Original scientific paper

Prediction of vulnerability of field crops production in South-East region of Macedonia affected by climate changes

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Abstract

The main aim of these simulations was to predict future trends of the basic climatic parameters: e.g. average yearly air temperature, average growing season air temperature, average yearly rainfalls and evapotranspiration in 2025 and 2050 and thier influence to the yield of wheat, maize and sunflower. The analysis is targeted to the South East (SE) region of Macedonia which was identified as a one of the most vulnerable regions to the negative impact of climate change in agriculture.

From the simulated data for temperature, a progressive increasing of the average air temperature can be noted (2.00-2.43ºC). Similar increasing of the annual air temperature is notable for the average values for the SE region as a whole and for the average air temperature values for the whole territory of the country. Also, the average air temperatures during the growing season will graduate increase. The average increase of the air temperatures in growing season for the SE region are 0.14ºC and 1.36ºC for the periods 2000-2025 and 2000-2050, respectively. The rainfalls do not follow certain pattern of increasing or decreasing yearly sums which may conclude that it is very difficult to predict the rainfalls and the rainfalls regime due to the fact that on a small area (as is SE region) several rainfall regimes exist. The evapotranspiration have very similar dynamics as air temperature. There are certain periods of increasing and decreasing of evapotranspiration but there is an obvious trend of increasing over time.

Analyzed the potential effects of climate change on crops productivity, the following simulations were obtain: the wheat yield will decrease for 21% in 2025 and 25% in 2050, the maize yield is expected to be reduced by 56% in 2025 and even by 86% in 2050 respectively as well as the yield of sunflower where the reduction will be to 30% in 2025 and up to 40% in 2050.

Key words: climate changes, prediction, vulnerability, wheat, maize, sunflower, yield

Introduction

Macedonia has a diverse agricultural resource base, with the capacity to produce most continental crop and livestock products, plus many Mediterranean crops. The agriculture sector, including the value added in the processing industry, contributes 16% to country's GDP and provides employment to 36% of the workforce. The official figures understate the importance of the agriculture sector since these include only a fraction of the value of smallholders' output which is sold at the traditional farmers markets. Also, the official statistics captures only a portion of the family labor inputs, which is the dominant type of informal employment at the family farms. The most recent national census recorded 192,675 family farms in a country of 2.1 million inhabitants

(State Statistical Office, 2010). Consequently, given the fact that about 45% of country's population live in rural areas where off farm employment opportunities are rather limited (active workforce unemployment rate in Macedonia is as high as 32%), a more realistic conclusion would be that the agriculture sector is of critical importance for the wellbeing of about half of country's population.

By area, wheat is clearly the major annual crop grown, with smaller areas used for barley, maize and a range of vegetable crops. Grapes are the main perennial crop in Macedonia and occupy close to 25000 ha (State Statistical Office, 2011). Although the area occupied by fruit and nut trees is relatively small, potential exists to expand this area in the future. As most crop production is rain-fed, there can be significant changes in mix and crop area planted on a year-to-year basis, depending on the timing and quantity of rainfall, as well as associated extreme events, like droughts and floods.

The sensitivity of the agricultural sector to climate has important implications in Macedonia. The recent report published "Adapting to Climate Change in Europe and Central Asia" (The World Bank, 2009) developed a series of indices to assess the exposure, sensitivity and adaptive capacity of countries in the ECA Region to climate change. These indices are based on a range of relevant parameters. The vulnerability index displayed in is a combination of the exposure, sensitivity and adaptive capacity indices. The vulnerability of Macedonia to climate change, based on this index, can be classified as medium compared to other countries in the region. In addition this report outlines that Macedonia is among the first five countries of the region which is likely to experience increases in climate extremes by the end of 21-st century.

The negative effect of Climate change impacts in the sector agriculture is increasing. Some analysis performed in the recent period suggested that under most likely climatic scenarios, agriculture in Macedonian will be the most affected structure where annual losses are estimates of ~€29 million by 2025 due to reductions on yields for winter wheat, grapes, and alfalfa if there is no irrigation (Second National Communication on CC to the UNFCCC, 2008).

The main objective of this study is to predict future trends of the basic climatic parameters: e.g. average yearly air temperature, average growing season air temperature, average yearly rainfalls and evapotranspiration in 2025 and 2050 and their influence to crops productivity in South East (SE) region of Macedonia which was identified as a one of the most vulnerable regions to the negative impact of climate change in agriculture.

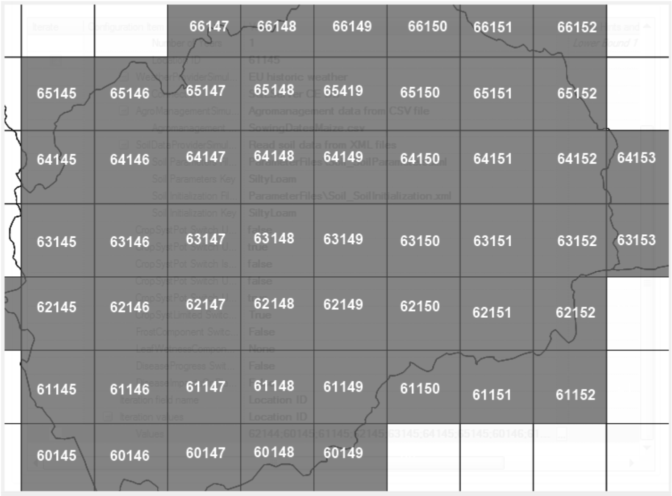
Materials and methods

UNDP and the Ministry of Environment and Physical Planning (MoEPP) of the Republic of Macedonia are implementing the project "Third National Communication to UNFCCC". The main aim of the project is to strengthen the information base, analytical and institutional capacity of the key national institutions to integrate climate change priorities into country development strategies and relevant sector programs by providing financial and technical support to prepare its Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC).

The preparation of the vulnerability assessment of the agricultural sector, as a part of the Third National Communication, is based on totally different approach. Unlike the First and Second National Communications where the vulnerability assessment was performed on a comparison base of two long monitoring climatic datasets (1961-1990 and 1971-2000) with a main aim to show the differences of the main climatic indicators over time which have the highest effect on agriculture, and a spatial identification of the most vulnerable areas in the Republic of Macedonia to the influence of climate change, for the Third National Report it's decide to use models in order to simulate the basic climatic parameters for the period 1993-2057 with centered 2000. The main aim of these simulations was to predict future trends of the basic climatic parameters. The data obtained were further used as input parameters in the ClimIndices model. With this model the future trends of different climatic indicators, sums and indexes were simulated - the indicators which have the most direct influence on agricultural production are analyzed in details: e.g. average yearly air temperature, average growing season air temperature, average yearly rainfalls, and evapotranspiration. The analysis is targeted to the South East (SE) Region of the Country. This region in the previous reports was identified as a one of the most vulnerable regions to the negative impact of climate change in agriculture, together with the central region.

Results with discussion

Whole territory of the country was divided in a mash of 53 grids. The scope of the analysis is the SE region of the country which falls within 7 grids (64151, 63150, 63151, 63152, 62150, 62151, and 62152), (Map 1), (each grid = 25 km^2).



Map 1. Spatial grid distribution and their codes

<u>Mean annual air temperature</u>

In the agricultural sector the air temperature is a basic indicator which is significant for assessing the intensity of climate change in a certain area, as well as an elementary parameter for calculation of other indicators e.g. start and end of growing season, vegetation period length, growing degree days, and for calculation of certain indexes: aridity index, dryness, etc. The mean annual air temperatures are calculated for the period 1993-2057.

Table 1. Mean annual air temperature

Year	Row Labels							SE reg. average	Country average
	62150	62151	62152	63150	63151	63152	64151		
2000	10.40	13.56	15.34	13.82	13.53	13.95	12.85	13.35	10.95
2010	9.58	12.99	14.80	13.14	12.89	13.47	12.27	12.74	10.82
2020	9.36	12.85	14.86	13.10	12.88	13.31	11.97	12.62	10.55
2025	9.75	13.15	14.83	13.42	13.15	13.41	12.24	12.85	11.32
2030	11.10	14.34	16.08	14.69	14.47	14.76	13.59	14.15	12.29
2040	12.34	15.95	17.55	15.82	15.81	16.38	14.94	15.54	13.57
2050	10.95	14.23	16.09	14.46	14.34	14.62	13.37	14.01	12.92
Average 2000-50	10.50	13.87	15.65	14.06	13.87	14.27	13.03	13.61	11.77

From the simulated data presented in Table 1 a progressive increasing of the average air temperature in all sub localities can be noted (2.00-2.43^oC). Similar increasing of the annual air temperature is notable for the average values for the SE region as a whole and for the average air temperature values for the whole territory of the country. This predictions of air temperature increasing are in line with the new elaborated climatic scenarios for the country, where the expected increasing of the average air temperatures up to 2050 is 2^oC (1.10-3.30). It is interesting to underline that the simulations showed increasing of air temperature up to 2040 which in average yields 2.19^oC, after this point the average air temperatures start to decrease for the 2040-2050. Such trends which are against all expectations is difficult to explain. Similar decreasing are also notable for the periods 2000-2010 and 2010-2020, but still the general trend for the period 2000-2040 goes upwards. In order to analyze the decreasing of air temperatures for the period 2040-2050, we need simulated values of the air temperature for a longer period (at least 2100), on this way we would have an complete and clear picture which will enable to conclude if this 10 years period is just a short breakout of the general trend like the previous 2 periods, or it is a general trend of decreasing up to 2100. There are some theories which such a trend of decreasing is explaining with the positive effect of applied measures towards decreasing of the emissions of greenhouse gases.

Mean air temperature growing season

Growing season air temperatures are very important indicator having in mind that it refers to the air temperatures for the period when most of agricultural crops are growing. Each crop has a sum of temperatures need for each development stage. Due to that temperatures in the growing season are very important for crop development. In case of significant changes of growing season temperatures, a certain shift of crop growing stages might be expected, mining that some growing stages might occur earlier or latter, which on the other side is closely connected with certain crop management practices.

Table 2. Mean annual air temperature (growing season)

Year	Row Labels							SE reg.	Country
	62150	62151	62152	63150	63151	63152	64151	Average	average
2000	9.91	12.09	13.21	12.23	12.09	12.34	11.53	11.92	10.57
2010	8.67	11.18	12.43	11.25	11.13	11.43	10.55	10.95	9.61
2020	9.83	12.04	13.38	12.41	12.19	12.48	11.67	12.00	10.92
2025	9.94	12.28	13.29	12.47	12.26	12.48	11.68	12.06	10.55
2030	10.46	12.95	14.15	13.08	13.03	13.30	12.41	12.77	10.73
2040	11.98	14.27	15.27	14.41	14.41	14.69	13.95	14.14	11.54
2050	11.39	13.46	14.51	13.50	13.48	13.66	12.94	13.28	11.35
Average 2000-50	10.31	12.61	13.75	12.77	12.66	12.92	12.11	12.44	12.73

Out of the data presented in Table 2 it can be concluded that the average air temperatures during the growing season will graduate increase. This increase is visible for all sub-regions of the SE region. The average increase of the air temperatures in growing season for the SE region are 0.14^oC and 1.36^oC for the periods 2000-2025 and 2000-2050, respectively. If we compare the average air temperatures of the SE region with the other parts of the territory we can see that the differences for the whole period are in the ranges of 1.08-2.04^oC. Such increasing of the average air temperature of more than 2.04^oC can have a serious impact of the agricultural production in the SE region having in mind the intensity of the agricultural production in that region.

Rainfalls

Rainfalls considered as a sum for the whole year and a sum for the growing season are important climatic indicator for the agricultural sector. For this study rainfalls were simulated as a yearly sum of rainfalls, which does not gives us an opportunity to analyze the dynamic of rainfalls on a monthly base (Table 3).

Table 3. Rainfalls yearly

Year	Row Labels							SE reg. average	Country average
	62150	62151	62152	63150	63151	63152	64151		
2000	448.89	399.04	449.54	473.47	411.31	438.57	413.73	433.51	527.9
2010	545.31	378.69	323.52	396.27	392.73	386.90	411.91	405.05	528.3
2020	591.06	445.44	401.80	556.93	482.67	385.82	429.49	470.46	641.8
2025	540.95	444.23	433.34	424.44	434.64	402.88	442.97	446.21	625.2
2030	369.40	318.43	314.41	376.44	360.98	379.94	400.25	359.98	496.3
2040	361.54	323.05	265.33	339.94	314.58	278.29	303.09	312.26	406.0
2050	519.57	447.42	441.42	468.16	456.19	494.90	534.04	480.24	665.2
Average 2000-50	482.39	393.76	375.62	433.67	407.59	395.33	419.35	415.39	555.80

Out of the presented data (Table 3) it can be noticed that the rainfalls in all analyzed sub regions do not follow certain pattern of increasing or decreasing yearly sums. Generally speaking it is very difficult to predict the rainfalls and the rainfalls regime due to the fact that on a small area of 26000 km^2 (as is SE region) several rainfall regimes exist. For instance, in Strumica valley, there are two rainfall regimes: modified Mediterranean and mountainous. Due to such diversity it is very hard to identify the ongoing and the future trends of rainfalls in the SE region and as well as at the whole territory of the country.

Evapotranspiration

Potential evapotranspiration was simulated using the basic climatological elements (air temperature, rainfalls, air moisture, wind speed insolation, sun radiation). This is an important indicator for vulnerability assessment of the agricultural sector, giving though that in Republic of Macedonia and more particularly in the SE region water is a limiting factor for agricultural crops. Increasing and decreasing of the evapotranspiration is primarily connected to the air temperature, rainfalls and plant growing stage.

Table 4. Evapotranspiration (mm)

Year	Row Labels							SE reg. average	Country average
	62150	62151	62152	63150	63151	63152	64151		
2000	1105.77	1007.66	1148.4	1012.49	953.15	1037.47	977.52	1034.64	1032.16
2010	1049.32	952.84	1110.4	970.26	912.28	991.79	932.99	988.55	971.66
2020	1066.97	969.01	1133.94	976.48	936.53	1009.74	941.96	1004.95	981.69
2025	1051.29	973.83	1107.81	982.71	927.85	975.80	926.76	992.29	968.80
2030	1148.88	1036.98	1177.92	1051.89	989.91	1066.86	1014.39	1069.55	1077.10
2040	1219.71	1107.86	1259.5	1107.44	1058.73	1145.53	1078.23	1139.57	1134.80
2050	1152.65	1037.78	1178.41	1043.43	985.89	1058.81	1007.64	1066.37	1076.37
Average 2000-50	1113.51	1012.28	1159.48	1020.67	966.33	1040.86	982.78	1042.27	1034.65

Out of the data presented in Table 4 it can be seen that the evapotranspiration have very similar dynamics as air temperature (Table 1). There are certain periods of increasing and decreasing of evapotranspiration but there is an obvious trend of increasing over time. Changes of evapotranspiration mostly depends to the changes of air temperature, due to what the total difference of the average values for the SE region for the period 2000-2050 is not very significant and yields only 31.74 mm (3%) while for the period 2000-2040 the difference is much higher and is 104.93 (10.14%). If we compare the evapotranspiration of the SE and the average of the whole territory, only a slightly differences were notices of only 2.5-23.5 mm.

Crop data

The CropSyst model uses a specific set of parameters corresponding to the crop type. The Crop parameters are numerical representation of the phenology, morphology, growth, residue, harvest index etc. For the purposes of this simulation three crop files were developed that represent the crops in the South-East region in Macedonia with the parameters given in the Table 5.

Table 5. Crop characteristics

Description	Max Value	Min Value	Units	Sunflower	Wheat	Maize
Vernalization A parameter	10	0	°C	0	7	0
Base temperature for development	40	-10	°C	6	1	8
Base temperature for growth	20	-10	°C	6	1	8
Cutoff temperature for development	50	10	°C	30	28	30
Days requirement to complete vernalization	200	0	unitless	0	50	0
Days requirement to start vernalization	30	0	unitless	0	10	0
Development stage beyond which there is no re-growth	3	1	unitless	3	3	3
Development susceptibility to water stress	1	0	unitless	0	0.3	0
Extinction coefficient for solar radiation	0.9	0.1	unitless	0.5	0.48	0.47
ET crop coefficient at full canopy	1.3	0	unitless	1.15	1.18	1.25
Full canopy water uptake maximum	13	7	kg m-2 d-1	12	9	13
Harvest Index	1	0	unitless	0.31	0.4	0.5
Maximum plant height	4	0	M	2	1.2	1.5
High temperature for optimal vernalization	20	0	°C	30	30	30
Initial leaf area index	0.5	0.001	m2 m-2	0.01	0.01	0.03
Maximum leaf area index	12	0	m2/m2	6	6	5
Leaf area index initial value shape	2	1	unitless	1.5	1.5	1.5
Leaf duration	1700	100	°C day-1	1000	1300	900
Low temperature for optimal vernalization	10	-10	°C	0	4	0
Maximum radiation use efficiency	8	0.1	g MJ-1	2.88	2.5	4.5
Maximum rooting depth	200	7	Cm	190	160	150
Minimum vernalization factor	1	0	unitless	0	0	0
Maximum initial green leaf area index	0.2	0.05	m2 m-2	0.1	0.1	0.05
Night Temperature Critical	50	10	°C	15	3	10
Night Temperature Maximum	50	20	°C	25	11	25
Optimum temperature for growth	40	8	°C	20	25	24
Factor to convert global solar radiation to PAR	0.6	0.4	unitless	0.5	0.5	0.5
Daylenght to inhibit flowering	24	0	Hour	0	10	0
Daylenght for insensitivity fo photoperiod	24	0	Hour	0	18	0
Development stage critical for re-growth	2	1	unitless	1.5	1.5	1.5
Specific leaf area at emergence	40	10	m2 kg-1	20	20	20
Stem leaf partition coefficient	7	1	unitless	4	1.5	3
Thermal Time To Begin Yield Formation	1700	200	°C-d	1150	1370	1050
Thermal Time To Emergence	400	70	°C-d	110	60	93
Thermal time to end green leaf area index	1700	0	C°-d	1000	1300	900
Thermal Time To Flowering	2000	300	°C-d	925	870	760
Thermal Time To Maturity	3000	800	°C-d	1630	2200	1480
Transpiration Biomass Coefficient	10	3	(kg/m²) kPa)/m)	4.9	5.8	7.6

A large number of studies have analyzed the potential effects of climate change on different crops productivity response (Rosenweig and Tubiello, 1996; Lal et al., 1998; Tubiello and Ewer, 2002; Parry et al., 2004; Trnka et al., 2004; Ventrella et al., 2009a). In particular, temperature rising can have either negative or positive effects on crop yield, but generally it have been found to reduce yields and quality of many crops. So, for instance, Stuczynski et al. (2002) reported that drier conditions and rising temperature in the Mediterranean region and parts of Eastern Europe may lead to lower yields. In fact, crop response to temperature increment depends on the degree of temperature increase as well as the development stage of the plant. Hatfield (2008) demonstrated that any increase in temperature result in reduced grain filling period for wheat and other some grain species and consequently, lower crop yield. In Argentina maize yield was projected to decrease, but yield projection for wheat were mixed depending upon projected temperature increases (Margin et al., 1997). Similar yield results were found in maize and wheat in the southern part of Romania (Cuculeanu et al., 1999). In southern Italy, the durum wheat yields were predicted to increase under different climate change scenarios. However, Tubiello et al. (2000) found that projected wheat yields using CropSyst would decrease under two climate change scenarios in two Italian locations. Although growing of field crops do not represent the main agricultural activates for the farmers in SE regions, there are several reasons for choosing wheat, maize and sunflower in the vulnerability assessment: winter wheat is mainly rainfed, and maize and sunflower are both a rainfed and an irrigated crop. The maize crop is sensitive to water availability, especially in the flower initiation/tasseling and silking/grain-filling phases. Winter wheat is a less water consumptive crop, but is sensitive to water stress in the anthesis phase. In addition, winter wheat and maize are different plants from the genetic point of view, so their response to doubled atmospheric CO_2 is different.

Wheat scenario

Figures 1 and 2 summarized the relationship between biomass and grain yield for winter wheat.

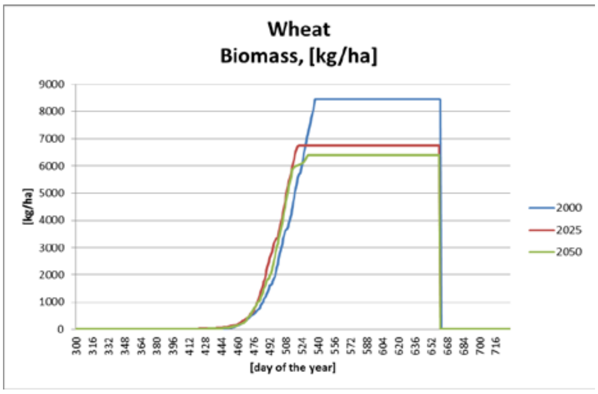


Figure 1. Total biomass produced in the South-Eastern region in the years 2000th, 2025th and 2050th, [kg/ha]

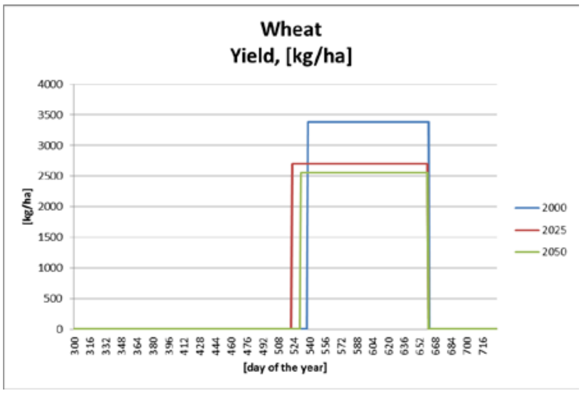


Figure 2. Total yield produced in the South-Eastern region in the years 2000th, 2025th and 2050th, [kg/ha]

The total crop biomass is cumulative biomass in the critical crop growth stages which are significant to final yield. The grain yield of wheat crop is determined by the level of biomass production and the extent of its transformation into economic product.

In the SE region in 2000, wheat occupied almost 3800 ha with average yield of around 8800 kg/ha for biomass and 3400 kg/ha for grain (Figure 1 and 2). The vegetation period (day of the year = DOY) is taken as one unit having in mind that the time of sowing is in one year and time of harvesting in the next one. In 2000, the peak for the yield of biomass was achieved 524 DOY and for grain 540 DOY. Compared those data with the targeted years, the wheat biomass will decrease for 23% in 2025 and 27% in 2050, as same as the yield where reduction is between 21 and 25% respectively. Obviously, a progressive increasing of the average air temperature in all sub localities (2 - 2.43ºC), will lead to the lower yield at all, although it is difficult to explain how the slight decreasing of the temperature in the period between 2000 and 2025 and between 2040 and 2050 has negative impact on hight of the yield overall. Also, these data especially for the grain yield are inconsistent with those set out in section Project Crop Yield Impacts as a part of the Second National Communication of Macedonia where for rain-fed wheat, the major growing areas in the continental and Mediterranean agro-ecological zones are projected to experience a moderate increase in yields of up to 10% for both 2025 and 2050. One reason is that could be a trend which is strictly influence from climate change, concretely from the temperature and refers only for SE region. The other explanation in reducing of the yield may be required in the fact that the concentration of CO_2 as a variable was not taken into account in this study. Many laboratory and field experiments have demonstrated a positive influence of elevated levels of atmospheric CO_2 on the magnitude of biomass and grain production in wheat. In one study estimated the impact of typically predicted climate changes on wheat production in the 21-st century, finding that a doubling of the air's CO_2 concentration would likely enhance wheat yields between 12 and 49% in spite of a predicted 2.9 to 4.1°C increase in air temperature (Alexandrov and Hoogenboom, 2000).

Maize scenario

Figures 3 and 4 summarized the relationship between biomass and grain yield of maize.

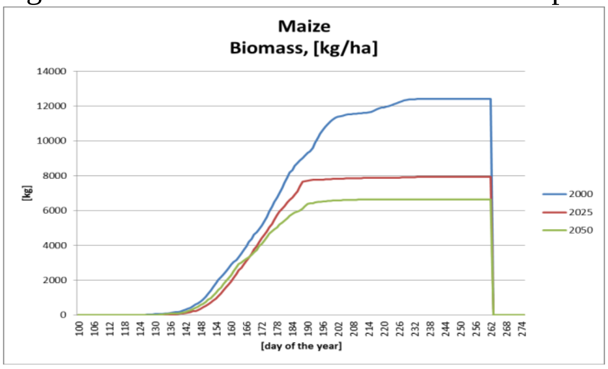


Figure 3. Total biomass produced in the South-Eastern region in the years 2000th, 2025th and 2050th, [kg/ha]

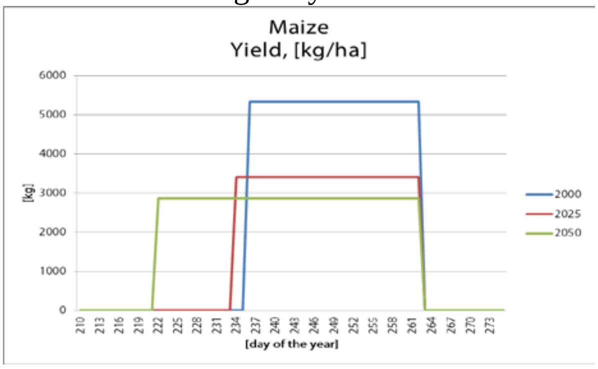


Figure 4. Total yield produced in the South-Eastern region in the years 2000th, 2025th and 2050th, [kg/ha]

In the SE region of Macedonia maize is sown on around 3200 ha from where the average yield is 5330 kg/ha which is 26% higher compared with the average level of the country obtaining from individual farmers (4200 kg/ha) and 22% lower from those of agricultural cooperatives (6500 kg/ha).

According the data presented in Figure 4 the grain yield will be significantly lower in the forthcoming period in common planting date. Under climate change scenario maize yield is expected to be reduced by 56% in 2025 and even by 86% in 2050 respectively (Figure 4), far more than the forecast presented in the Second National Communication which seeks to reduce the yield of corn by 25%. At the same time, higher temperatures will greatly affect the shortening of the vegetation of maize that is specifically expressed in 2050 where the maximum yield is noted 220 DOY, which represents a reduction of vegetation for 15 days (maximum yield in 2000 was realized from 235 DOY and further). Identical correlativity is determined on the yield of biomass where reduction ranges from 34% in 2025 to 58% in 2050, compared to 2000. It may conclude that if traditional varieties and agro-management practices are maintained, maize cycle will be shortened because of higher temperatures. The decrease in maize's ET could be caused by decreases in growing days and in Leaf Area Index due to higher temperature, and a lower transpiration due to stomata closure.

Sunflower scenario
Sunflower is not a relevant crop in SE region of Macedonia. Current sunflower production is realized on 1 ha with yield of around 1700 kg/ha (Figure 5).

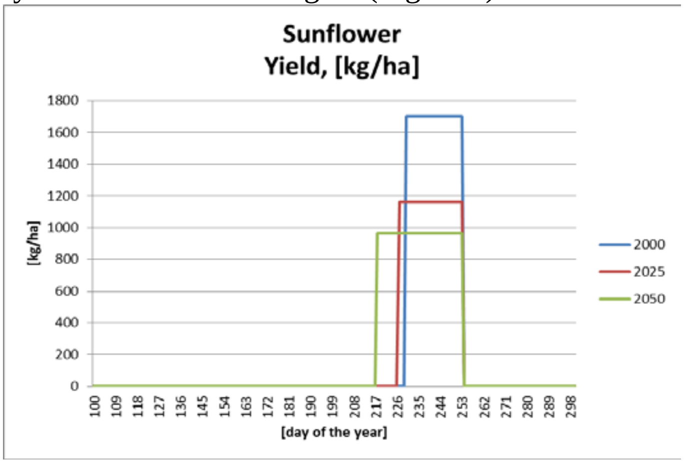


Figure 5. Total yield produced in the South-Eastern region in the years 2000th, 2025th and 2050th, [kg/ha]

The climate change analysis describes the strong effect of temperature increment on sunflower production. The achene yield will be considerably reduced with increasing temperatures up to 2^{o}C in the area. Compared with present scenario than it can be estimated that there will be reduction in yield to 30% in 2025 (expected yield 1190 kg/ha) and up to 40% in 2050 (expected yield 990 kg/ha) for sunflower crop (Figure 5). In the same time, higher temperature affects the rate of plant development (vegetative growth), and the vegetation period will be shorter for approximately 13 days in 2050 where the peak of the yield will be 217 DOY. These data are identical with those obtaining from different regions in Europe where the yield of sunflower in Eastern Europe will be lower from 10 – 30% by 2030. The assertion can be summarized by higher evapotranspiration coupled with less rainfall compared to baseline period.

Conclusions
The sensitivity of the agricultural sector to climate has important implications in Macedonia. With a considerable proportion of the rural population dependent on agriculture for their livelihood, rural communities are particularly vulnerable to risks posed by changes that may occur as a result of climate change.

High vulnerability is due to several key factors: (a) small primary producers with low annual income and ability to implement adaptation measures which in some cases can be costly to implement; (b) small plots which prevents effective implementation of adaptive measures; (c) insufficient financial support to the farmers to cope with the negative impacts of CC; (d) low awareness among the key players about the climate change and its negative effects in agriculture; (e) weak networking and insufficient level of cooperation between scientific institution; (f) extension service and farmer associations for implementing know-how; (g) modern technologies of productions and dissemination of research results to the broader audience; (h) insufficient experience with implementation of modern approaches in assessment of impact and prediction of future effects and trends.

Climate change is expected to reduce the yields of most crops. These losses are projected to increase over time. Without adaptation, these climate change damages may become approximately the same or bigger than current net income jeopardizing the economic sustainability of farming in some areas.

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