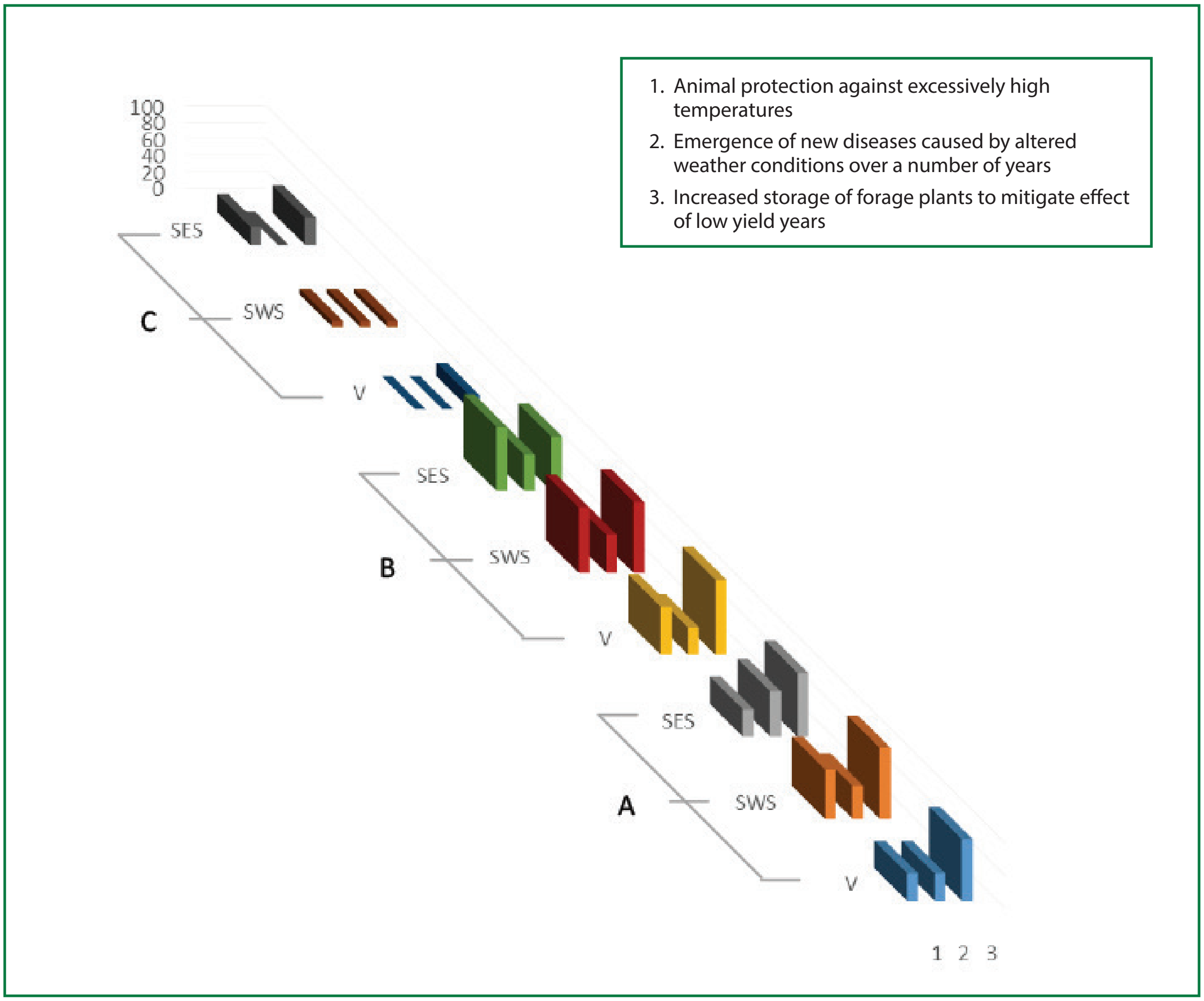

Figure 2c. Results ofa survey of farmers' perceptions and local experts' assessments of the regional importance and relevance of adaptation options to climate change for animal production

Alcamo, J., Moreno, J.M., Nováky, B., Bindi, M., Corobov, R., Devoy, R.J.N., Giannakopoulos, C., Martin, E., Olesen, J.E., Shvidenko, A., 2007: Europe. Climate Change 2007: Impacts, Adaptation and Vulnerability. *In: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edt. M.L. Parry, O.F.Canziani, J.P.Palutikof, P.J. Van der Linden, C.E. Hanson,* Cambridge University Press, Cambridge, UK, pp. 541-580.

Chakraborty, S., Datta, S., 2002: *How will plant pathogens adapt to host plant resistance at elevated CO2 under a changing climate?* New Phytol., 159, pp. 733-742.

Coakley, S.M., Scherm, H., Chakraborty, S., 1999: Climate change and plant disease management. *Annu. Rev. Phytopathol.*,37, pp. 399–426.

Disaster Preparedness and Prevention Initiative for South Eastern Europe (DPPI SEE) 2006 http://reliefweb.int/report/hungary/report-april-2006-floods-south-eastern-europe

Eitzinger, J., Thaler, S., Orlandini, S., Nejedlik, P., Kazandjiev, V., Vucetic, V., Sivertsen, T.H., Mihailovic, D.T., Lalić, B., Tsiros, E., Dalezios, N.R., Susnik, A., Kersebaum, K.C., Holden, N.M., Matthews, R., 2008: Agroclimatic indices and simulation models. In: *Survey of agrometeorological practices and applications in Europe regarding climate change impacts, edt. P. Nejedlik and S. Orlandini.* European Science Foundation, COST Action 734 and Earth System Science and Environmental Management, 2, pp. 15 -114.

Ellsworth, D., Oren, R., Huang, C., Phillips, N., Hendrey, G.R., 1995: Leaf and canopy response to elevated co_2 in a pine forest under free air CO_2 enrichment. Oecologia 104, pp. 139-146.

European Environment Agency (EEA), 2006: Vulnerability and adaptation to climate change in Europe. EEA Technical report No 7/2005. EEA, Copenhague, p. 84.

European Environment Agency (EEA), 2007: Climate change: the cost of inaction and the cost of adaptation. EEA Technical reportNo 13/2007. EEA, Copenhague, p. 72.

European Commission (EC) 2014, Serbia Floods 2014, United Nations, European Commission, World Bank Group, Belgrade, 2014.

Hoogenboom, G., Tsuji, G. Y., Pickering, N. B., Curry, R. B., Jones, J. W., Singh, U., Godwin, D. C., 1995: Decision Support System to Study Climate Change Impacts on Crop Production. In: *Climate Change and Agriculture: Analysis of Potential International Impacts,Special Publication No. 59* (Eds C. Rosenzweig, Jr. L. H. Allen, A. Harper, S. E. Hollinger & J. W. Jones), pp. 51-75. Madison, Wisconsin, U.S.A.: ASA.

Intergovernmental panel on Climate Change (IPCC), 2007: Climate Change 2007 – Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the IPCC.

International Commission for the Protection of the Danube River (ICPDR) 2007, The Analysis of the Danube Floods 2006.

Jančić, M., 2013: Impact of Climate Change on Maize Yield in the Region of Novi Sad (Vojvodina), Field and Vegetable Crops Research, 50, 3, pp. 110-114 (in Serbian)

Jevtić, R., 1997: Occurrence and significance of tawny spot of wheat leaf (*Pyrenophoratritici-repentis*), Plant Doctor, Vol 25, no. 5, pp. 320-524. (in Serbian)

Jevtić, R., Telečki, M., Lalić, B., Mihailović D.T, 2010: Climate change impact on small grains diseases apperance in vojvodina region, *In:Advances in Environmental Modeling and Measurements,*edt. D.T. Mihailovic and B. Lalic, Nova Science Publishers, Inc., New York, pp. 209-222. ISBN: 978-1-60876-599-7.

Jevtić, R., Lalić, B., Mihailović, T.D., Maširević, S., Telečki, M., Medić-Pap, S., 2011: Impact of climate change on diseases of field and vegetable crops: Adaptation measures and control, Plant Doctor, Vol. 39, No. 1, pp. 60-67 (in Serbian)

Krupa, S., McGrath, M.T., Andersen, C.P., Booker, F.L., Burkey, K.O., Chappelka, A.H., Chevone, B.I., Pell E.J., Zilinskas, B.A., 2001: Ambient ozone and plant health. *Plant Dis.,* 85, pp. 4-12.

Lalić, B., Mihailović, D.T,Malešević, M., 2008: Estimating winter wheat yield and phenology dynamics using Met and Roll weather generator. *In:Environmental, Health and Humanity Issues in the Down Danubian Region. Multidisciplinary Approaches. Proceedings of the 9th International Symposium on Interdisciplinary Regional Research,University of Novi Sad, June, 21-22 2007*, edt. D.T. Mihailović and M. Vojinović-Miloradov). World Scientific, New York, London, Singapore, 25, pp. 233-244. ISBN 978-981-283-439-3.

Lalić, B. and Mihailović, D.T., 2009: Assessment of climate change impact on phenology dynamic in Vojvodina region, *9th Annual Meeting of the EMS / 8th ECAC*, 28.9.-2.10.2009., Toulouse (France), *Abstracts*, Vol.6., EMS2009-504-1. M34

Lalić, B. and Mihailović, D.T., 2011: Impact of climate change on food production in northern Serbia (Vojvodina), *In: The impact of Climate Change on food production in the Western Balkan region*, Regional Environmental Center (REC), pp. 67-85.

Lalić, B., Eitzinger, J., Mihailović, D.T., Thaler, S., Jančić, M., 2012: Climate change impacts on winter wheat yield change – which climatic parameters are crucial in Pannonian lowland? **The Journal of Agricultural Science, 151, 06, pp. 757-774.**

Lalić, B., Janković, D., Ninkov, M., 2013: Assessment of climate change impact on downy mildew appearance in Serbia using ECHAM5 climate model outputs, *Environmental changes and adaptation strategies*, Proceedings, Ed.: B. Siska and J. Skvarenina, *Skalica,(Slovakia), 9th – 11th September 2013,* str. 160-164.

Maslac, 2012, Drought Driven Declines in Serbian Crops Increased Food Prices, Grain report

Mearns, L.O., Rosenzweig, C., Goldberg, R., 1997: Mean and variance change in climate scenarios: Methods, agricultural applications, and measures of uncertainty. *Climatic Change,* 35, pp. 367-396.

Mihailović, D.T. B. Lalić, I. Koči, M. Malešević, R. Jevtić, Z. Keserović, M. Jančić, 2011: Vulnerability assessment, climate change impacts and adaptation measures in sector of agriculture. *In: Initial National Communication of the Republic of Serbia under the United Nations Framework Convention on Climate Change, edt. D. Bozanic and M. Gasperic*, The Ministry of Environment and Spatial Planning of Republic of Serbia, pp. 150.

Mihailović, D.T., B. Lalić, N. Drešković, G. Mimić, V. Djurdjević and M. Jančić, 2014: Impact of observed and projected shifts of Köppen climate zones on the crops yield change in Serbia under the SRES-A1B and SRES-A2. *International Journal of Climatology*.

Meehl, G.A., Tebaldi, C., 2004: More intense, more frequent and longer lasting heat waves in the 21st century, Science, 305, pp. 994– 997.

Olesen, J.E., Bindi, M., 2002: Consequences of climate change for European agricultural productivity, land use and policy. European Journal of Agronomy, 16, pp. 239-262.

Rowell, D.P., Jones, R., 2005: The causes and uncertainty of future summer drying over Europe. Climate Dynamics, 27(2-3), pp. 281-299.

Ruml M, Vukovic A, Vujadinovic M, Djurdjevic V, Rankovic-Vasic Z, Atanackovic Z, Sivcev B, Markovic N, Matijasevic S, Petrovic N, 2012, On the use of regional climate models: Implications of climate change for viticulture in Serbia, Agric. Forest. Meteorol. 158-159, str. 53-62, doi: j.agrformet.2012.02.004.

Svobodová, E.,Trnka, M., Dubrovský, M., Semerádová, D., Eitzinger, J., Štěpánek, P., Žalud, Z., 2014: Determination of areas with the most significant shift in persistence of pests in Europe under climate change, Pest. Manag. Sci., 70, 5, pp. 708-715.

Thornton, P. K., Bowen, W. T., Ravelo, A. C., Wilkens, P. W., Farmer, G., Brock, J. & Brink, J. E.(1997).Estimating Millet production for Famine Early Warning: An application of Crop Simulation Modeling Using Satellite and Ground Based Data in Burkina Faso.Agriculture and Forest Meteorology**,** pp. 83, 95-112.

Trnka, M., Olesen, J., Kersebaum, C., Skjelvåg, A., Eitzinger, J., Seguin, B., Peltonen-Sainio, P., Iglesias, A., Rötter, R., Orlandini, S., Dubrovský, M., Hlavinka, P., Balek, J., Eckersten, H., Cloppet, E., Calanca, P., Gobin, A., Vučetić, V., Nejedlik, P., Kumar, S., Lalić, B., Mestre, A., Rossi, F., Kozyra, J., Alexandrov, V., Semerádová, D., Žalud, Z., 2011: Agroclimatic conditions in Europe under climate change, Global Change Biology, 17, 7, pp. 2298-2318.

World Bank (WB), 2014, Report: Turn Down the Heat: Confronting the New Climate Normal.

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