FROM SCIENCE TO POLICY

CLIMATE CHANGE RISKS ASSESSMENT AND ADAPTATION PLANNING IN AGRICULTURE IN SERBIA

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CLIMATE HAZARDS

change in conditions of climate system

change of climate conditions

1 TEMPERATURE INCREASE,
HEAT WAVES,
EXTREMLY HIGH TEMPERATURES

2 DROUGHT AND INCREASE IN ARIDITY

3 INTENSIFICATION OF PRECIPITATION
AND STORMS

4 SOIL DEGRADATION

5 WATER SCARCITY

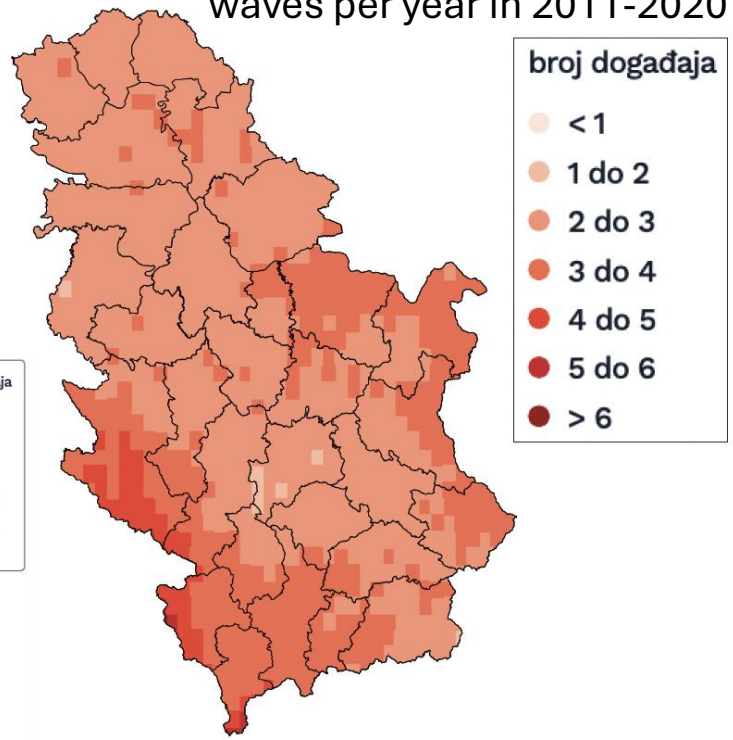
6 FIRES, LANDSLIDES FLOODS,
AIR POLUTION,...

1. TOO WARM

TEMPERATURE INCREASE,
HEAT WAVES,
EXTREMELY HIGH TEMEPRATURES

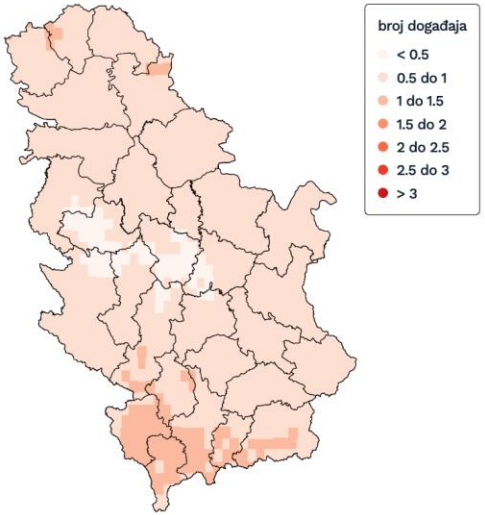
	2011-2020	2041-2060	RCP8.5 2081-2100
Tsr	+1.8°C	**+3.1°C**	**+5.8°C**
Topl. talasi	+3	**+4, +5**	**+8,+10**
Tx35	+7, +10	**+20**	**+35,+45**

increase in number of heat waves per year in 2011-2020

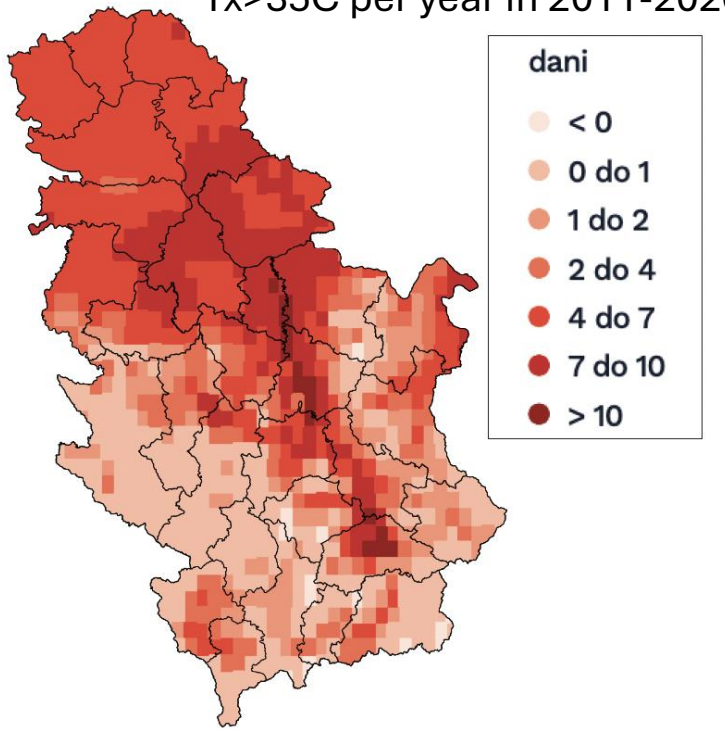


<u>referent values</u>

number of heat waves per year in 1961-1990

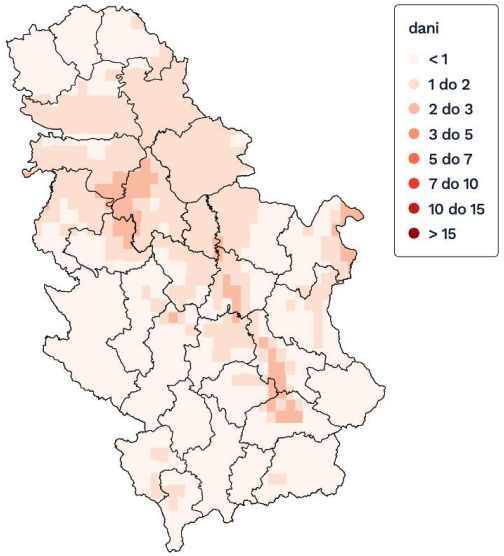


increase of number of days with Tx>35C per year in 2011-2020



<u>referent values</u>

number of days with Tx>35C per year in 1961-1990

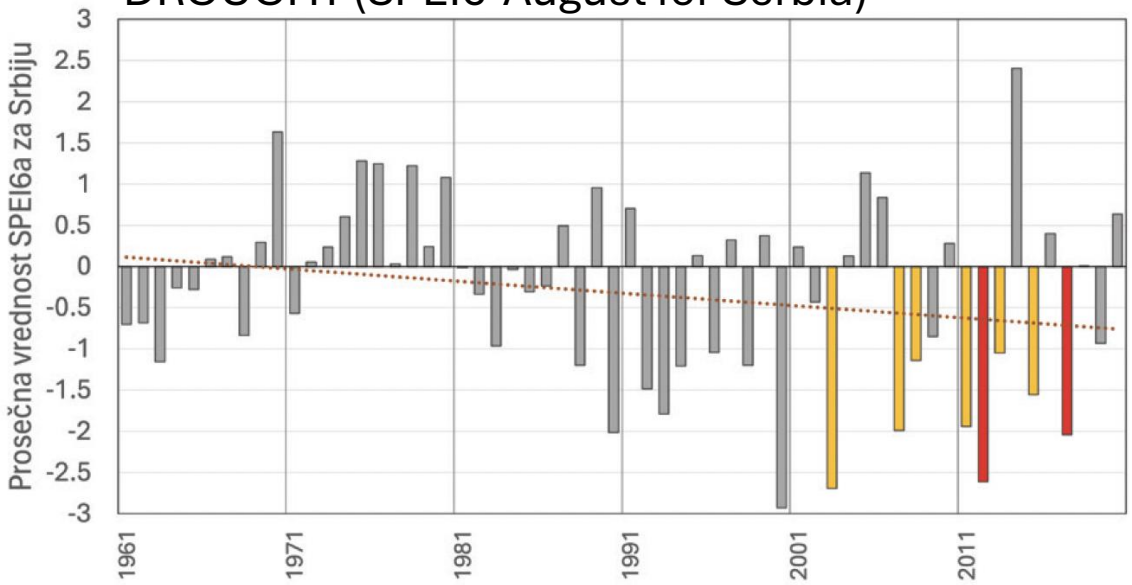


2. DROUGHT AND INCREASE IN ARIDITY

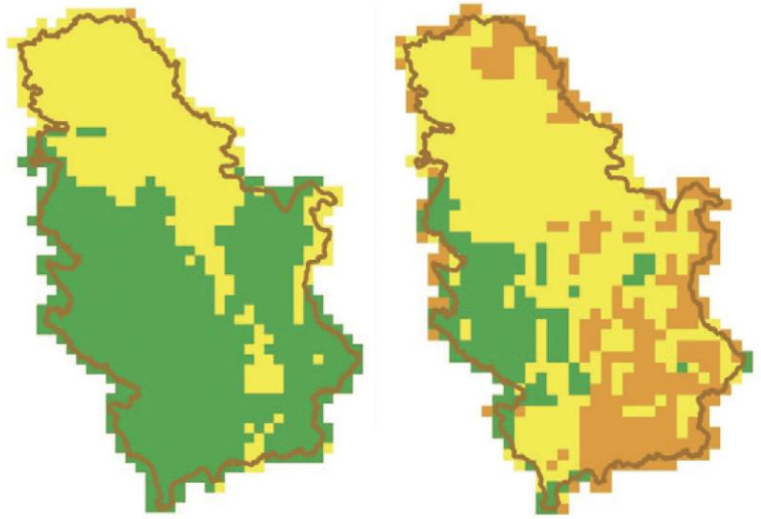
INCREASE IN DROUGHTS AND IN ARIDITY
- change of annual precipitation distribution
- change of distribution of precipitation by intensity
- high temperatures

	2011-2020	2041-2060	RCP8.5 2081-2100
Droguht	5 years with drought per decade	every year is with drought	every year is with drought
Extreme drought	1 per decade	3 to 4 per decade	over 8 per decade
Climate type	humid	dry sab-humid	?

DROUGHT (SPEI6-August for Serbia)



Climate characteristic humid/arid



Average for Serbia:
2001-2020 humid climate
2041-2060 dry sub-humid

semi-dry
dry sab-humid
humid

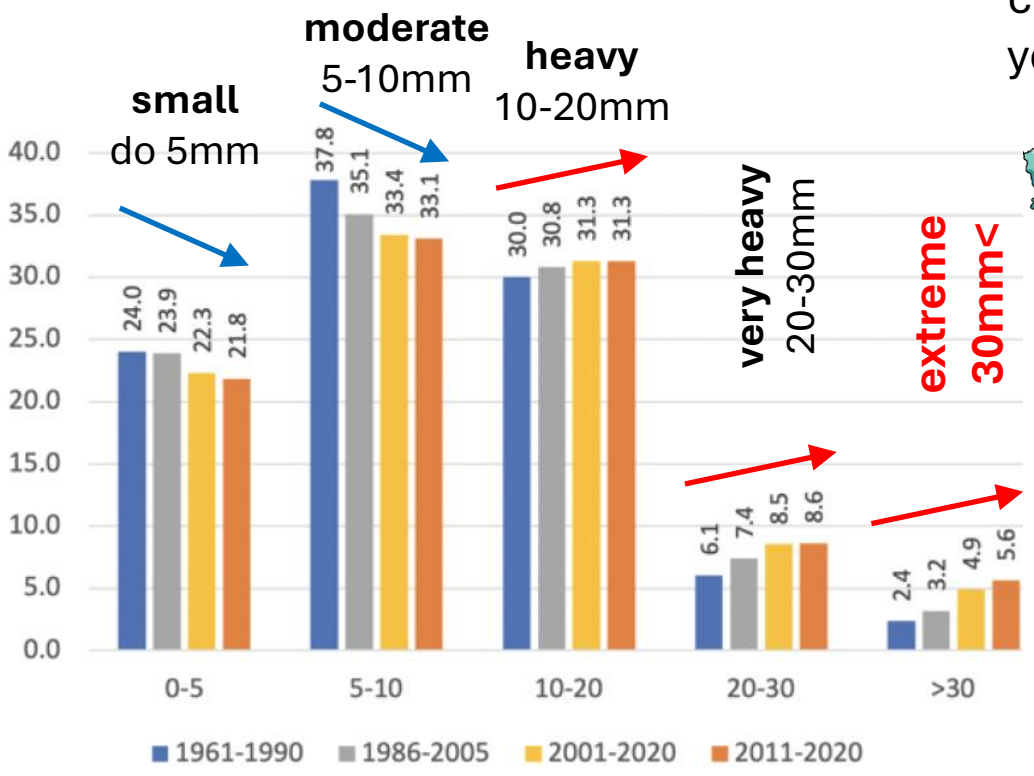
3. INTENSIVE PRECIPIATION

INTENSIVE PRECIPITATION AND STORMS
- change of precipitation distribution by intensity,
- high temperatures

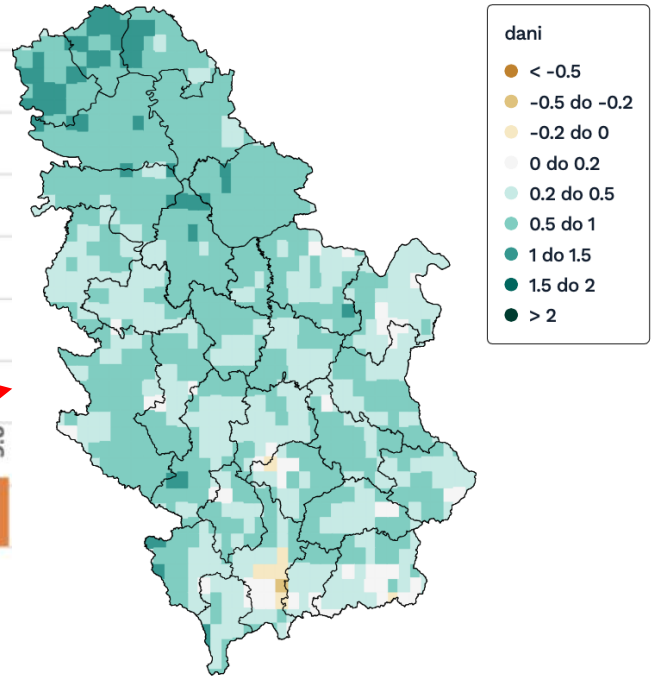
	2011-2020	2041-2060	RCP8.5 2081-2100
Change in number of days with extreme precipitation	0,9	1-1,4	1,2-1,9

average for Serbia compared to 1961-1990

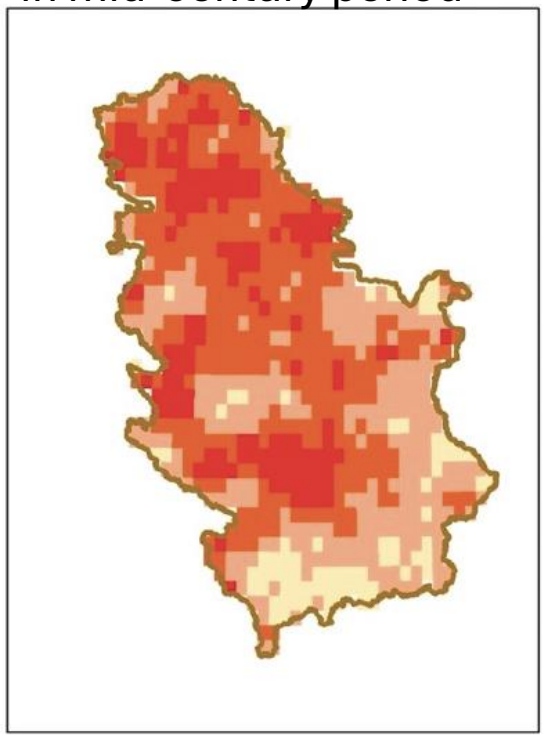
Distribution of daily precipitation by intensity, in percent (%) of total amount over Serbia



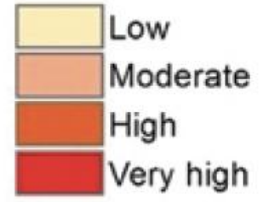
change in number of days per year in mid-century period



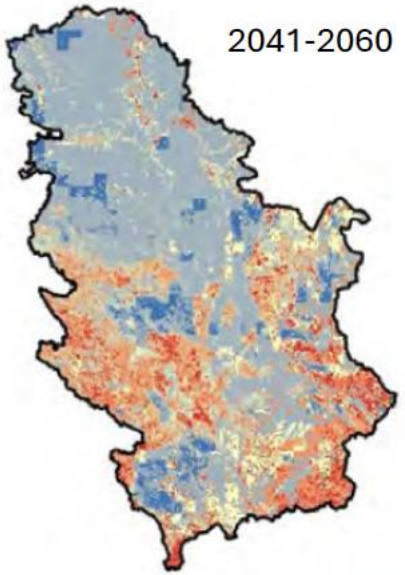
risk of extreme precipitation in mid-century period



2041-2060
10% low
34% moderate
56% high and very high



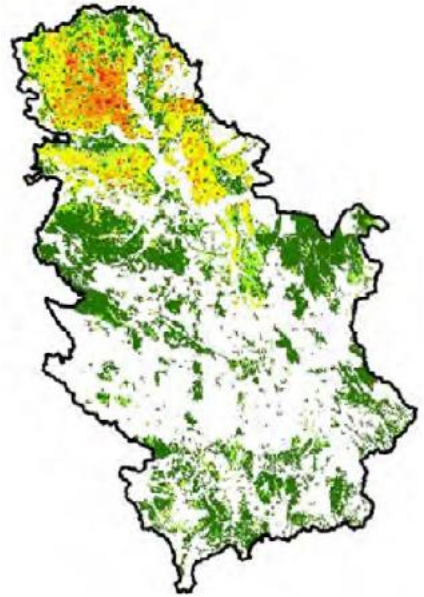
4. SOIL DEGARDATION



Risk of soil degradation under climate change because of increase in aridity and increase of risk of extreme precipitation

% teritorije Srbije

Nivo rizika	2001-2020	2041-2060
nizak	43,2	6,4
umeren	29,2	51,6
visok	13,9	17,1
veoma visok	11,2	18,6
ekstremno visok	2,5	6,3

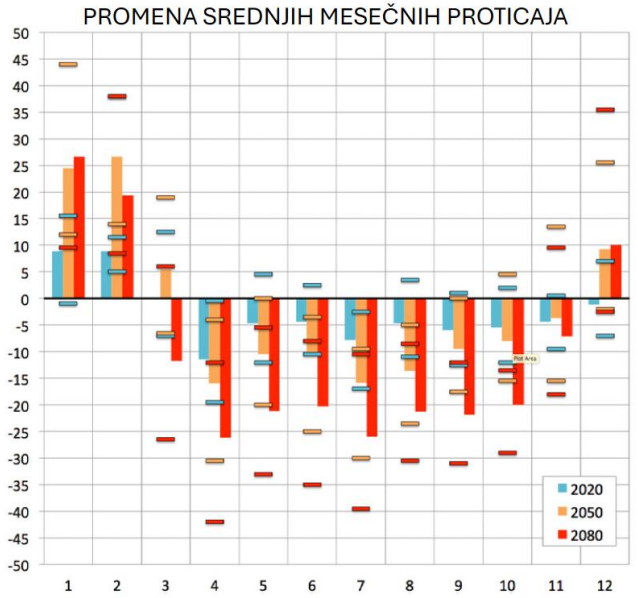


Vulnerability of land surface to witd erosion (depending on the season)

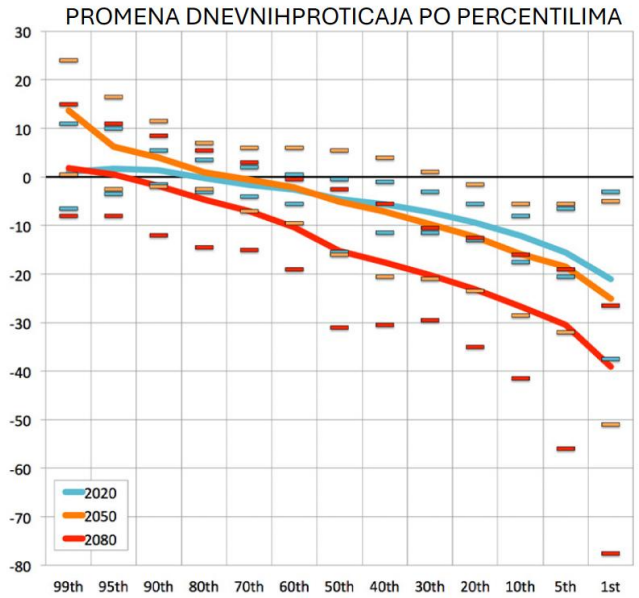
- nije ranjivo
- nizak nivo ranjivosti
- umeren nivo ranjivosti
- visok nivo ranjivosti
- veoma visok nivo ranjivosti

5. WATER RESOURCES

RIVER DISCHARGE CHANGE



April-October (March-November) decrease in river discharge



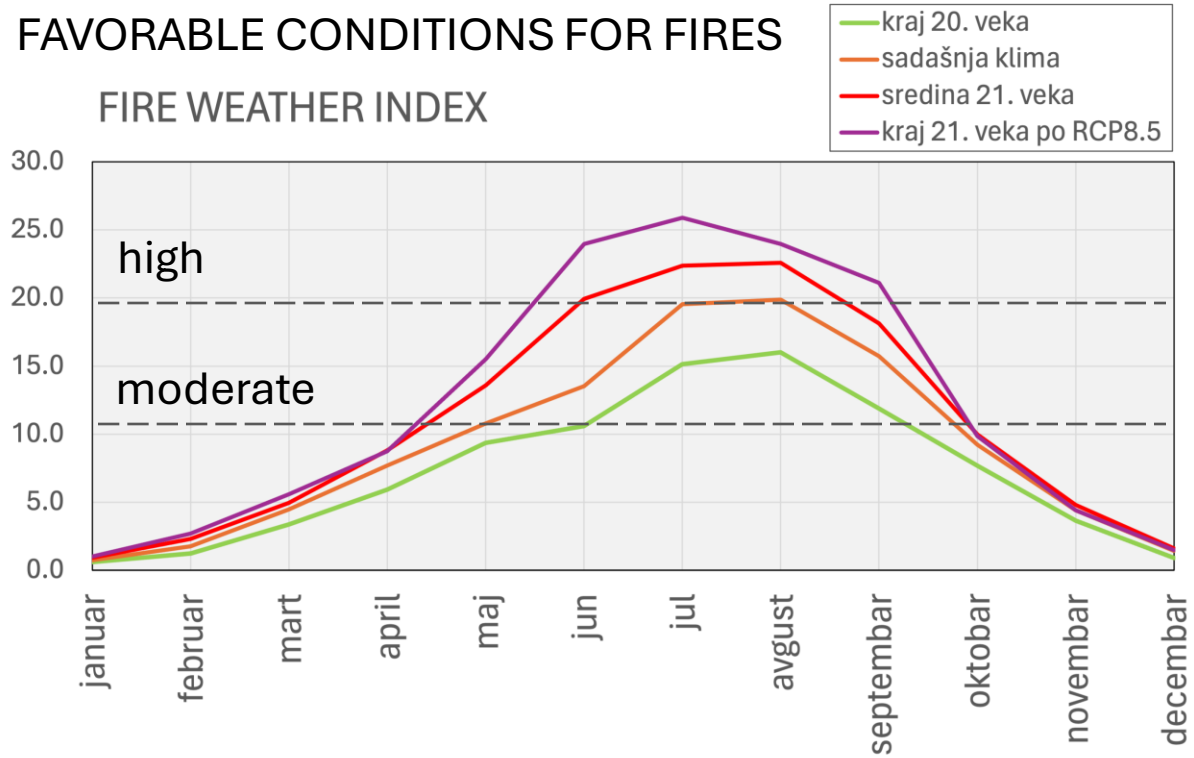
increase in maximum dischrges and decrease in median and low discharges

SPEED OF UNDERGROUND WATER RECHARGE

Mid-century period: reduction in recharge 20-40% (depending on the season and region); end of century period according to RCP8.5: over 50% reduction, in southeast of Serbia 70%.

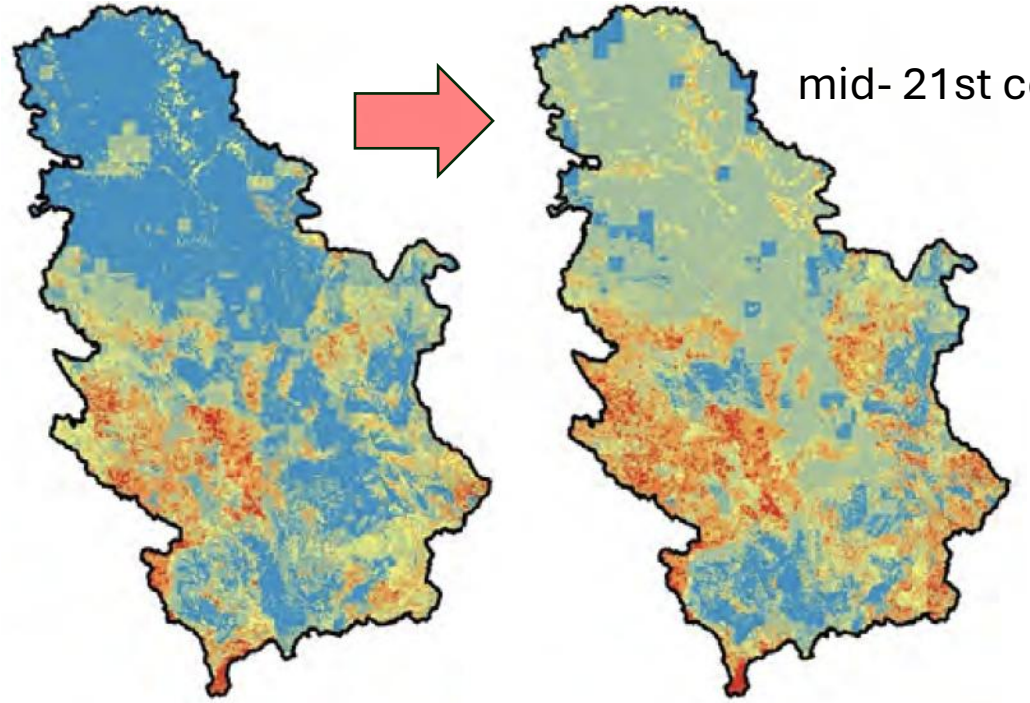
6. OTHER CLIMATE HAZARDS

FAVORABLE CONDITIONS FOR FIRES



https://climate-adapt.eea.europa.eu/en/metadata/indicators/fire-weather-index

SOIL WATER EROSION RISK



mid- 21st century

rizik	2001-2020	2041-2060
nizak	44.5%	12.9%
umeren	31.8%	53.3%
visok	11.3%	14.3%
veoma visok	10.6%	16.4%
ekstremno visok	1.8%	3.1%

high
very high
extremely high

AIR POLLUTION:

- tropospheric ozon increase in concentration
- prolonged stable conditions and high air pollution
- more fires

AGRICULTURE - RISK ASSESSMENT

Annual crops

(maize, sunflower, winter wheat, soy and sugar beet)

- **Extension of growing to higher alt.**
- **Water deficit risk**
- **High summer temperatures risk**

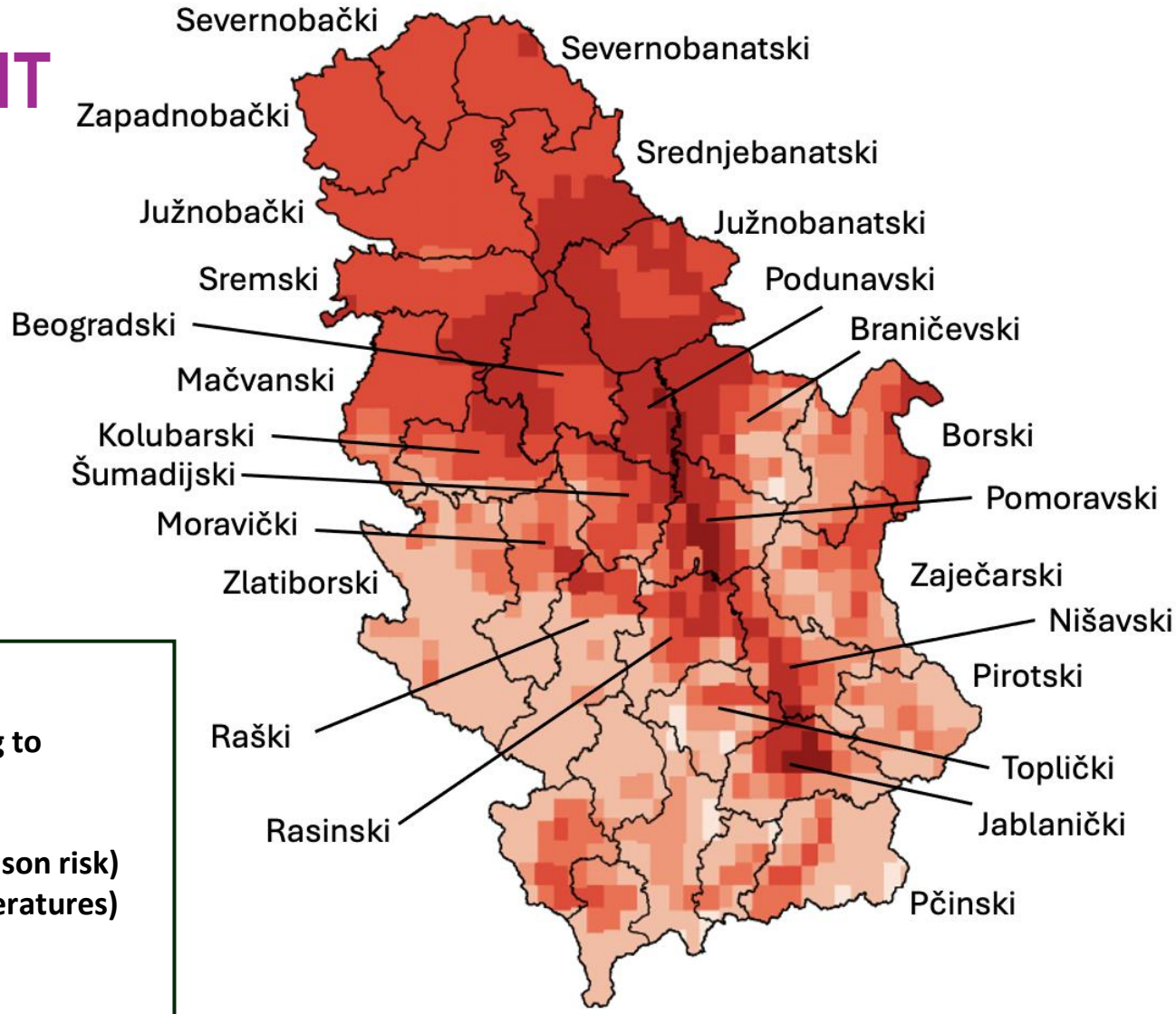
Fruit production

(almond, apricot, peach, strawberry, currant, walnut, plum, sour cherry, cherry, raspberry, blackberry, apple, pear, quince, blueberry)

- **Extension of growing to higher alt.**
- **Water deficit risk**
- **Frost in growing season risk**
- **High summer temperatures risk**
- **Hail risk**

Viticulture

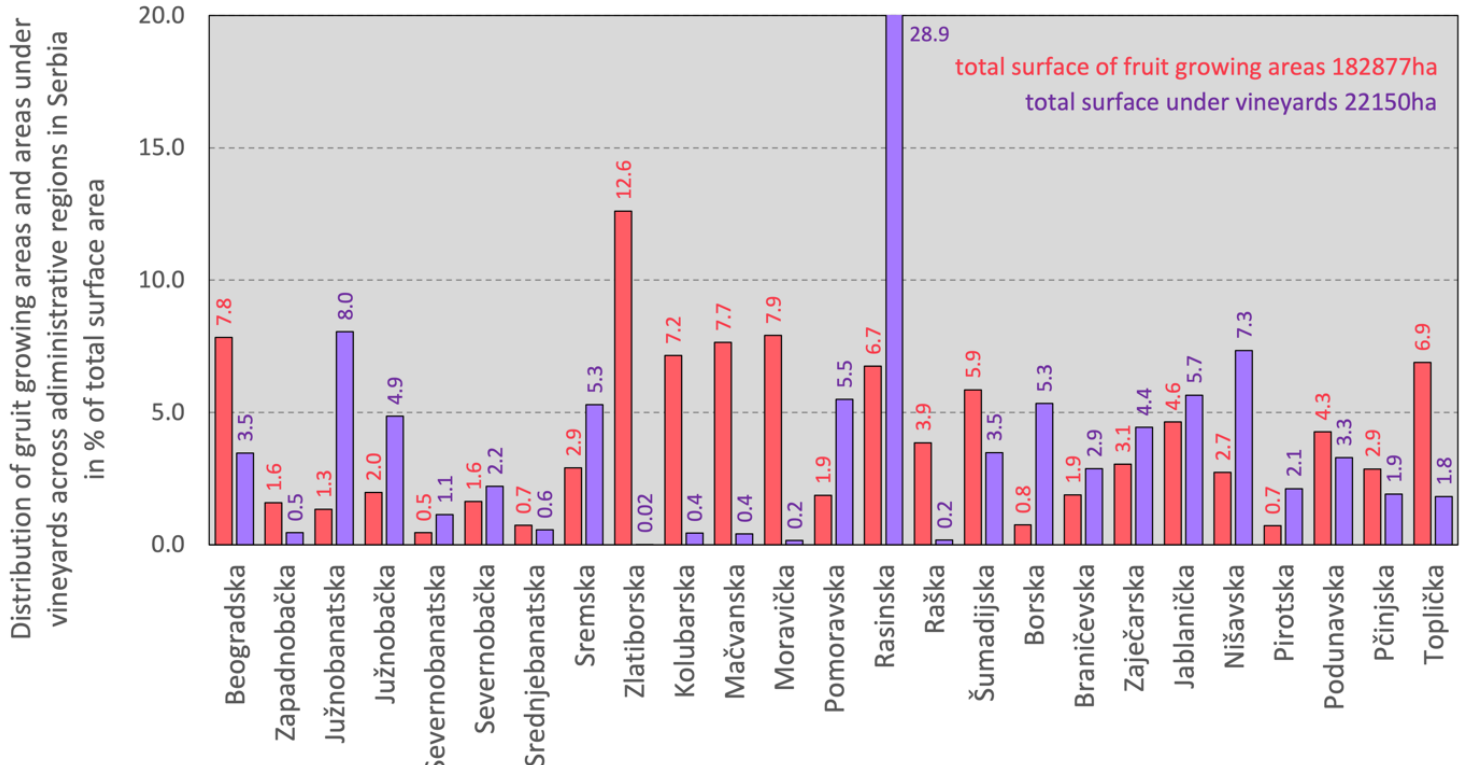
- **Extension of growing to higher alt.**
- **Hail risk**
- **(Frost in growing season risk)**
- **(High summer temperatures)**
- **(Water deficit)**



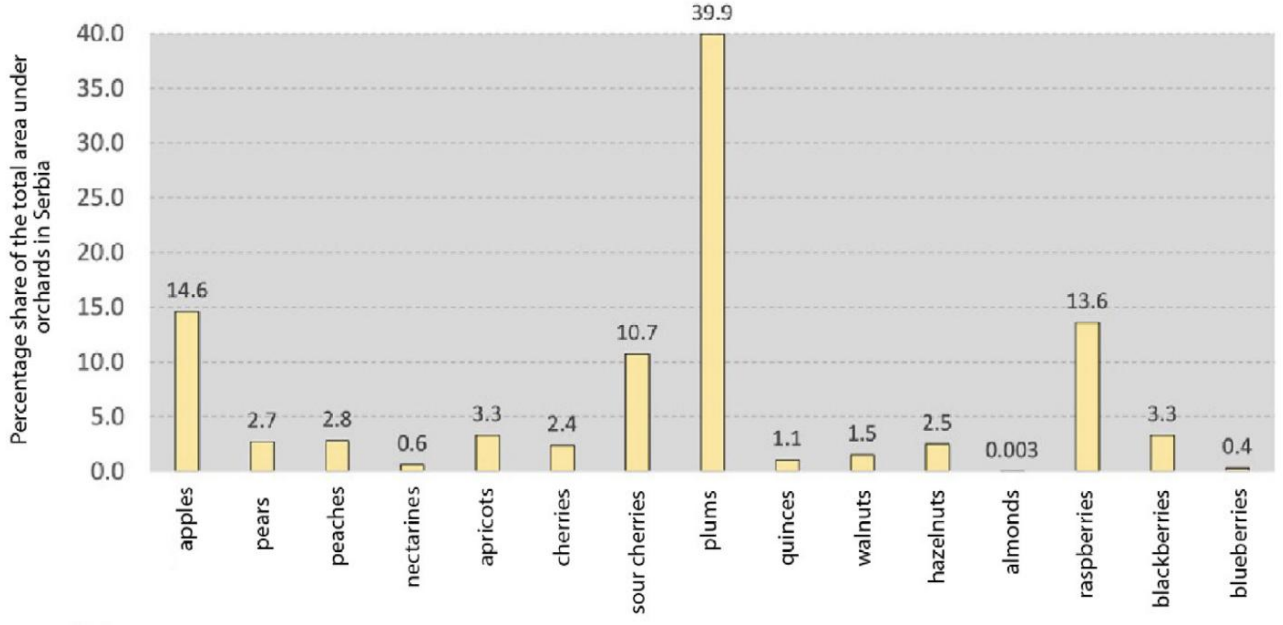
RISK ASSESSMENT IS DONE ON REGIONAL LEVEL (sub-national level)

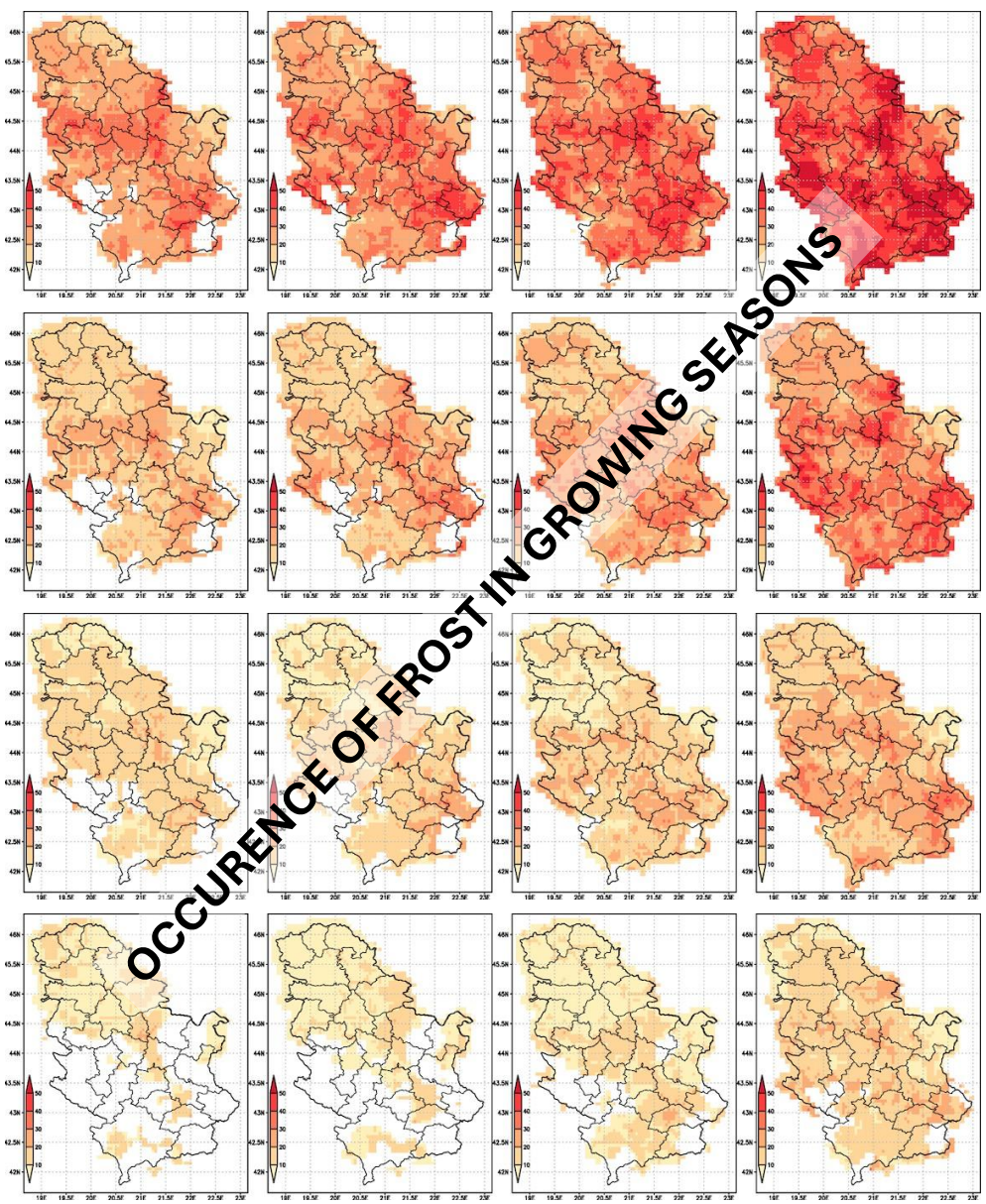
CLIMATE HAZARDS IN FRUIT GROWING

distribution of orchards and vineyards by regions

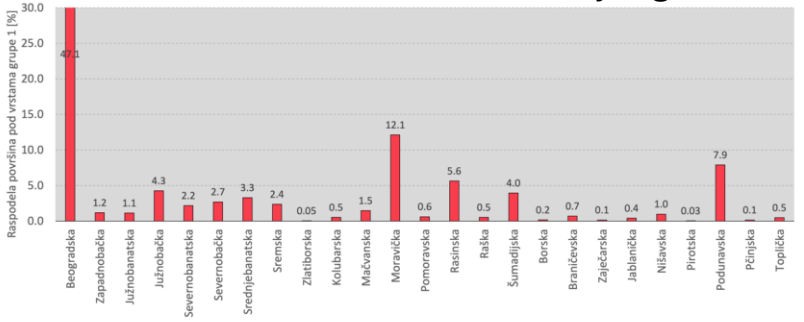


distribution of orchards by varieties

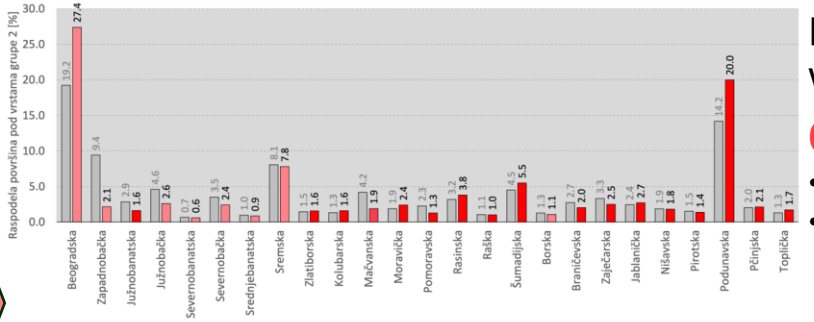




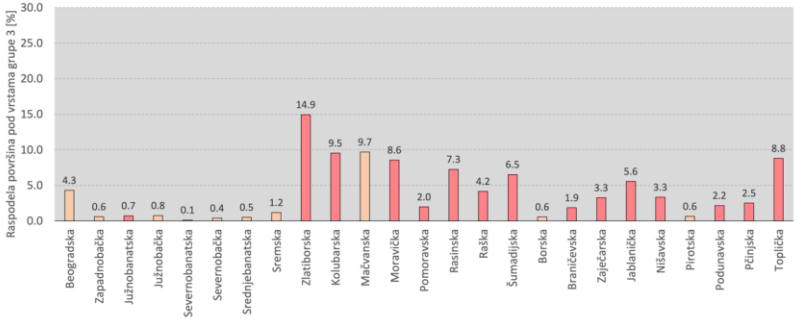
distribution of risk levels by regions for different varieties and their distribution by regions



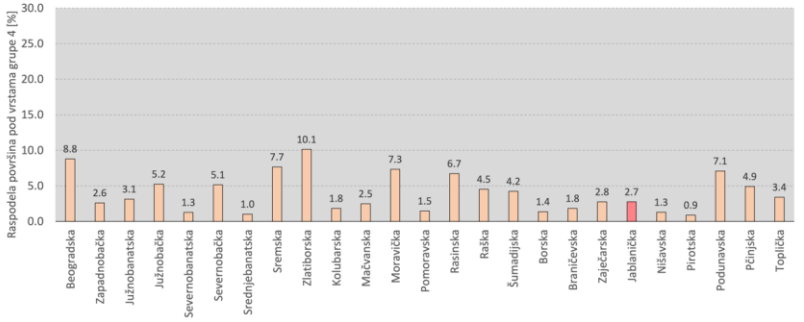
almond, apricot



peach, strawberry, currant, walnut (and hazelnut)



plum, sour cherry, cherry, raspberry and blackberry



apple, pear, quince blueberry

	high
	increasing
	acceptable

3,3% of total orch surface

- **3,3%** in areas with high risk

6,9% (4,4% without hazelnut)

- **3,9%** in high risk,
- **3%** in increasing risk

69,9%

- **56,9%** in increasing risk,
- **13%** in acceptable risk

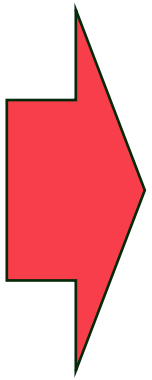
18,4%

- **0,5%** in increasing risk,
- **17,9%** in acceptacble risk

FROST IN GROWING SEASON RISK ASSESSEMNT ON NATIONAL LEVEL

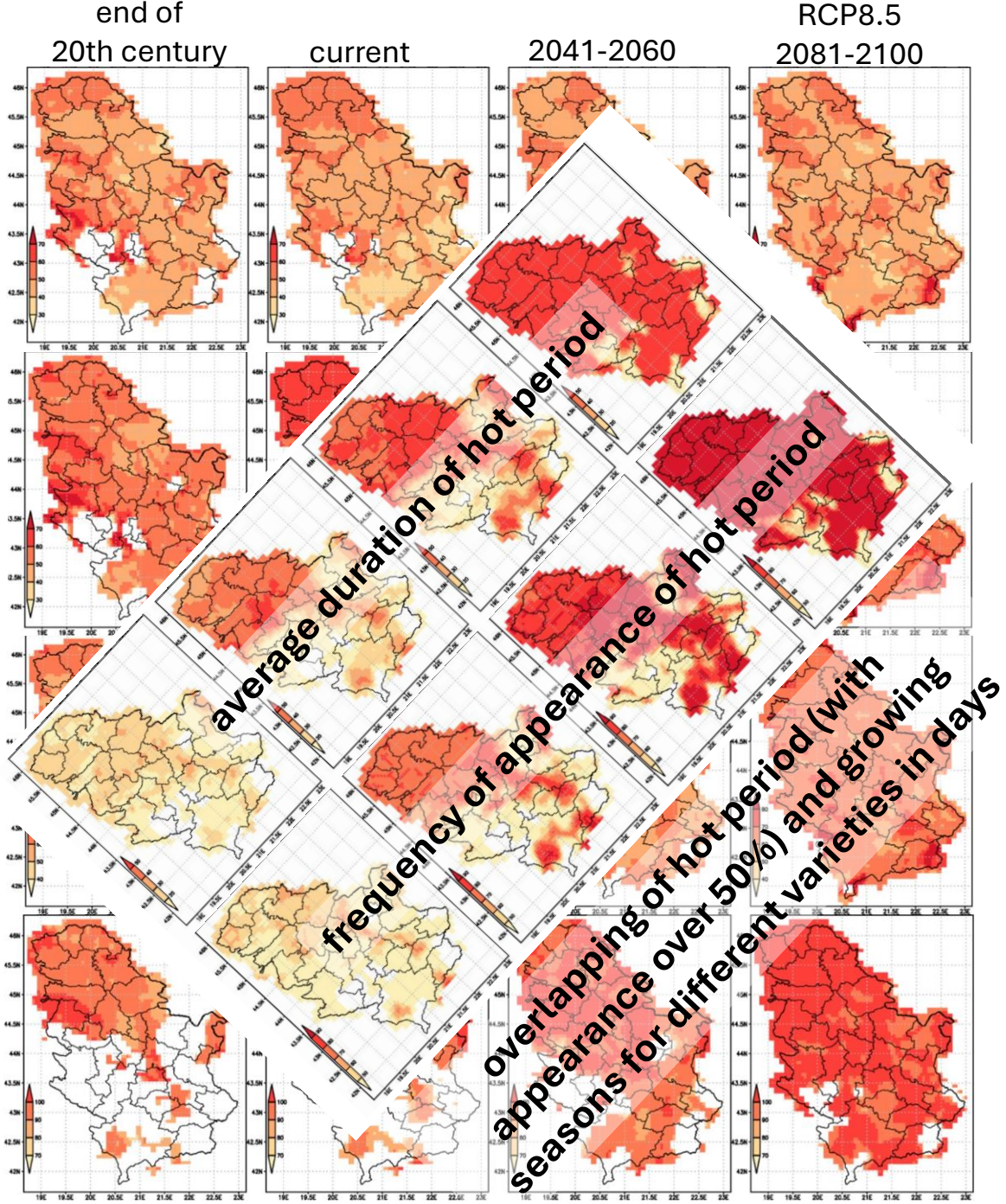
in current climate conditions

7.2%	7.2% of orchards is in areas where is for those verieties high risk from frost in growing season
60,4%	60,4% of orchards is in areas where is for those verieties increasing risk from frost in growing season up to high level risk in mid-century climate period
32,4%	32,4% of orchards is in areas where is for those verieties acceptable risk from frost in growing season and will not change significantly by mid-century climate period



in climate conditions 2041-2060

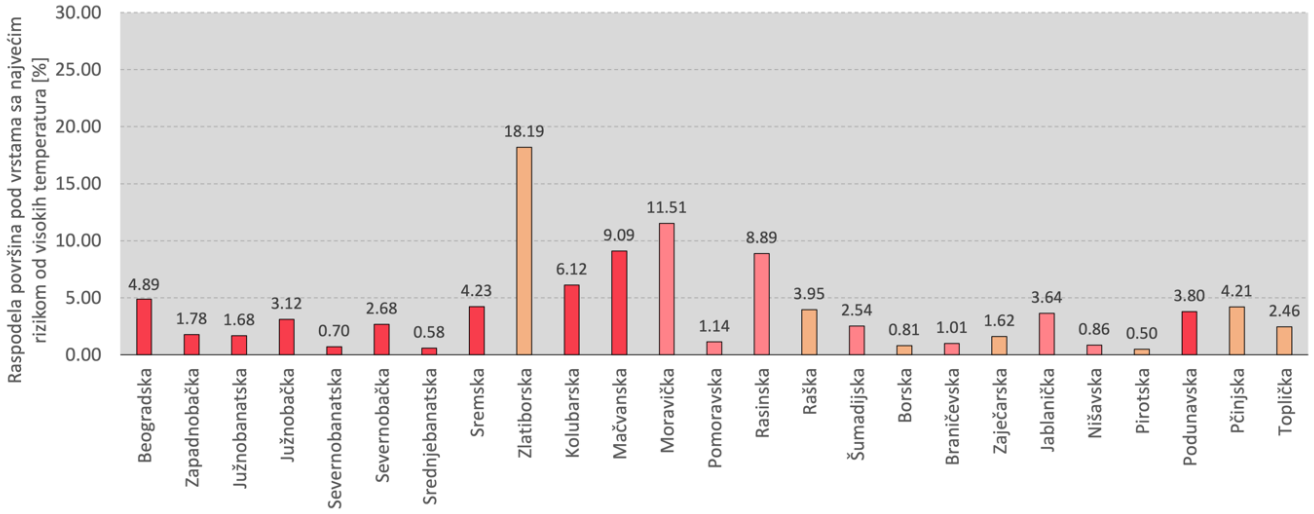
67,6%	67,6% of orchards is in areas where is for those verieties high risk from frost in growing season



	high
	increasing
	acceptable

most sensitive to high temperatures (hot days): apple, pear, quince, blueberry, raspberry, blackberry are in **35,7%** of total surface area of orchards in Serbia

- **13,9%** in areas of high risk,
- **10,6%** in areas of increasing risk
- **11,2%** in areas of acceptable risk



RISK OF EXTREMELY HIGH TEMEPRATURES IN GROWING SEASON ON NATIONAL LEVEL

in current climate conditions

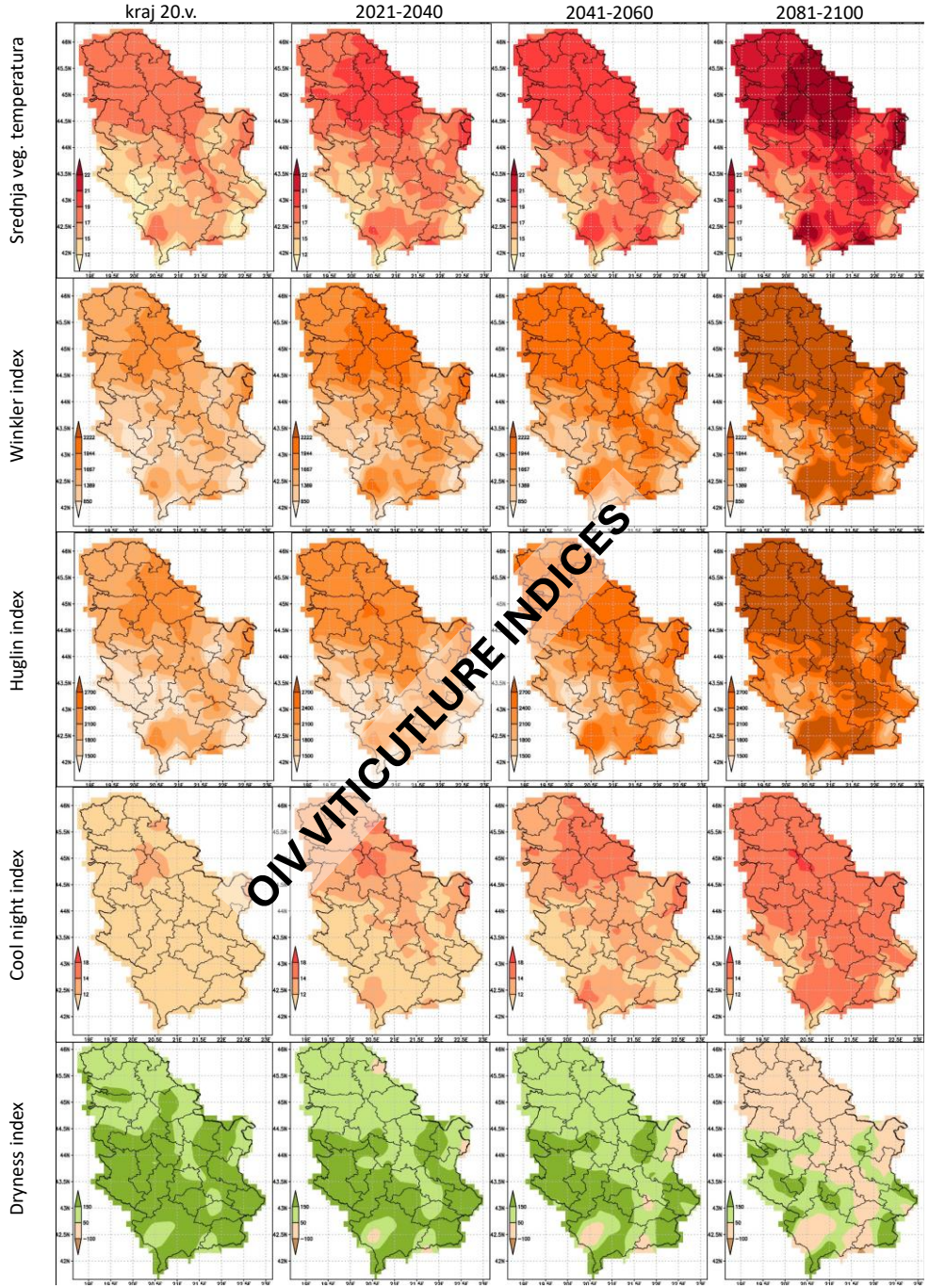
13,9%	13,9% of orchards is in areas where, for most sensitive varieties, is high risk from extreme temperatures in growing season
10,6%	10,6% of orchards is in areas where, for most sensitive varieties, is increasing risk from extreme temperatures in growing season up to level of high risk in mid-century climate period
11,2%	11,2% of orchards is in areas where, for most sensitive varieties, is acceptable risk from extreme temperatures in growing season

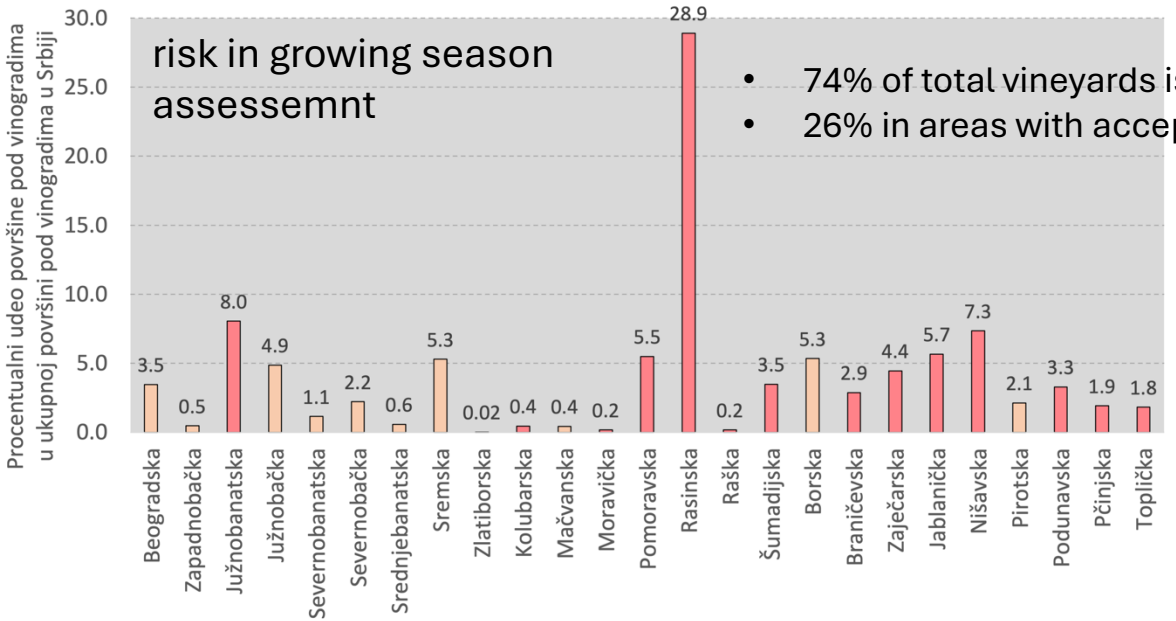
in climate conditions 2041-2060

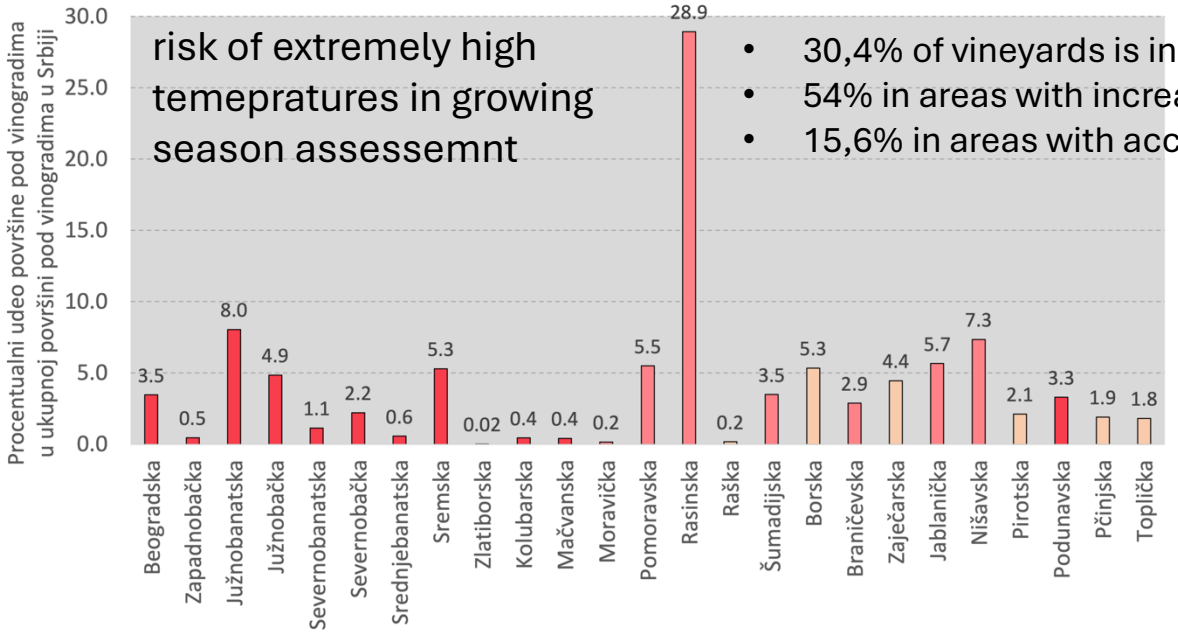
24,5%	24,5% of orchards is in areas where, for most sensitive varieties, is high risk from extreme temperatures in growing season

IMPRTANT NOTE: assessemnt here is given only for most sensitive varieties (to extreme temepratures because of the longer growing season), and this assessemnt can be understood as lower threshold for high risk abundance in orchards.

CLIMATE HAZARDS IN VITICULTURE



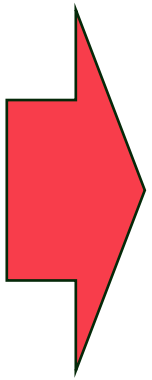




RISK ASSESSEMENT IN VITICUTLURE:
RISK FROM EXTREMELY HIGH TEMEPRATURES AND FROM FROST IN GROWING SEASON

in current climate conditions

30,4%	30,4% is in areas with high risk of extremly high temperatures in growing season
50,4%	50,4% of vineyards is in ares with increasing risk of extremly high temperatures in growing season
70%	70% of vineyards is in ares with increasing risk of frost in growing season
15,6%	15,6% of vineyards is in ares with acceptable risk of extremly high temperatures in growing season
26%	26% of vineyards is in ares with acceptable risk of frost in growing season

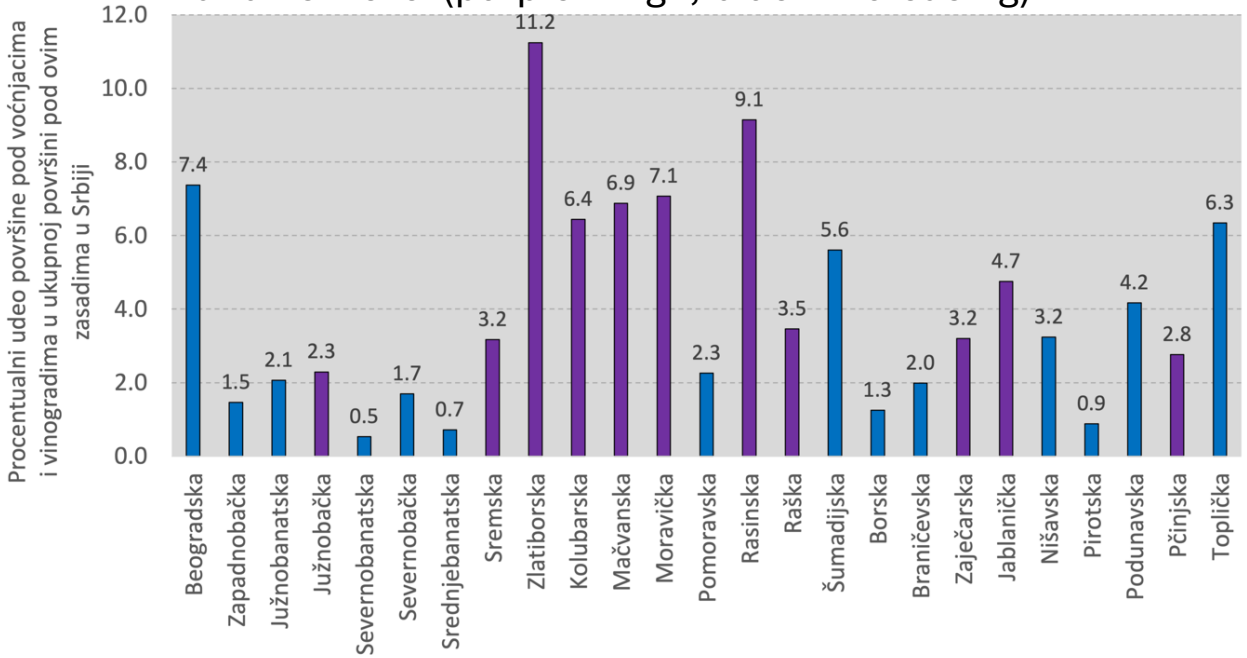


in climate conditions 2041-2060

80,8%	80,8% in areas with high risk of extremly high temperatures in growing season
70%	70% of vineyards is in ares with high risk of frost in growing season

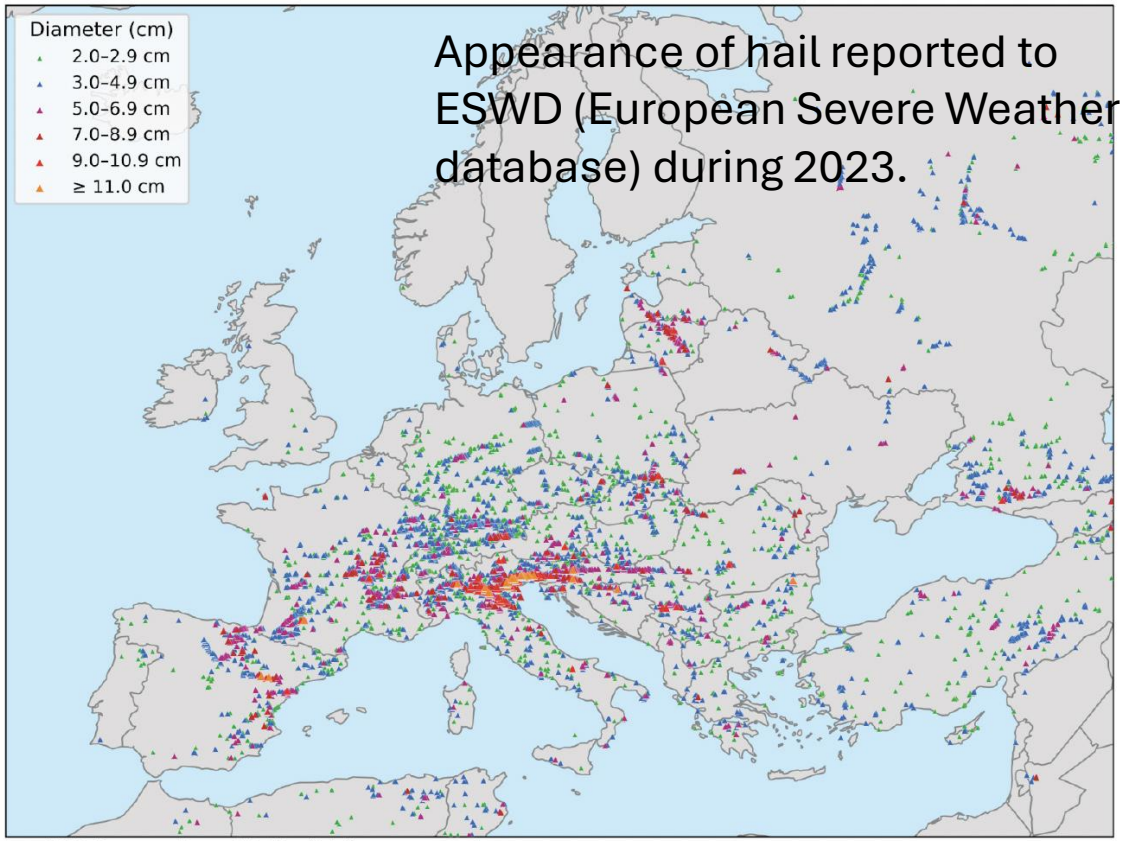
HAIL RISK IN FRUIT GROWING AND VITICULTURE

distribution of orchards and vineyards by regions and risk level (purple – high, blue – increasing)



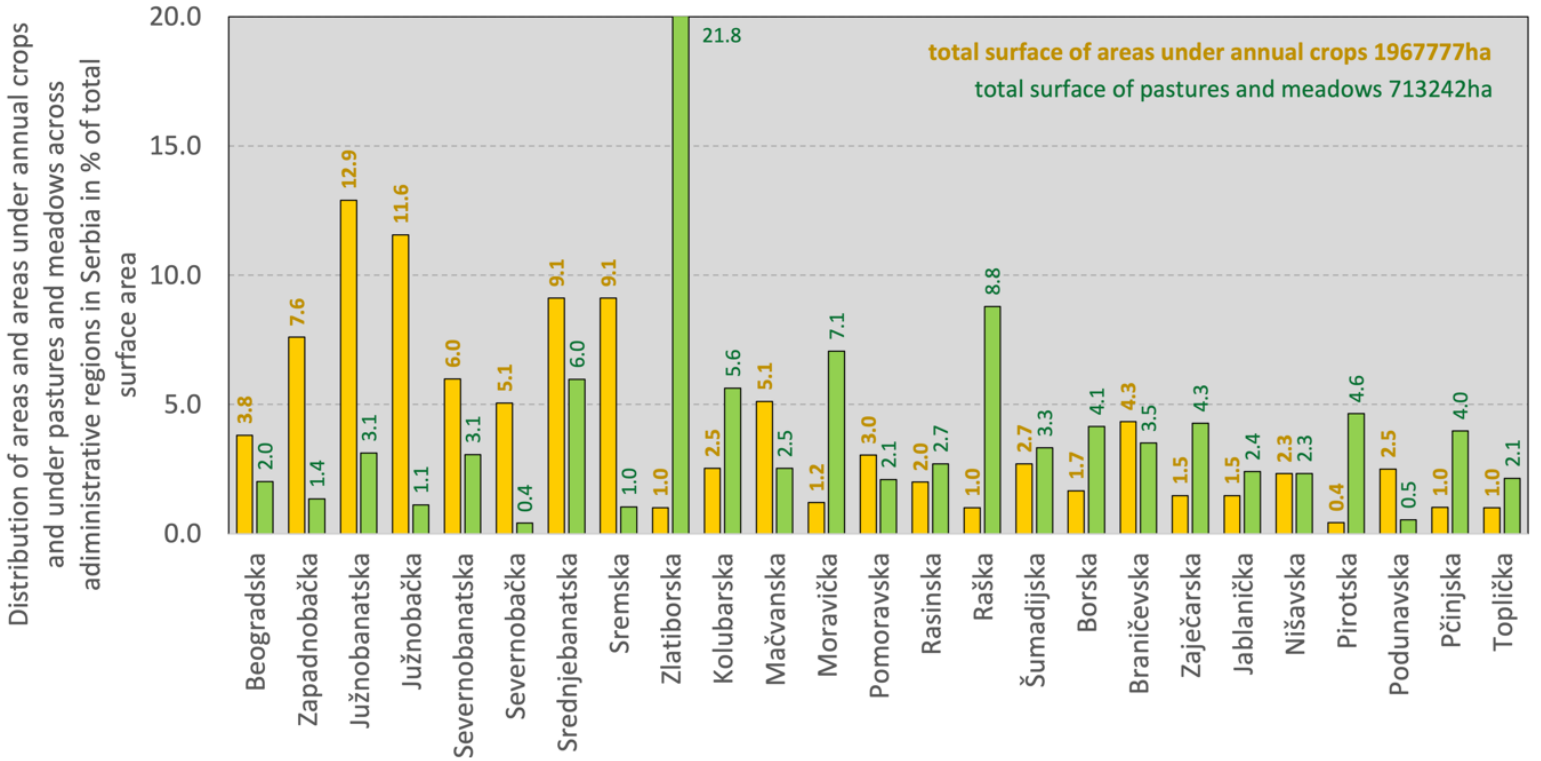
High risk of hail is increasing in surface area and average hail size is increasing.

- **60,4%** of total surface of orchards and vineyards is in areas with **high risk** from hail,
- **39,6%** is in areas with **increasing risk** from hail, meaning it will be high risk in mid-century climate period.

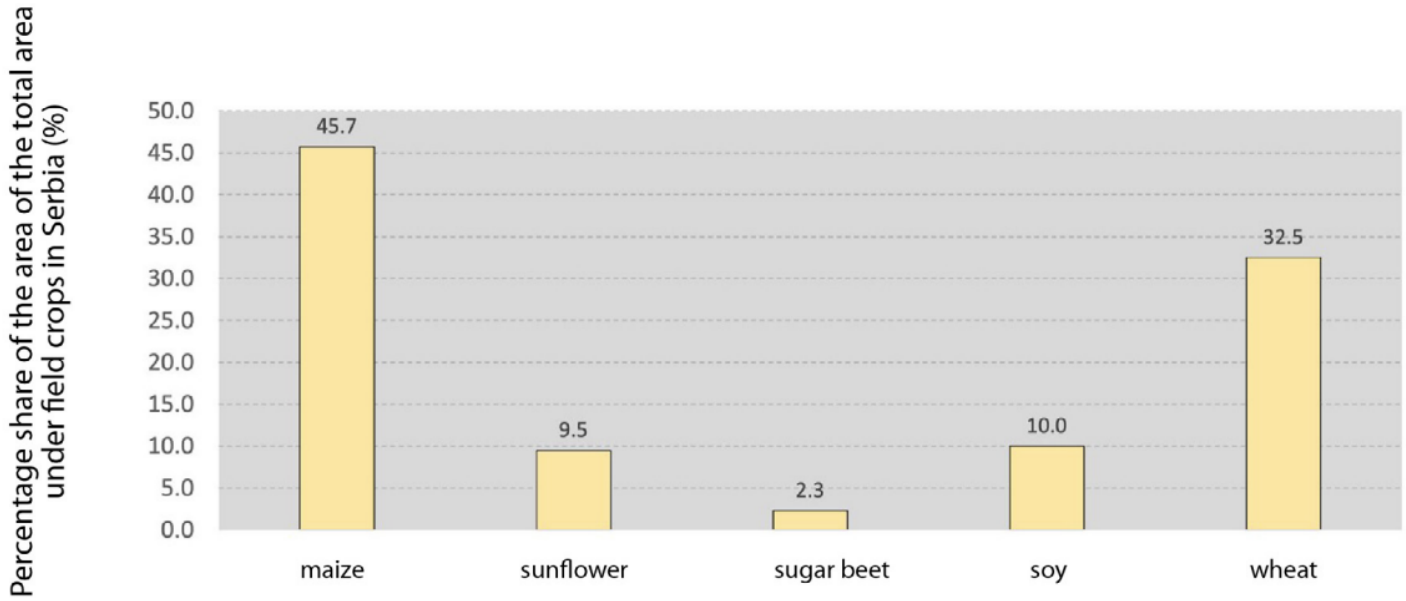


CLIMATE HAZARDS IN ANNUAL CROP PRODUCTION

distribution of croplands and pastures and medows by regions



distribution of croplands by varieties



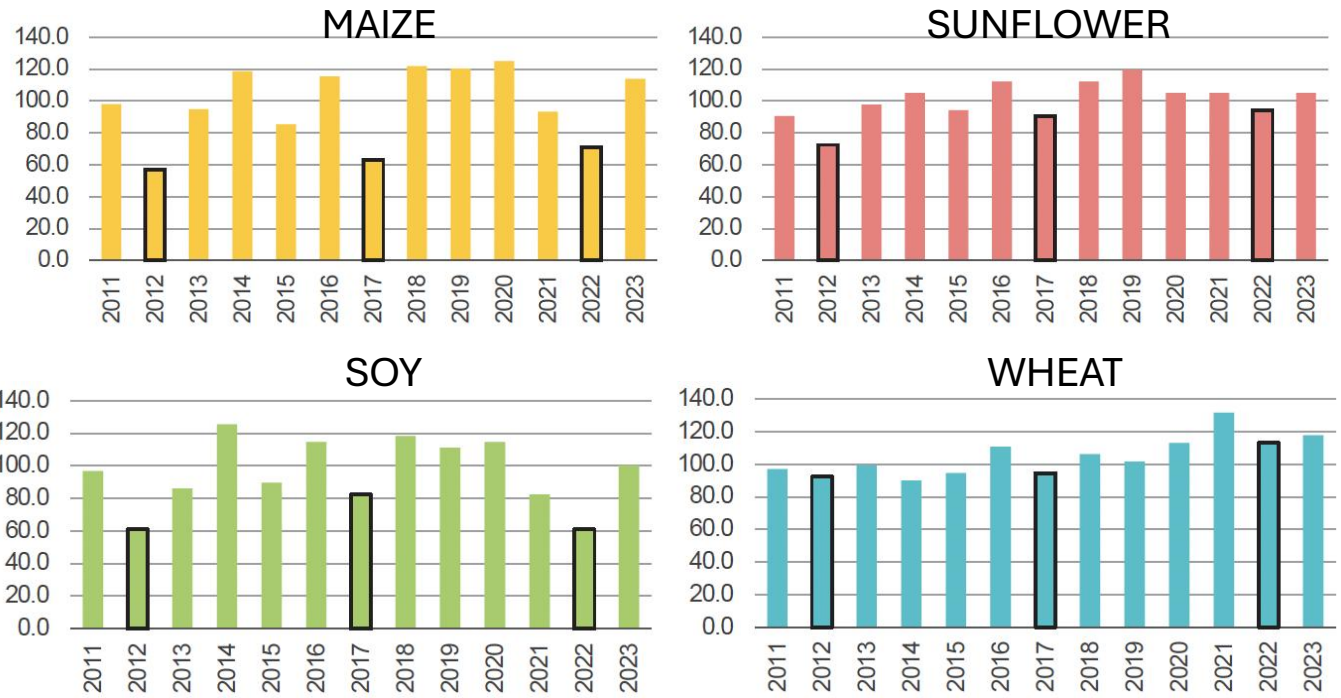
Parameter	Definition
Optimal sowing date	Maize: the first date from the beginning of the year after one day with minimum daily temperature above 10°C and three subsequent days with mean daily temperature above 10°C. Sunflower: the first date from the beginning of the year after five consecutive days with mean daily temperature above 10°C. Winter crops: the first date in the second half of the year meeting the following conditions: average mean daily temperature in the previous 10 days lower than 15°C, the precipitation sum in the previous 20 days greater than 10 mm, and in the previous three days the precipitation not exceeding 3 mm per day. Sugar beet: the first date from the beginning of the year after 5 consecutive days with minimum daily temperature above 5°C. Soybean: the first date from the beginning of the year after three consecutive days with minimum daily temperature above 10°C and the fourth day with mean daily temperature above 10°C.
Effective temperature sum	Effective temperature sum for the base temperature 10°C (maize, sunflower, soybean) and 3°C (winter crops and sugar beet)
Frost during critical phenological stages	The percentage of years in which after the optimal sowing date, minimum temperature was lower than -3°C for 2 days (maize), -3°C for two days (sugar beet), -4°C for more than one day (soybean).
High summer temperatures and drought during critical phenological stages	The percentage of years in which a certain number of days with high daily temperatures occurred during the identified critical phenological stages with possibly an additional condition related to precipitation sum. The beginning and the end of the critical phenological stage is determined based on the effective temperature sum calculated from the optimal sowing date. Winter crops: more than 5 days with maximum daily temperatures over 35°C in the period before full flowering (effective temperature sum less than 1700°C). Maize: Sowing–silking thermic index, in the period when effective temperature sum is between 430°C and 1170°C; frequency of values lower than 0.7. Sunflower: more than 5 days with maximum daily temperatures above 35°C and precipitation sum less than 100 mm when effective temperature sum is between 850 and 1450°C
Water deficit during critical phenological stages	The percentage of years in which precipitation amount during the identified critical phenological stages is under the specified threshold. The beginning and the end of the critical phenologi… from the optimal … Winter crops: pre… than 388°C, and p… between 650 and… Sunflower: precip… 150 and 1000°C Sugar beet: precipitation sum less than 50 mm when effective temperature sum is between 1300 and 2000°C. Soybean: precipitation sum less than 100 mm when effective temperature sum is between 400 and 1300°C

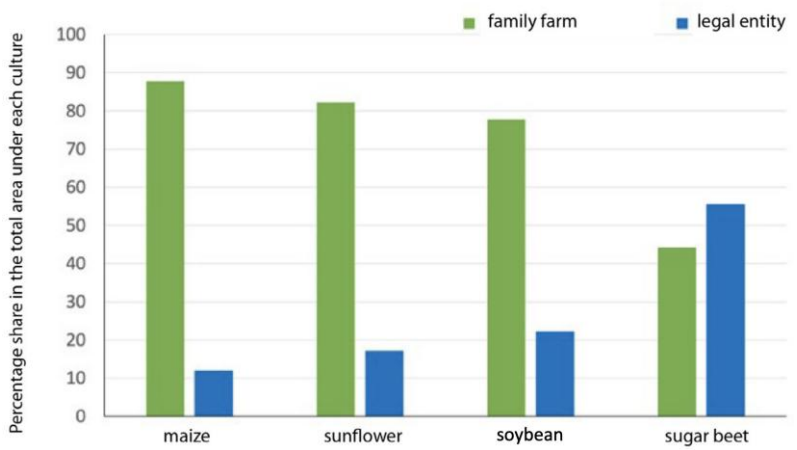
NEW INDICES FOR RISK ASSESSMENT DEVELOPED INCLUDING TEMERATURE AND PRECIPITATION CINDITIONS AND IMPACT ON PHENOLOGICAL DEVELOPMENT

Risk assessemnt is done for each crop variety according to its sensitivity.

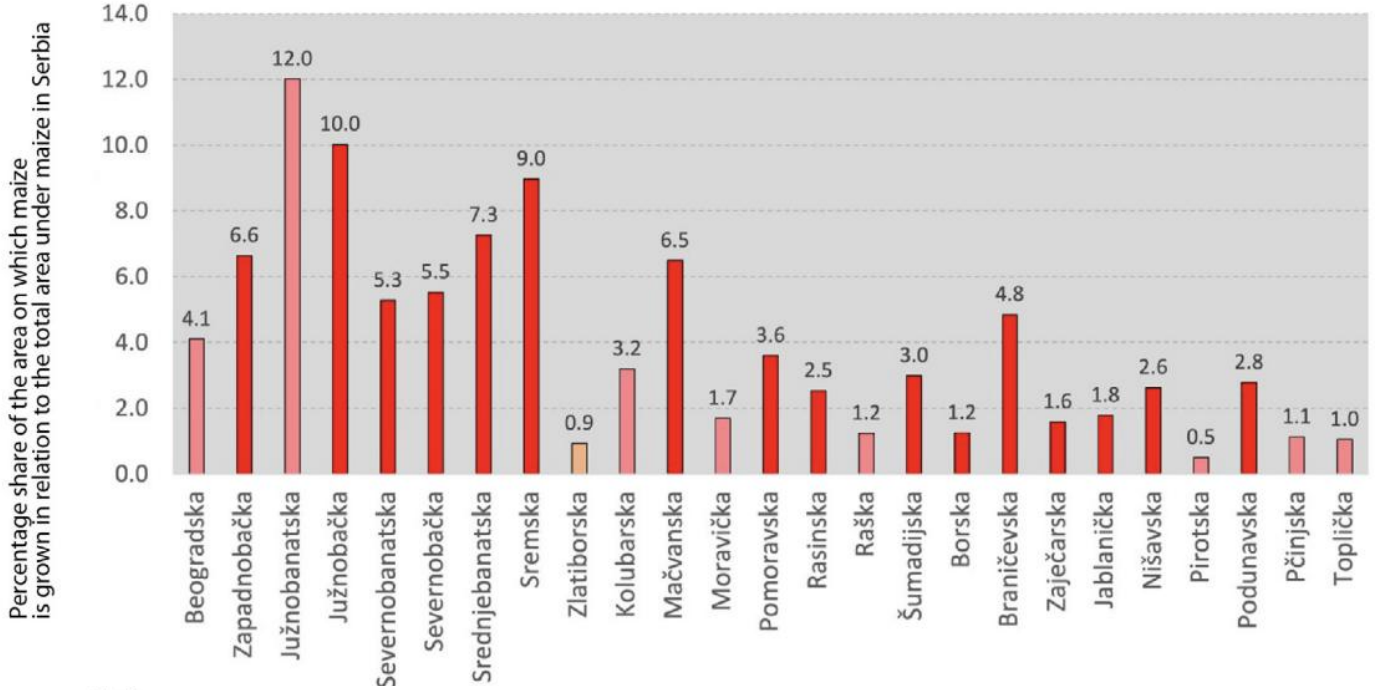
Yield is highly vulnerable to drought

yield in % from average for the period 2011-2020;
2012, 2017, 2022 are years with more severe drought in Serbia





relatively low adaptive acapcity except in sugar beat growing

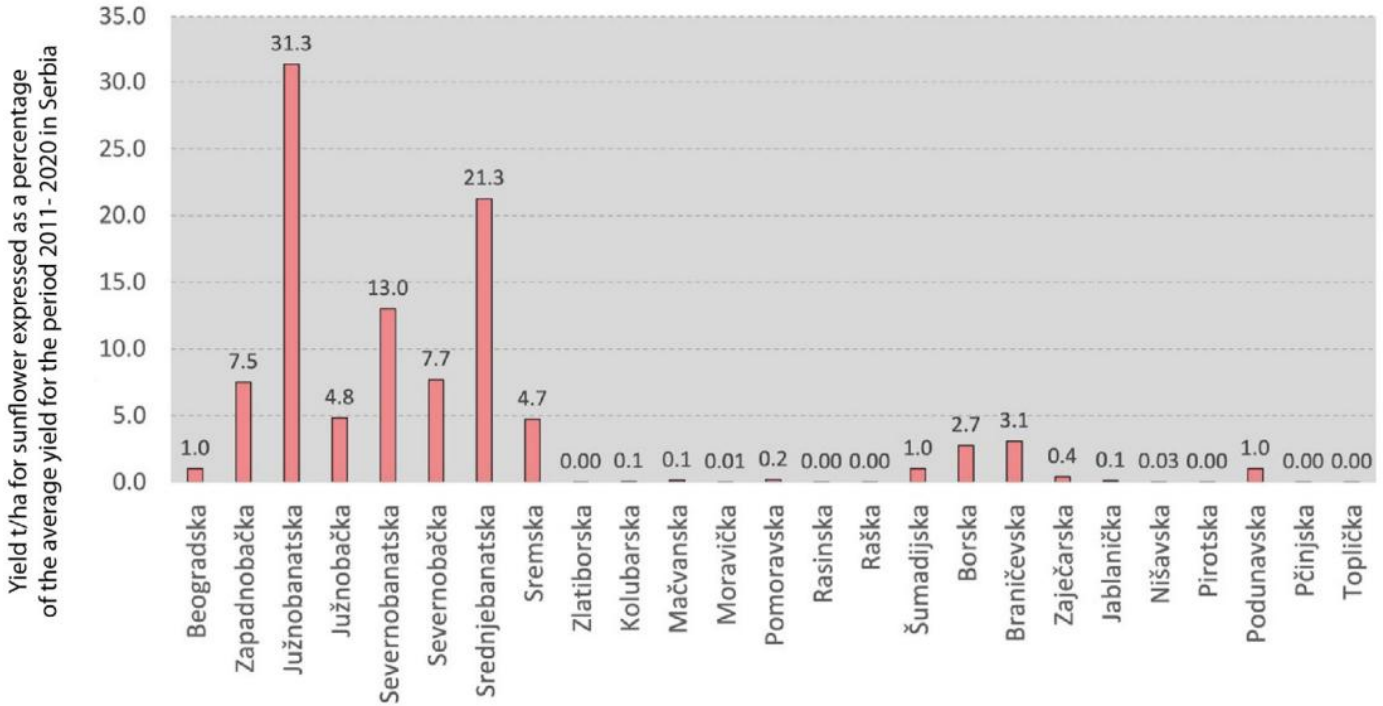


MAIZE

74.1% of croplands under maize is in areas with high risk (**33,7%** of total croplands in Serbia)

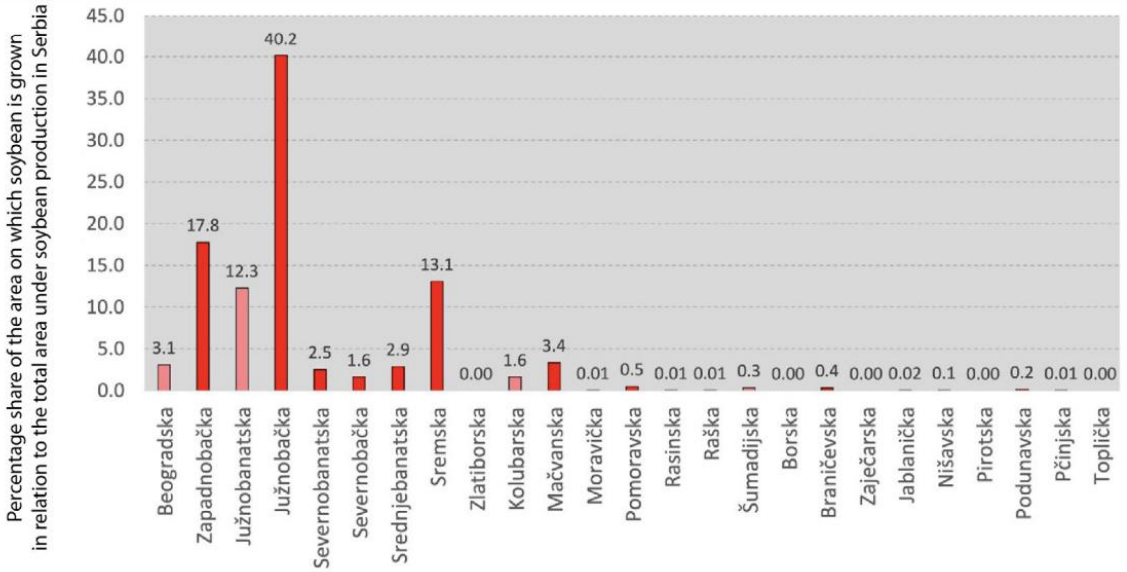
25% of croplands under maize is in areas with increasing risk (**11.4 %** of total croplans)

	high
	increasing
	acceptable



SUNFLOWER

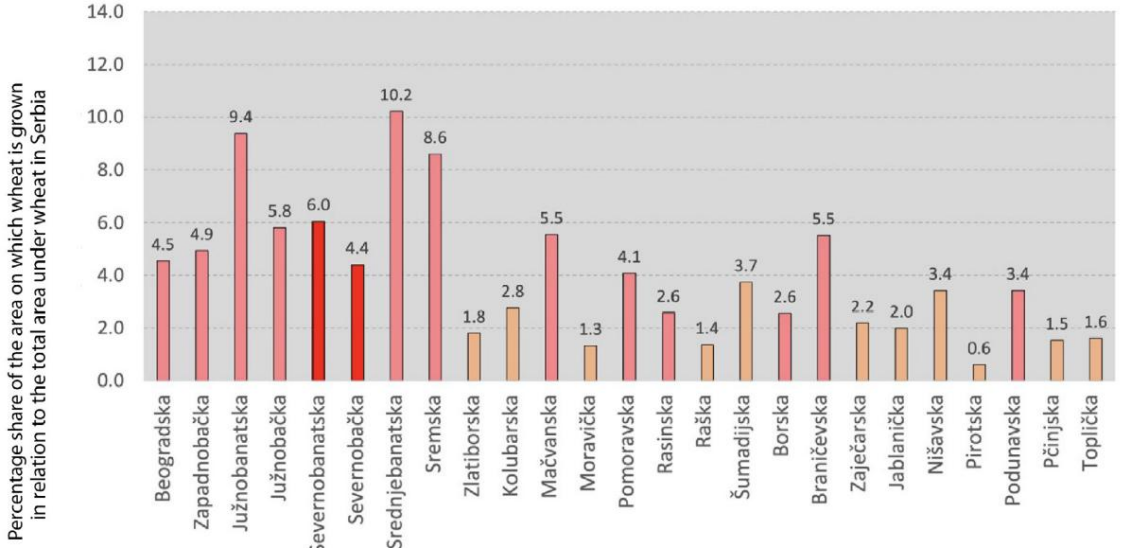
all croplands under sunflower are in areas with increasing risk (**9.5%** of total croplands in Serbia)



SOYBEAN

82.5% of croplands under soybean is in areas with <u>high</u> risk (**8.25%** of total croplands in Serbia)

17.3% of croplands under soybean is in areas with <u>increasing</u> risk (**1.73 %** of total croplans)

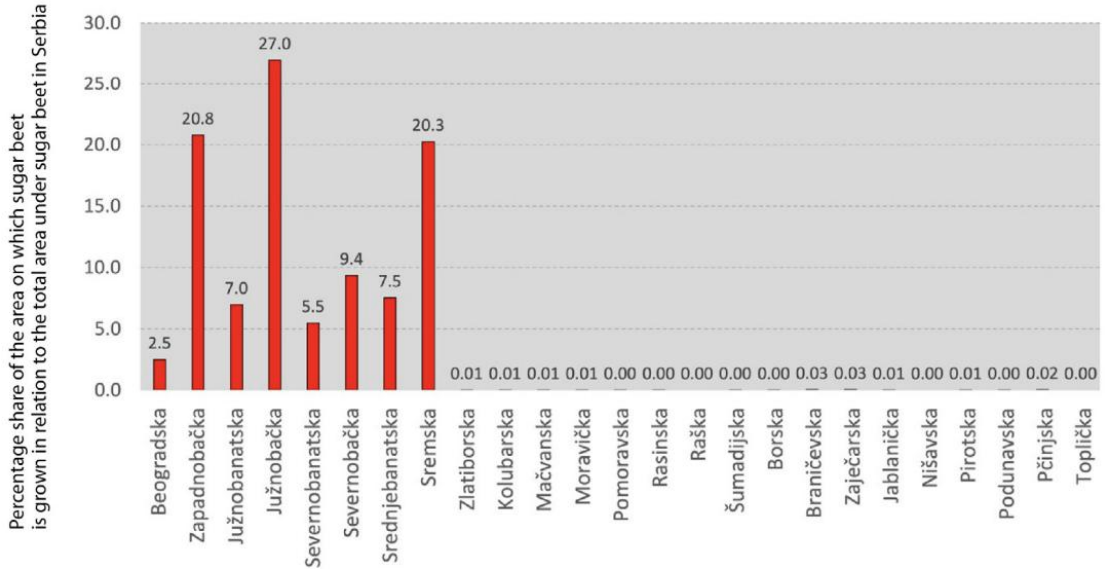


WHEAT

10.4% of croplands under wheat is in areas with <u>high</u> risk (**3.4%** of total croplands in Serbia)

67.1% of croplands under wheat is in areas with <u>increasing</u> risk (**21.8 %** of total croplans)

22.5% of croplands under wheat is in areas with <u>acceptable</u> risk (**7.3 %** of total croplans)



SUGAR BEET

all of croplands under sugar beet is in areas with <u>high</u> risk (**2.3%** of total croplands in Serbia)

	high
	increasing
	acceptable

RISK OF HIGH TEMPERATURES COMBINED WITH WATER DEFICIT IN CROP PRODUCTION ON NATIONAL LEVEL

in current climate conditions

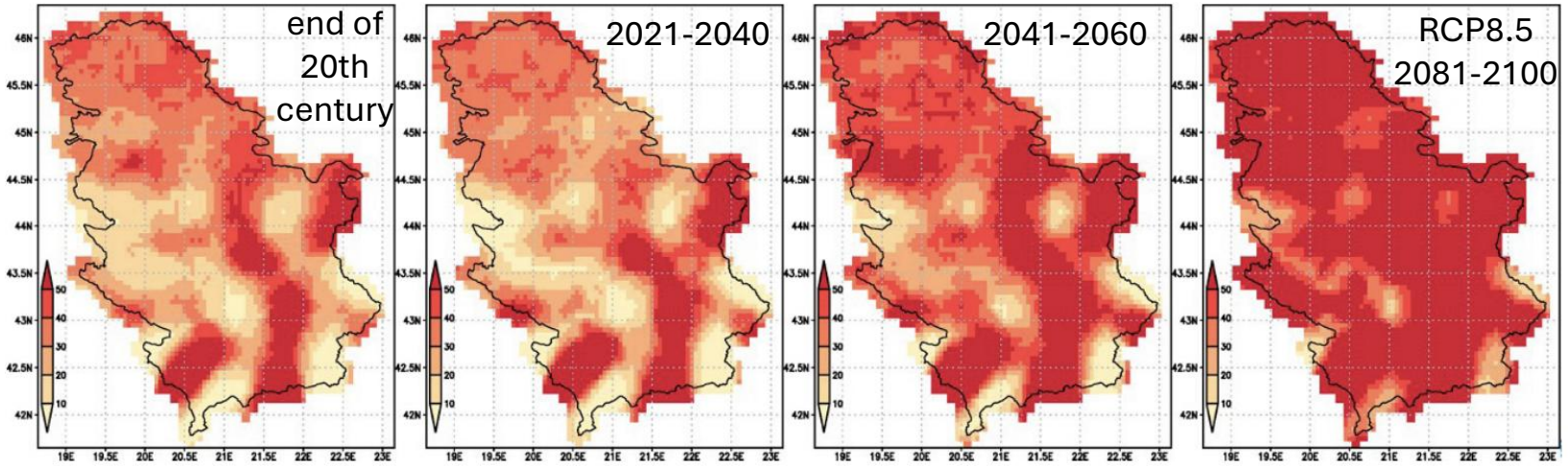
47.7%	47.7% of croplands are in areas where is high risk of unsuitable weather conditions during growing season
44.4%	10,6% of croplands are in areas where is increasing risk of unsuitable weather conditions during growing season and will increase to high in mid-century climate conditions
7.9%	7.9% of croplands are in areas where is acceptable risk of unsuitable weather conditions during growing season and will not significanlty change

in climate conditions 2041-2060

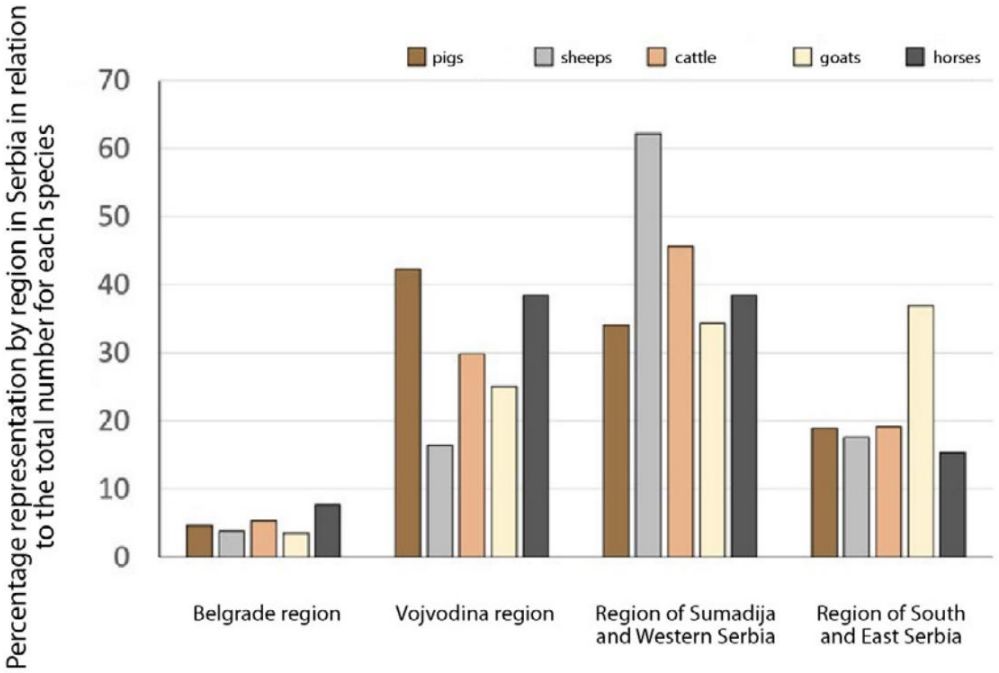
92.1%	92.1% of croplands are in areas where is high risk of unsuitable weather conditions during growing season

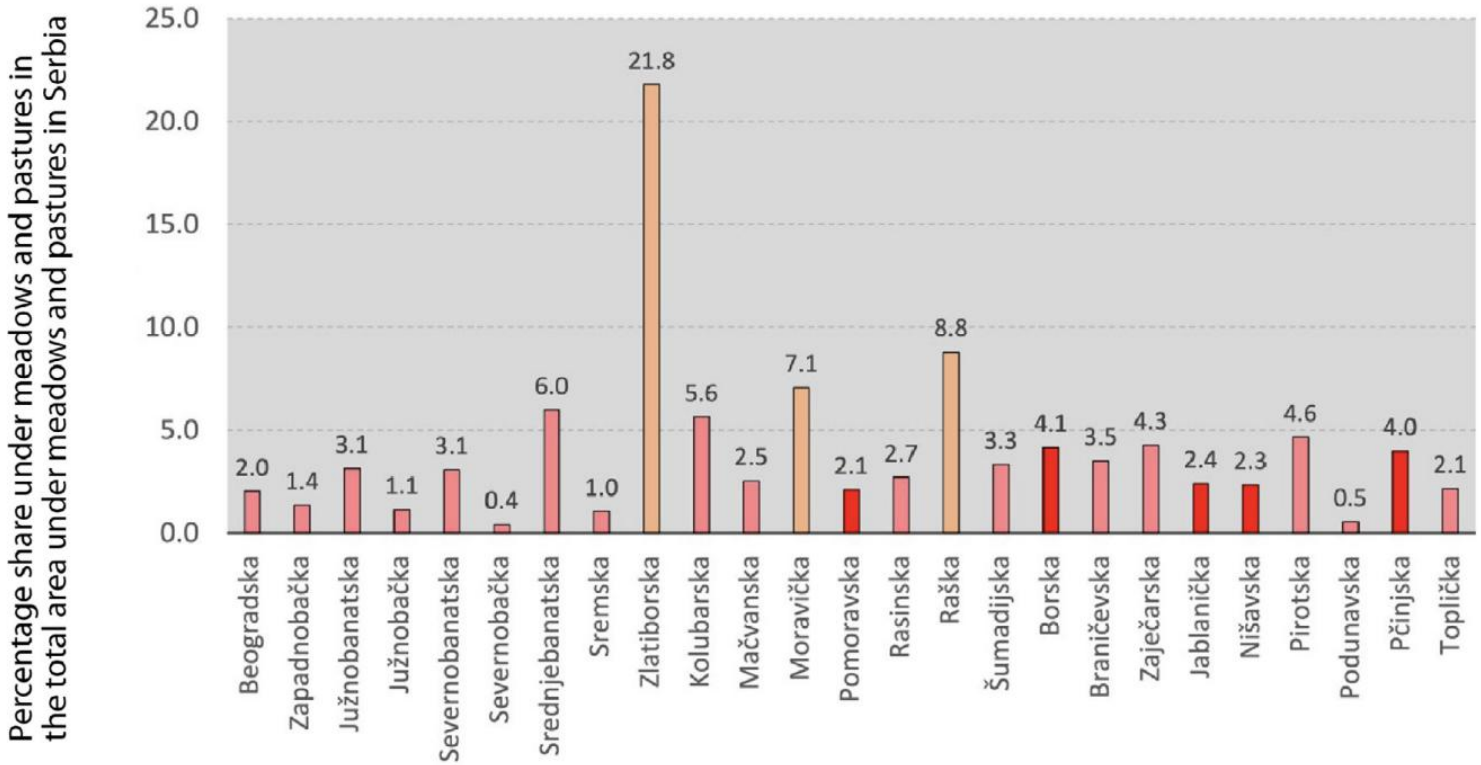
+ risk of soil degradation is increasing!

PRECIPITATION DEFICIT RISK FOR MEDOWS AND PASTURES

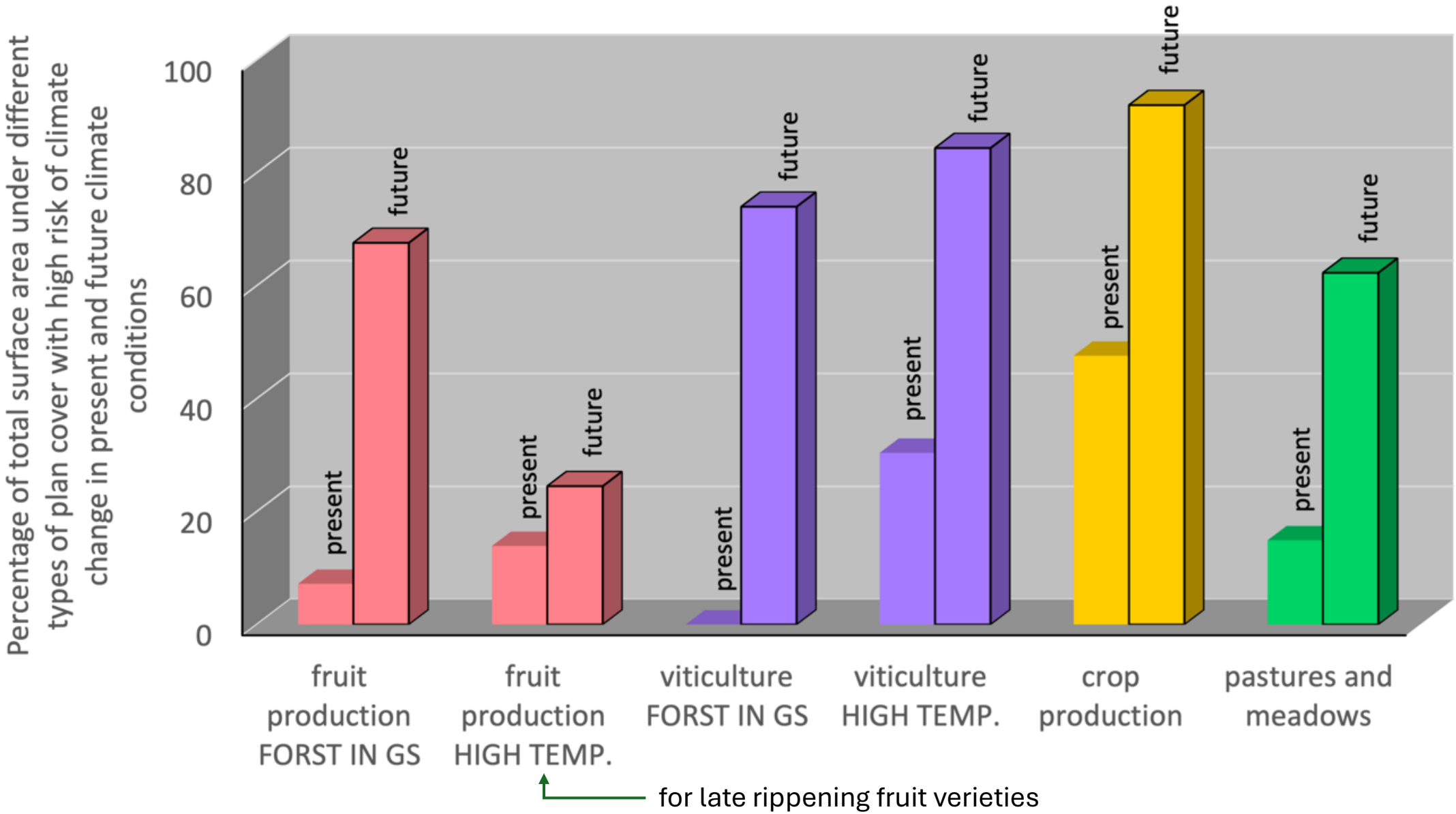


Share in total number of animals on national level:
50% are pigs, 30% sheeps,
cattle ~15%, goats ~5%



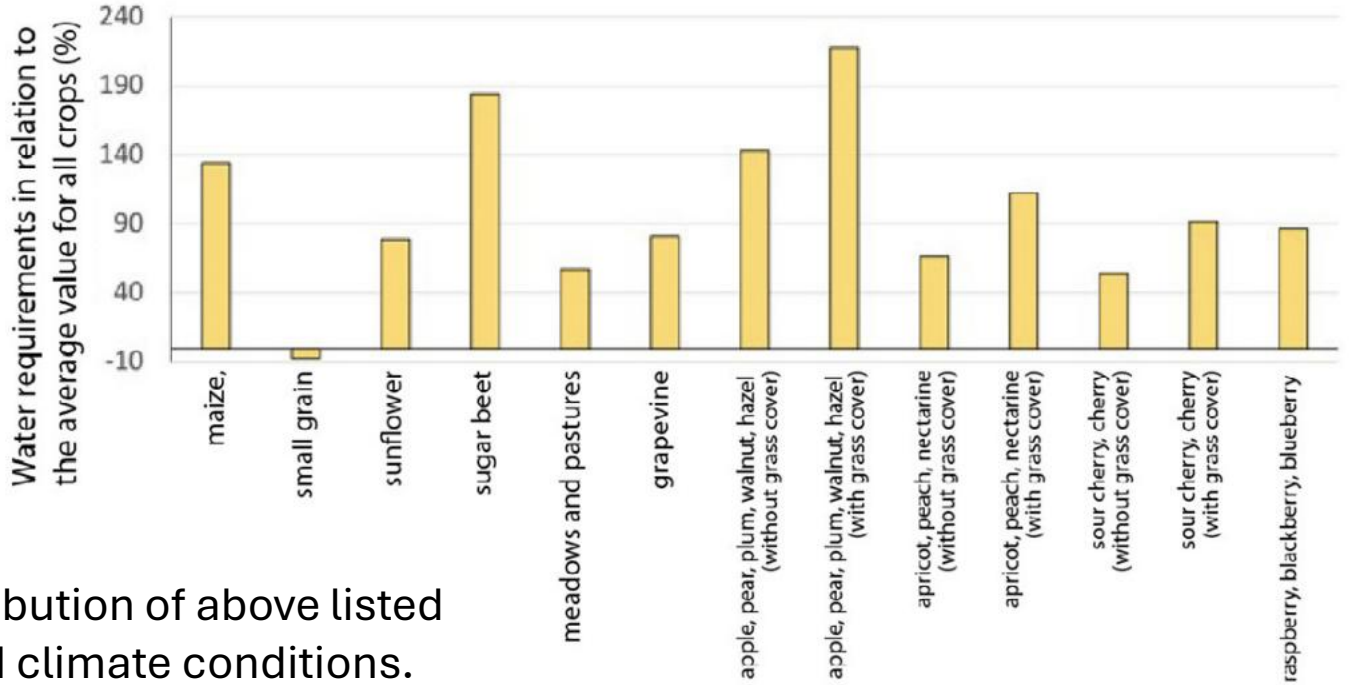


SUMMARY ON NATIONAL LEVEL



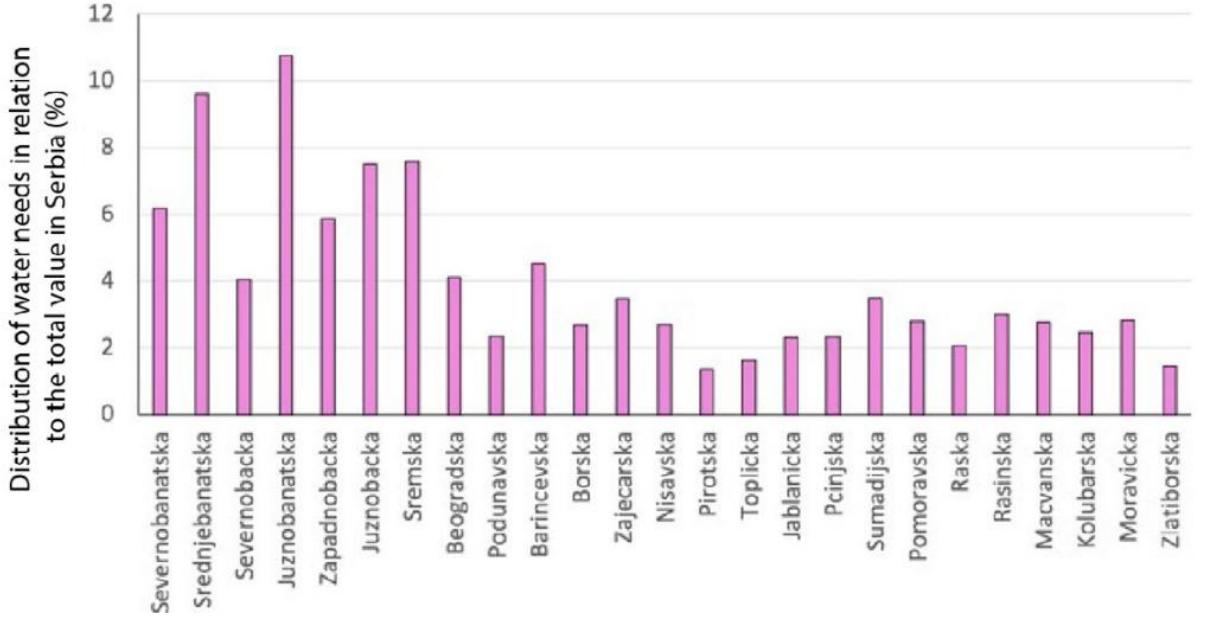
WATER NEEDS FOR IRRIGATION

EXPECTED INCREASE OF WATER REQUIEREMENTS FOR IRRIGATION IN 2041-2060 AT LEAST 18%;
IN 2081-2100 ACCORDING TO RCP8.5 44%-48%.

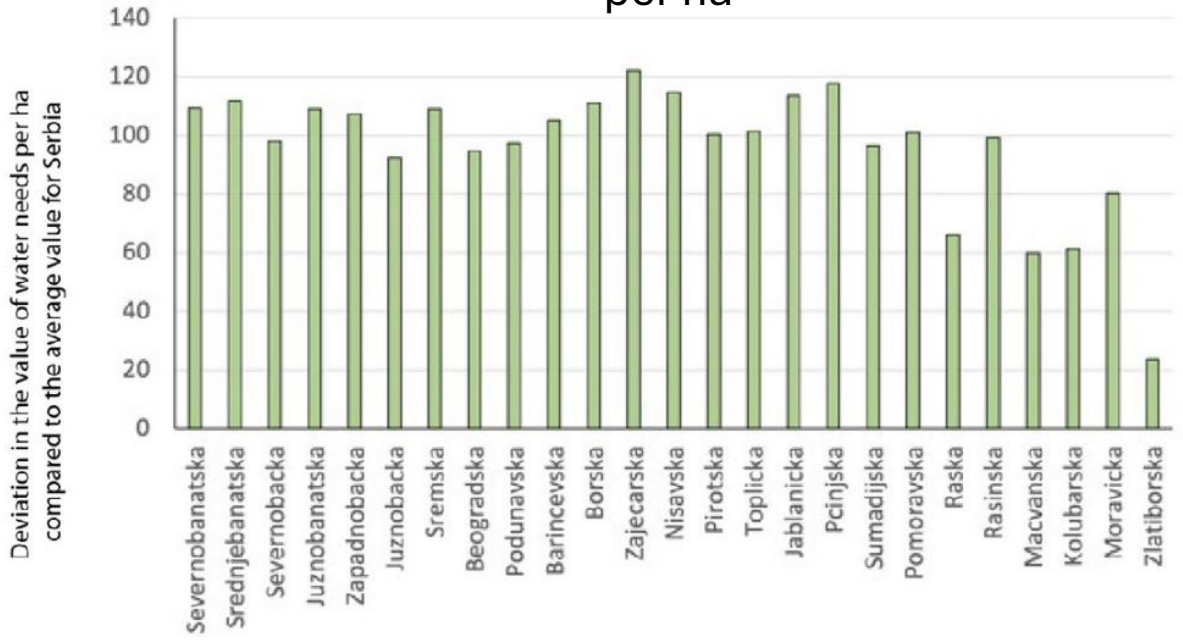


Distribution of water needs derived using the distribution of above listed varieties per region, their water requieremens and climate conditions.

per region



per ha



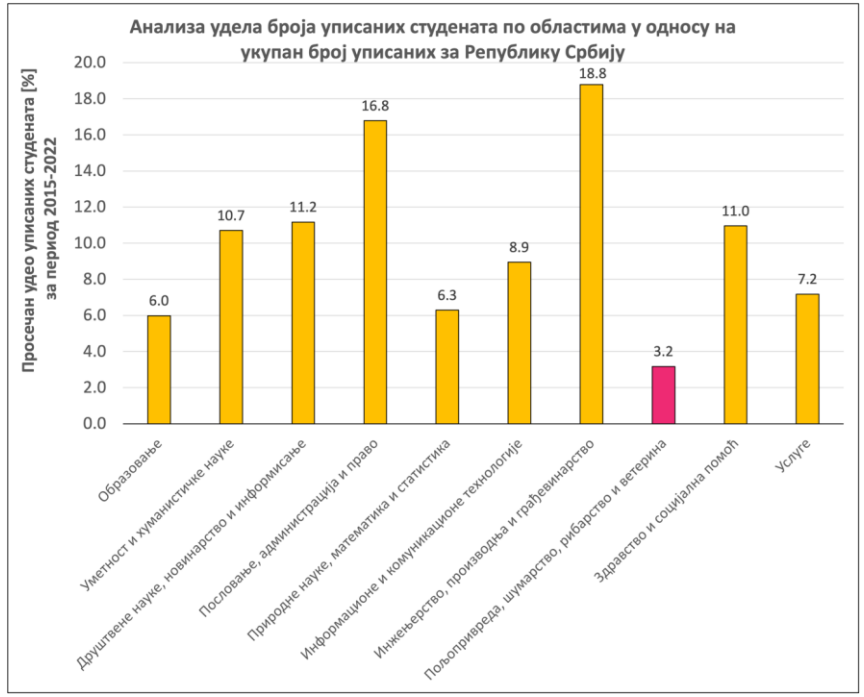
WHAT ELSE IS INCREASING RISK IN AGRICUTLURE?

DECREASE IN ADAVPTIVE CAPACITY

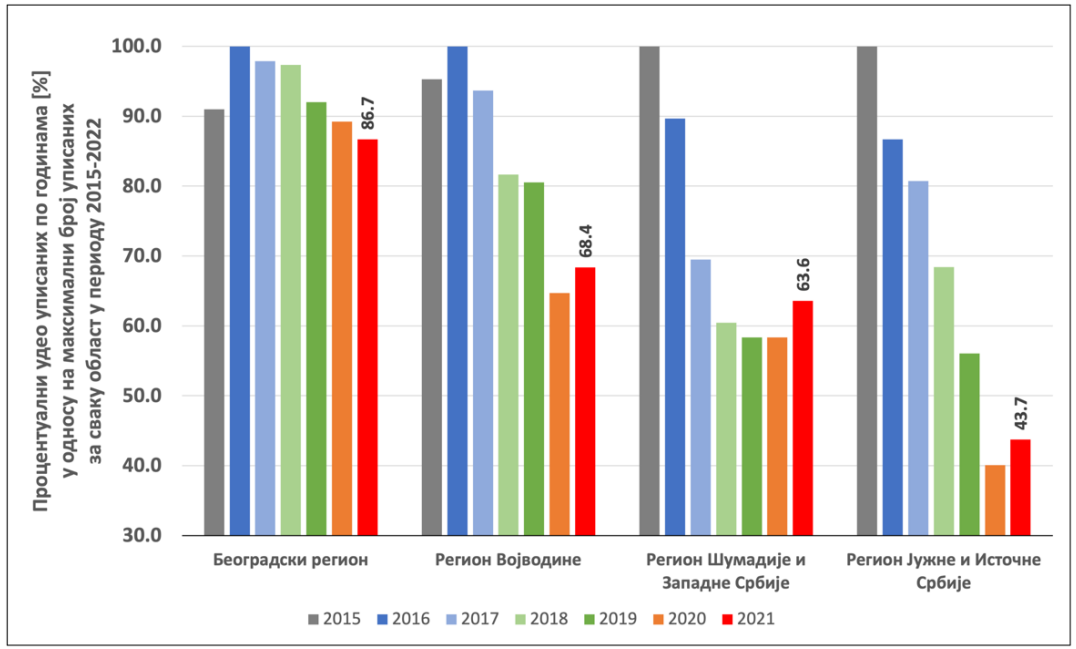
- not enough finance in adaptation
- insufficient speed of recovery from damages (unaffordable insurance)
- **insufficient expertiese (REDUCING RAPIDLY)**

<u>45% OF REPUBLIC OF SERBIA IS UNDER AGRICUTLURAL LAND</u>

Average of total first year university students for 2015-2022, only **3,8%** is in agriculture-forestry-veterinary medicine



In all areas of Serbia **number of new students** in area agriculture-forestry-veterinary medicine **is decreasing**



Additional notes:

- Jobs in agriculture-forestry-veterinary medicine employs 400 thousand people, with unfavorable age structure,
- there is no decreasing trend in total number of new students in all areas.

ADAPTATION (POLICY)

UNSOLVED: improvement in insurrance policies, provision of professional youth, centralized portal for adaptation.

Education of producers through advisory services; advisors earn their certificate in adaptation by learning from guidelines provided by science; guidelines are regularly updated

SHORT TERM ADAPTATION
on-time inteventions to reduce potential damage from upcoming extreme weather, and thereby reduction of losses

LONG TERM ADAPATION
planning of production according to changing climate conditions

ZONING
of fruit growing and viticulture including climate change information with growing risks of climate hazards.
PUBLICLY AVAILABLE MAPS! (interactive interface)

Introduction of **sustainable land management and irrigation optimisation in nexus with CC adaptation**

More money from state for subsidies for **ANTI-HAIL NETS, NETS FOR SHADING; ANTI-FROST SYSTEMS**

Significant upgrade of argometeorological services

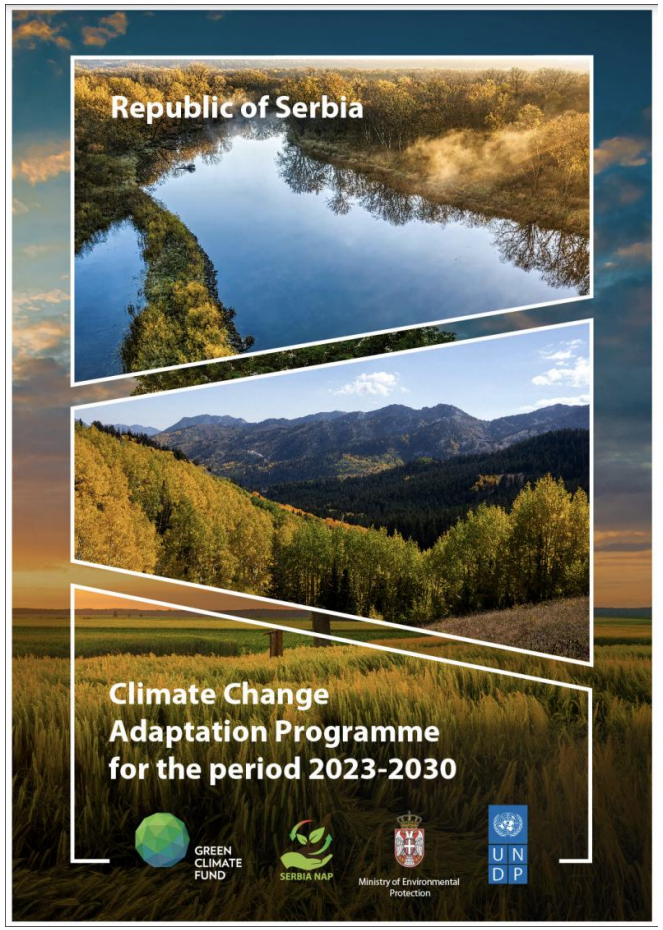
Improvement of professional capacities, scientific analysis and knowledge

Drought monitoring (as multidimensional hazard) and enabling the **declaration of drought emergency**.

Assessment of potential in Serbia to use irrigation ponds.

INTRODUCTION OF NEW CLASS ON CC AND ADAPTATION IN HIGH SHOOLS FOR AGRICUTLURE AND VETERINARY

	Measure	Implementation	Potential gaps
1	fast implementation of new knowledge to practice through functioning system of science-advisories-practitioners	On-going, partially implemented; manuals for education of advisory services for fruit production, viticulture and vegetable production; no progress for crop production	Regular update of knowledge and number of reached producers; there is no vulnerability and risk assessment for vegetable production; annual crop production (maize, winter crops, sugar beet, sunflower, soybean) remains without scientifically based progress in adaptation implementation
2	technical capacities for development of warning systems and monitoring	On-going	Insufficient funds for capacities fast information sharing; drought monitoring as an multidimensional hazard needs to be implemented to enable declaration of emergency under drought in agriculture
3	monitoring of damages and losses from climate change impacts	On-going	Still unknown methodology for monitoring; uncertainty for transparency of monitoring
4	subsidies for protection of unavoidable impacts and for implementation of sustainable land management measures for prevention of soil and water resources degradation and implementation of Nature-based solutions	Partially implemented	Increasing the share for subsidies for unavoidable impacts do not follow the increasing market prices; subsidies for implementation of regenerative agriculture lack the systemic implementation, as a systemic NbS implementation planning
5	upgrade existing zoning for viticulture and fruit growing and to implement project on zoning of annual crop production and for livestock breeding	On-going for viticulture and fruit production; for crop production and livestock breeding under consideration and planned as a national study	Methodologies for their implementation not yet determined; crop production and livestock breeding will not be regulated according to the needs and conditions for sustainable production
6	provide subsidies for producers which implement production according to zoning requirements	Partially implemented	Works for viticulture; in fruit production the problem is access of zoning to the producers and no regulations to support zoning implementation
7	assessment of capacities for sustainable irrigation and to enable the development sustainable irrigation systems	On-going	Insufficient funds for development of sustainable irrigation systems; needs to consider as a part of water management strategic planning under the climate changing conditions
8	ensure affordable insurance policies for the agricultural producers	No improvement	Not considered as an adaptation measure in terms of management of residual risks of climate change
9	fast response for funding of the recoveries from damages through dedicated funds	No improvement	It is not known if funds for recovery or to which extent are available for recoveries of agricultural producers
10	scientific advisory body and use it for policy making in agriculture	No improvement	There is no national scientific advisory body for climate actions, which can lead to ineffective adaptation planning
11	ensure the sustainability of the future national expertise in agriculture	No improvement	The problem of decreasing technical staff and university degree engineers in agriculture is not recognized in strategic planning and no actions are considered



Climate change adaptation programme for the period 2023-2030 with Action plan for 2024-2026
https://unfccc.int/sites/default/files/resource/NAP_Serbia_2024.pdf

Životić, Lj., Vuković Vimić, A., 2022: **Soil degradation and climate change in Serbia**, UNDP, Belgrade, Serbia, ISBN 978-86-7728-356-8, https://www.undp.org/serbia/publications/soil-degradation-and-climate-change-serbia

DIGITALNI ATLAS
KLIME SRBIJE

atlas-klime.eko.gov.rs
portal with climate data for Serbia

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Group of authors form Faculty of Agriculture, University of Belgrade, **textbook for high schools** specialized for agriculture and vetenerian medicine

Vuković Vimić, A., at al., 2022: Enhancing Capacity for Short-Term Climate Change Adaptations in Agriculture in Serbia: Development of Integrated Agrometeorological Prediction System, Atmosphere 2022, 13, 1337. https://doi.org/10.3390/ atmos13081337.

Vujadinović Mandić, M., et al.., 2022: Observed Changes in Climate Conditions and Weather-Related Risks in Fruit and Grape Production in Serbia, Atmosphere 13, no. 6: 948, https://doi.org/10.3390/atmos13060948.