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The influence of extreme weather events on farm economic performance – a case study from Serbia

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Abstract. Western Balkan region, particularly Serbia, is faced with an increased frequency of extreme weather events, as a consequence of global climate change. However, there is still no enough research on how the effects of extreme weather events could be measured on the farm level. More importantly, there is no standard international methodology that is used regularly to address the issue. Therefore, the aim of this research was to evaluate the effects of extreme weather events on business performances of two the most common farm types in Serbia. To achieve this goal, the authors performed a financial loss assessment on a farm level. Panel models and R software environment were used to perform a multiple regression analysis allowing to indicate determinants of financial loss indicator depending on the farm's production type. The results indicated that performance of both farm types is more influenced by drought than by floods. The regression analysis revealed that for both farm types financial stress is the most important independent variable.

Keywords: flood, drought, climate change, type of farming, regression analysis.

INTRODUCTION

Irrespective of the fact that there is a considerable amount of scientific evidence on denying climate change (Dunlap, 2013; Björnberg et al., 2017; Karlsson and Gilek, 2020), there is a widespread agreement that the climate changes (Pachauri et al., 2014) and that humans seem to be responsible for it (Cook et al., 2016). It significantly impacts agriculture and food systems (Gornall et al., 2010; FAO 2016) as the effects become more pronounced (McCallum et al., 2013).

In the Europe, the climate changes have already caused a shift of agro-climatic zones to the north, prolonged growing season and increased active temperature accumulation (Peltonen-Sainio et al., 2009; EEA, 2019). The predictions are that these processes will continue by the end of century, resulting in an increase in drought frequency and intensity in the Mediterranean area, western Europe and northern Scandinavia (under the climate scenario RCP 4.5), and/or more intense droughts all over Europe (under the worstcase climate scenario RCP 8.5) (Spinoni et al., 2018). Yet, the effects of climate change vary by regions, as well as predictions of future scenarios and seasonal patterns. The predictions are that in southern Europe agriculture sector will be adversely affected by an increase of the heat wave intensity (high confidence) (Kovats et al., 2014; IPCC, 2019); that the migration of agro-climatic zones in eastern Europe will be twice as fast as that recorded during the period 1975-2016 (EEA, 2019); and that extreme precipitation in northern Europe will increase (Kovats et al., 2014; Zampieri et al., 2017).

The impact assessments of climate changes on agriculture sector have been extensively examined, at a multiple scales and in a variety of contexts (Moore and Lobell, 2014; Olsen and Bindi, 2002), yet without considering the complex interdependencies within human and environmental systems (Harrison et al., 2015). However, various scenarios of future change in climate variables impacting the productivity of agriculture sector, predict similar patterns of changes in crop yields for the EU 2080s: southern Europe would experience yield decreases (25% under 5.4°C scenario), central Europe regions would have moderate yield changes, whereas the northern Europe regions would benefit from growing yields (Ciscar et al., 2009; Iglesias et al., 2012; Knox et al., 2016).

According to Zurovec et al. (2015) on the territory of Western Balkan drought is "frequent adverse climatic event over the last decade". In Serbia, there is an increase in average annual temperatures of about 0.6°C/100 years, with a higher trend in the northern and mountainous parts of the country (MAEP, 2015). Nonetheless, compared to the second half of the twentieth century, Serbia has been exposed to more frequent extreme weather occurrences and natural catastrophes in the recent two decades. As per relevant studies, there were 2,000 natural disasters in Serbia between 1980 and 1990, with 2,800 instances documented throughout the 1990s (Kovačević et al., 2012; Lukić et al., 2013; Anđelković and Kovač, 2016). Within the first two decades of the twenty-first century, these patterns remained as the severity and frequency of natural disasters grew and became more extreme. Serbia was affected by severe floods in 1999, 2002, 2005, 2006, and 2014, with most of them taking place during the growing period (April–June) (FAO, 2020).

At the same period of time (1999 – 2019), Serbia experienced above-average temperatures followed by drought in 2003, 2007, 2012, 2015, and 2017. Additionally, the 2012 and 2017 years were among the driest, with record-low rainfall, severely impacting Serbia's agricultural output (FAO, 2020). Temperatures surpassed 35°C for more than 50 days in a row in 2012, resulting in a loss of crop output of over one million hectares and damage caused of more than $141 million (USAID, 2017).

The results of the temperature forecast show an increase in temperature between 0.5°C and 2°C in the next fifty years. The recent regional climate models indicate that in the near future can be expected surplus rainfall in summer and early autumn period (which is in line with current trends), as well as the significant drop in precipitation in the distant future. Regional Climate Model (RCM) also suggests for Serbia an average annual decrease in precipitation, ranging from 0% to 25% / 100 years (MAEP, 2015).

Considering the high importance of agriculture sector for Serbian economy (forming of about 7% of Gross domestic products (GDP)), and livelihood of rural dwellers (40% of total population), the economic losses and damages caused by climate changes can have a profound effects. Despite the large number of studies examining the effects of climate change on individual sectors (Stričević et al., 2020), crop yields (Jančić, 2013), and regions (Lalić et al., 2011; Armenski et al., 2014), the impact on farmers income has not been systematically assessed, mostly due to the lack of data at the level of individual farms or smaller territorial units. Hence, both agricultural producers and policy makers are deprived of the number of important inputs relevant for decision making.

This paper aims to fulfil the gap in understanding the economic effects of climate change on dominant types of farms in Serbia. To determine this, we conducted analysis of selected financial indicators of farm performances in the 14 districts of Serbia which were, in two consecutive years, affected by both floods (2014) and drought (2015). In 2014 heavy rainfall and flooding severely affected many parts of Serbia's territory. According to estimations provided by different sources, in total, 1.6 million people, and 34,500 family holdings were affected by flood and related disasters (WB, 2015; FAO, 2015). The following year (2015) was characterized by extreme drought which affected majority of Serbian territory causing significant drop in most crop yields. In addition to these two years, the analysis also included 2016, during which the weather conditions were stable.

A wide variety of approaches have been used in the different countries/regions to determine the damage caused by extreme weather events. Most of the methods used for economic evaluation of flood damage in agriculture are limited to the national level, while "little research is carried out on the transferability of local methodologies" (Brémond et al., 2013). Research conducted by Cogato et al. (2019) revealed that the relations between extreme weather events, food security and economic loss are of major interest within scientific community. Nevertheless, authors noticed "low level of international collaboration of the vulnerable countries" related to research of extreme weather events, while "developing countries have only more recently been approached through international research". Similarly, Jongman et al. (2012) emphasized the need to develop models for flood damage assessment not only on European but also on global level. Merz et al. (2010) discussed that attention is usually paid to flood hazard assessment, while flood damage assessment "is frequently seen as some kind of appendix within the risk analysis". The authors also noticed that methodology for damage assessment related to other natural disasters (such as storms or droughts) is even less developed. Similarly, Parisse at al. (2020) stated that in future research it is necessary to "consider indicators for events such as hail and strong wind".

Messeri et al. (2015) discussed relations between weather types in Italy and frequency of floods and landslides. Considering each weather type, specific risk indexes for entire country as well as for specific Italian regions were determined (applicable on seasonal and annual level). Such approach could help in appropriate planning, prevention and reduction of damages caused by unfavourable weather events. Vallorani et al. (2018) discussed relations between large-scale circulation and local climate because they "could be useful to evaluate the weather and climate risk on a regional scale linked to extreme weather conditions such as heavy precipitation, flood or drought events and heat waves or cold spells". In such a way it is possible to develop adequate tools (applications) which are "related to water and energy resources management, agronomy, severe weather risk prevention and seasonal forecasts".

Generally, approaches used in assessing the effects of natural hazards may be summarized within the two main concepts – economic loss assessment and financial loss assessment (Penning-Rowsell et al., 2013):

- An economic loss assessment is usually performed on a macro-scale level (i.e. for the entire country or region, usually larger than the affected area) by macroeconomic variables, such as changes in GDP, changes in the output volume and the trade balance, employment etc.
- A financial loss assessment is performed on a micro-scale level (farm) or at the meso-level (of a local community), while the crop damage is usually used as a simplistic proxy of the total damage.

When assessing financial loss in agriculture, various economic indicators are used in the existing literature. According to comprehensive review conducted by Brémond et al. (2013) the most frequently used indicators for estimation of financial loss in plant production are the Gross product and Gross margin adjusted with variable costs. Similarly, Thieken et al. (2008) used percentile deduction of average revenues to calculate crop loss related to flood damage, while Jega (2018) analyzed changes in income of smallholder farmers to evaluate effects of flood disasters. Antolini et al. (2020) used HAZUS-MH estimation model to evaluate crop loss by multiplying damage to crops by crop prices. In the same way Shrestha et al. (2018) performed flood damage assessment by estimation of yield loss and its multiplication by the value of farm gate price. Torrente (2012) explained post disaster losses in agriculture as forgone output (income) as a result of disaster as well as higher production costs.

Vega-Serratos et al. (2018) estimated the damage caused by floods on the basis of production costs of the crop (depending on the phase in its production). Analyzing performance of farms affected by drought, Lawes and Kingwell (2012) used indicators such as return on capital, business equity, the debt-to-income ratio and operating profit per hectare, while Kingwell and Xayavong (2017) also used retained profit per hectare.

MATERIALS AND METHODS

A vast amount of data from both primary and secondary sources needs to be considered in performing analysis of financial loss assessments caused by extreme weather events. The key challenge of data collection relates to the availability of data at lower territorial units from official public sources (statistics, registers, state agencies), while economic data on the farm level is often scarce and may lack accuracy and reliability due to the different methods of data collection and aggregation. Therefore, data on economic and structural characteristics of farms in 14 affected districts (107 farms, out of which 70 farms with mixed crop and livestock production and 37 farms specialized for crop production) was used as a base for panel models. The study area was selected to cover the municipalities which in two consecutive years were affected by both floods (2014) and drought (2015) (Figure 1).

The study area has a continental climate, warm and humid from June through September and cold and dry from December through February. Precipitation occurs throughout the year, but there is a peak in May through July (one third of the annual precipitation). However, climate projections show that these districts in the future

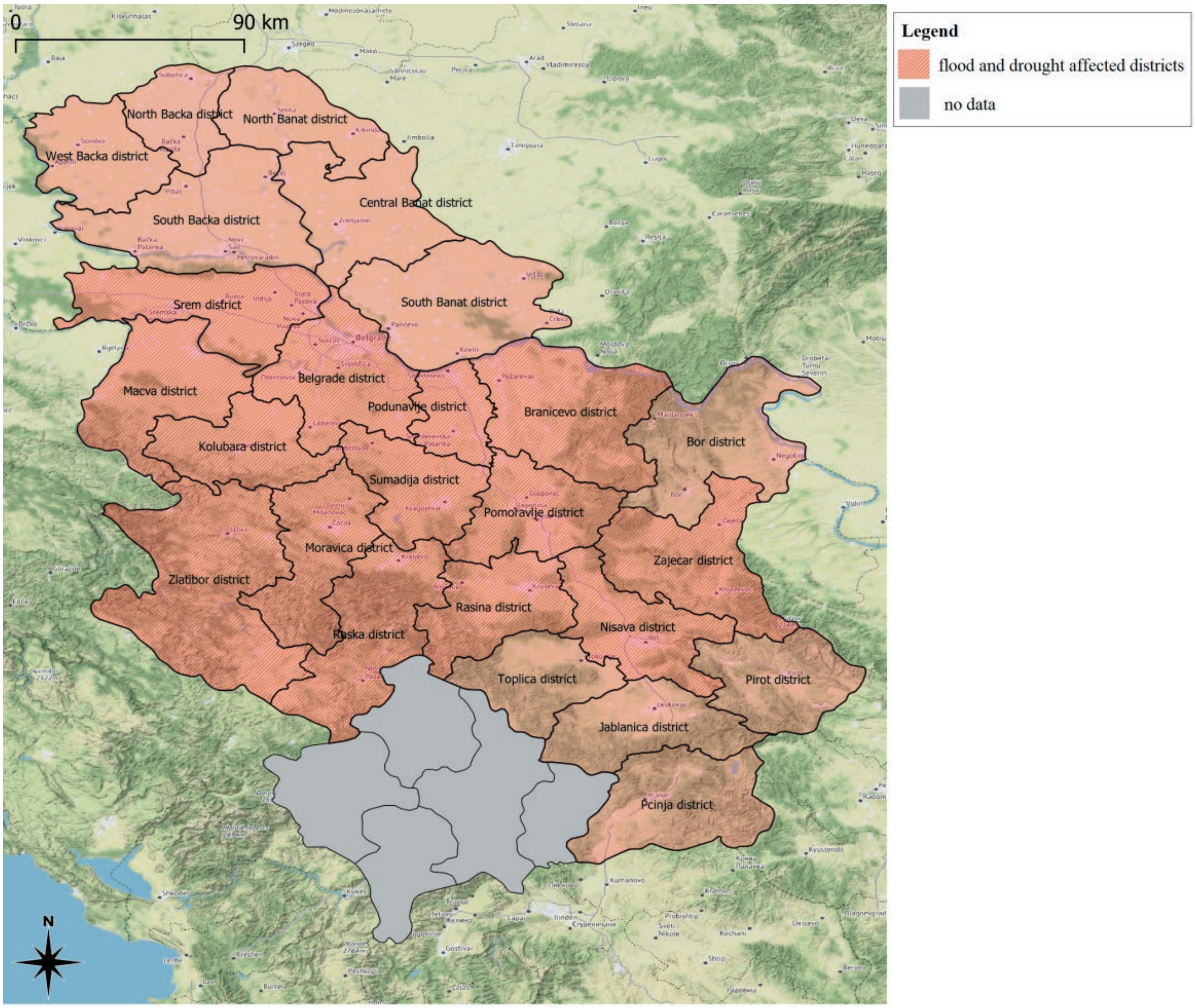

Figure 1. Districts of Serbia which were, in two consecutive years, affected by both floods (2014) and drought (2015). Since the data for the territory of Autonomous Province of Kosovo and Metohija have not been available for the analyzed period, all data and estimates refer to Serbia but without this province.

will experience decrease in precipitation and increase in temperature, especially in summer, compared to an average precipitation and temperature for the period 1979-2013 (Figure 2) and increasing risk of extreme rainfall days and river floods (Alfieri et al., 2017).

Primary data set (which has not been initially collected for the purposes of assessing influence of extreme weather events on farm economic performance) was formed of the database created as a result of an annual survey on a representative sample of farms in these districts. The data were verified through focus groups discussions with farmers in affected districts. To gain a more detailed insight into the support measures and types of assistance to farms in the years with extreme weather events (that could significantly influence the farm business results) semi-structured interviews with institutions and government line agencies were also conducted.

Due to the lack of the official data on economic results of farms within the time period covered by this analysis, the described approach can be considered as sufficiently reliable. A retrospective questionnaire on the selected sample would be less reliable because it would be necessary to collect a large number of economic indicators for previous years (prices, yields, and production costs) based on (unreliable) recollection of the farmers.

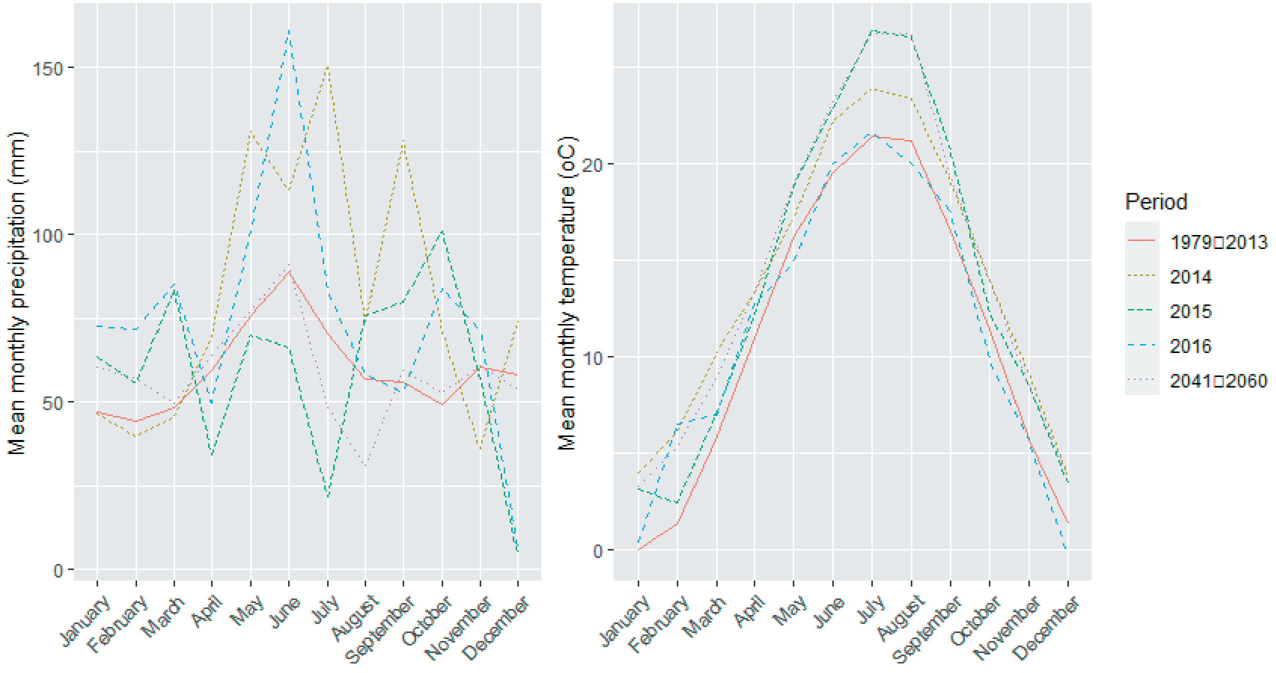

Figure 2. Mean monthly precipitation (mm) and temperature (°C) in study area. (Source: Authors calculations based on TerraClimate dataset, climatic variables 2014-2016, 4 km spatial resolution and CHELSA database, climatic variables 1979-2013, 1 km spatial resolution with future projections, under the climate scenario RCP 8.5). [TerraClimate is a dataset of monthly climate and climatic water balance for global terrestrial surfaces from 1958-2015 (Abatzoglou et al., 2015). CHELSA (Climatologies at high resolution for the earth's land surface areas) is a high resolution (30 arc sec) climate data set for the earth land surface areas currently hosted by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL (Karger et al., 2017a, 2017b)].

In this analysis, as indicators for financial loss assessment, Gross product (GP) and Gross margin adjusted with variable costs (GMAVC) were used. The GP represents the total value of all the products and services produced at a particular farm in a particular year (regardless of whether the products were sold, stored at the end of the year, or used in the household or on the farm). The GP comprises of the crop production, livestock production and other products and services (such as contracted work for others, rural tourism etc.), and is calculated in the following way:

$$\text{Gross product} = \text{Total value of crop production} + \text{Total value of livestock production} + \text{Value of other products and services related to the farm}$$

As already mentioned, majority of authors directly used the variation in the GP as a proxy for crop damage. However, this approximation overlooks variation in production costs due to extreme weather events, so this indicator does not reflect the real changes in the results of the farm business operations caused by the floods or droughts. Therefore, in addition to the GP, the other indictor - the gross margin adjusted with variable costs is also used:

$$\text{Gross margin adjusted with variable costs} = \text{Gross product} + \text{Total subsidies (excl. subsidies on investments)} - \text{Adjusted variable costs}$$

Contrary to the GP, the GMAVC takes into account some variable production costs, which are usually caused by the floods or droughts. These variable costs include, for example, seed costs, plant protection products and fertilizers costs, feed costs and the like (which are expected to be higher if the farm production is renewed/restored in the same year). On the other hand, some costs can decrease, for example harvesting costs related to drought affected crops. In this way, GMAVC allows better determining of the impacts of extreme weather events on the changes in farm economic performance.

In this paper, Gross products and Gross margin adjusted with variable costs were determined for the flood year (2014), for year with extreme drought (2015), as well as for the following year (2016) which was characterised by average climatic conditions.

Considering that GMAVC provides better understanding of farms performance, the effort is made to obtain the panel models. These models characterize the determinants of the GMAVC according to the farm's type of production. Balanced panel data set consisting of 107 farms (70 farms with mixed crop and livestock production and 37 farms specialized for crop production) was used as a base for panel models, while R software environment for statistical computing and graphics was used to perform a multiple regression analysis allowing to indicate determinants of GMAVC depending on the farm's production type.

The most general formulation of a panel data model may be expressed as the following equation (Baltagi, 2005):

$$y_{i,t} = \alpha_i + X'_{i,t}\beta + u_{i,t} + \varepsilon_{i,t} \quad (1)$$

with i ($i = 1,\ldots, N$) denoting individuals, t ($t = 1,\ldots, T$) denoting time periods, and $X'_{i,t}$ denoting the observation of K explanatory variables in farm i and time t.

It should be noted that α_i is time invariant and accounts for any individual-specific effect not included in the regression equation. Two different interpretations may be given to the α_i, and, consequently, two different basic models may be distinguished. If the α_i's are assumed to be fixed parameters to be estimated, the model expressed in the equation (1) is fixed effect panel data model (FEM). Conversely, if the α_i's are assumed to be random, the random effect panel data model (REM) is generated (Arbia and Piras, 2005). Fixed effect model is particularly suitable when the regression analysis is limited to a precise set of individuals, farms or regions; random effect, instead, is an appropriate specification if a certain number of individuals are drawn randomly from a large population of reference (Arbia and Piras, 2005).

In order to choose between REM and FEM approach, the Hausman test is used. The null and alternative hypotheses of Hausman test are (Adkins, 2014):

$H_o : Cov(x_i; e_i) = 0$, against $H_a : Cov(x_i; e_i) \neq 0$.

In order to estimate the model, a set of variables describing characteristics of the farm, human capital and technology employed is used (Table 1).

Table 1. Dependant and independent variables used in panel models.

Variable	Description
y Gross margin adjusted with variable costs (EUR)	*Gross product (EUR) + Total subsidies excluding subsidies on investments (EUR) - Adjusted variable costs (EUR)*
x1 Age of farm manager (years)	
x2 Share of rented land (%)	*Rented Utilised Agricultural Area (ha) / Total Utilised Agricultural Area (ha)*
x3 Share of hired labour (%)	*Paid labour input (AWU) / Total labour input (AWU)*
x4 Capital to land ratio (EUR / ha)	*(Depreciation (EUR) + Interest paid (EUR)) / Total Utilised Agricultural Area (ha)*
x5 Capital to labour ratio (EUR / hours)	*(Depreciation (EUR) + Interest paid (EUR)) / Total labour input (hours)*
x6 Labour to land ratio (hours / ha)	*Total labour input (hours) / Total Utilised Agricultural Area (ha)*
x7 Financial stress	*(Rent paid (EUR) + Interest paid (EUR)) / Total output crops & crop production (EUR)*
x8 Marketability of production (%)	*(Total Output (EUR) – Farmhouse Consumption (EUR) - Farm use (EUR)) / Total Output (EUR)*
x9 Percentage of costs of external factors (%)	*Total external factors (wages, rent and interest paid) (EUR) / Family Farm Income (EUR)*
x10 Number of crops grown on farms	

Source: The variables were derived from database of the research team.

RESULTS AND DISCUSSION

A financial loss assessment was conducted on the sample of farms representing the dominant farm types in the affected districts. Farm types were determined based on the share of different lines of production in the gross product of a particular farm. Two types of farms-mixed farms for crop and livestock production, as well as farms specialized for crop production were selected for further analysis because these farm types are dominant in the analyzed districts. According to the data of Farm structure survey conducted in Serbia in 2018, these farm types represent 34.24% (mixed farms for crop and livestock production) and 14.93% (farms specialized for crop production) of total number of farms in analysed districts (SORS, 2019). The key structural characteristics of selected farms are presented in Table 2.

The results indicated that extreme weather events had a different impact on analyzed farm types (Table 3). The GP of farms with mixed crop and livestock production was particularly affected in flood year (2014). It rose in the following year (2015) characterized with drought, and continued to increase in the year with regular weather conditions (2016). On the other hand, the 2015 drought caused a significant decrease in GP of

Table 2. Descriptive statistics of the sample by farm types.

Indicators / Variables	Unit	2014		2015	
		Mean	Standard Deviation	Mean	Standard Deviation
Mixed farms for crop and livestock production (70 farms)					
Structural characteristics					
Farm size	ha	17.54	15.14	16.96	13.42
Livestock units	LU[1)]	9.18	7.46	12.02	10.43
Total labour input	AWU[2)]	2.61	1.14	2.53	1.10
Panel model					
Age of manager	years	45.81	11.80	46.76	11.83
Share of rented land	%	32.00%	30.51%	31.19%	29.43%
Share of hired labour	%	9.50%	13.40%	7.90%	13.61%
Capital to land ratio	EUR per ha	156.73	137.81	229.55	187.81
Capital to labour ratio	EUR per hours	0.64	0.88	0.81	0.79
Labour to land ratio	hours per ha	415.49	304.18	397.93	266.51
Financial stress		0.03	0.05	0.03	0.05
Marketability of production	%	69.41%	22.08%	65.32%	27.35%
Percentage of costs of external factors	%	8.64%	134.08%	16.22%	82.17%
Number of crops grown on farms		2.83	1.05	2.87	1.20
Farms specialized for crop production (37 farms)					
Structural characteristics					
Farm size	ha	62.45	80.45	64.29	82.05
Livestock units	LU	1.51	2.67	1.26	2.53
Total labour input	AWU	2.29	1.26	2.14	1.00
Panel model					
Age of manager	years	47.59	11.27	47.81	11.46
Share of rented land	%	49.11%	32.06%	53.80%	28.47%
Share of hired labour	%	15.42%	19.09%	10.47%	17.82%
Capital to land ratio	EUR per ha	183.94	194.76	184.58	103.91
Capital to labour ratio	EUR per hours	3.22	5.10	3.74	6.17
Labour to land ratio	hours per ha	318.62	593.91	220.97	360.13
Financial stress		0.06	0.05	0.08	0.06
Marketability of production	%	93.33%	12.05%	96.24%	6.74%
Percentage of costs of external factors	%	21.39%	102.71%	15.04%	135.25%
Number of crops grown on farms		2.89	1.26	2.76	1.21

[1] Livestock unit.

[2] Annual work unit is the full-time equivalent employment, i.e. the total hours worked divided by the average annual hours worked in full-time jobs (1,800 hours).

Source: authors' calculations.

farms specialized for crop production (comparing with the year characterized with floods). These indicate that GP of mixed farms is more vulnerable to floods than to drought. On the other hand, GP of specialised crop farms is more affected by drought, because the damage caused by floods could be compensated to some extent by resowing the part of the flooded land.

Analysing values of GMAVC for the observed farm types and weather conditions, it was determined that both farm types were more influenced by drought than by floods, while negative effect of drought on GMAVC was more important for specialized crop farms.

The results indicate that the changes in both the GP and GMAVC for specialized crop farms are similar, which is not the case with mixed crop – livestock farms. The results of the analysis also confirm that the mixed crop–livestock farming systems, with diversified sources of income, made GP and GMAVC of these farms less risky and less dependent on extreme weather events over the observed period.

Table 3. The changes of GP and GMAVC by type of farms in case study regions.

Years	Mixed farms for crop and livestock production Basic indices (2016=100)		Specialised farms for crop production Basic indices (2016=100)	
	Gross product	Gross margin adjusted with variable costs	Gross product	Gross margin adjusted with variable costs
2014 (year of floods)	91.82%	90.17%	98.41%	92.96%
2015 (year of drought)	94.31%	88.22%	89.91%	81.64%
2016 (usual production conditions)	100.00%	100.00%	100.00%	100.00%

Source: authors' calculations.

To extend the understanding of the problem, multiple regression analysis is performed resulting in the random effect models (REM) for GMAVC. In other words, based on the Hausman test, REM proved to be more appropriate than FEM approach for evaluation of GMAVC indicator. The results of the estimation of its parameters according to the type of production are presented in Table 4.

The impact of independent variables on GMAVC depends on the type of production. For the specialized crop farms the share of rented land and capital to labour ratio are the most important (level of significance $p<0.01$). On the other hand, for the mixed crop and livestock farms number of important independent variables at the same level of significance is much higher (the share of rented land, share of hired labour, capital to labour ratio, labour to land ratio, financial stress and marketability of production). At the same time, estimation of regression equation is better for mixed crop and livestock farms.

In the obtained models, one independent variable - financial stress has negative statistically significant influence on dependent variable GMAVC of both types of farms. Besides, the same effect could be noticed for capital to land ratio and labour to land ratio in a model describing mixed crop and livestock farms.

On the other hand, there are two independent variables (share of rented land and capital to labour ratio) which have positive statistically significant influence on dependent variable GMAVC of both types of farms. The highest positive influence on GMAVC is exerted by the share of rented land (for specialized crop farms) and marketability of production (for mixed crop and livestock farms).

Table 4. Panel models for GMAVC by the type of production.

Dependent variable in the models:	Gross margin adjusted with variable costs	
	Specialized crop farms	Mixed crop and livestock farms
Hausman Test	$\chi^2(10) = 6.7649$ (0.7474)	$\chi^2(10) = 13.437$ (0.2002)
Model's type	REM	REM
Independent variables in the models:		
Constant	1,110.472	-6,895.491
	(48,716.070)	(8,150.715)
X1 Age of manager (years)	-654.450	3.805
	(427.502)	(109.137)
X2 Share of rented land (%)	53,259.920***	16,172.320***
	(20,616.470)	(5,149.191)
X3 Share of hired labour (%)	31,906.610	*29,735.810****
	(22,676.150)	(9,331.109)
X4 Capital to land ratio (EUR / ha)	6.401	*-22.481***
	(31.573)	(9.046)
X5 Capital to labour ratio (EUR / hours)	4,794.260***	11,532.420***
	(893.845)	(2,476.407)
X6 Labour to land ratio (hours / ha)	4.950	*-15.527****
	(12.107)	(5.386)
X7 Financial stress	-199,869.900**	-178,593.000***
	(100,673.400)	(38,130.930)
X8 Marketability of production (%)	2,563.432	*34,943.620****
	(38,256.420)	(4,722.506)
X9 Percentage of costs of external factors (%)	-85.142	-375.230
	(2,131.955)	(1,019.573)
X10 Number of crops grown on farms	*8,296.196***	-129.755
	(3,502.391)	(1,163.260)
Observations	74	140
R^2	0.481	0.552
Adjusted R^2	0.398	0.517

Levels of significance: $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Note: REM - Random-effects model; Standard error of the coefficients estimates are shown in round brackets.
Source: Authors' calculations.

CONCLUSIONS

There is a growing concern among policy makers about the effect of climate change on food security and farmers' income. Considering the already observed climate change trends and projections, climate conditions will affect agricultural sector in Serbia in many ways. Therefore, it is important to research and understand the potential impacts of extreme weather events on changes in farmers' income of different farm types.

In this research we examined the impact of extreme weather events on business performances of the two most common farm types in Serbia, by applying a farm-scale approach. Panel models and R software environment were used to perform a multiple regression analysis to indicate determinants of financial loss indicator for both farm types. The results of GMAVC indicator (which considers not only variations of GP but also changes in the appropriate variable costs) indicate that performances of both farm types are more sensitive to drought than to floods. It is also determined that specialized crop farms are more vulnerable to extreme weather events comparing to mixed farms for crop and livestock production.

The results of panel models reveal that financial stress is the variable which dominantly negatively impacts GMAVC for both farm types. This indicated the high relevance of rent and interest costs on economic performance of farms in years characterized with extreme weather events. On the other hand, an increase of share of rented land has positive impact on GMAVC. Therefore, keeping rent paid per hectare at a low level as well as finding ways to decrease interest cost (primarily using loans subsidized by the state) is the key for reducing financial stress of the farms in the years to follow.

The obtained results confirm previous findings indicating the great influence of drought on the decrease of farm economic performance. Therefore, increasing frequency of droughts creates significant risk not only for livelihood of farm households, but also for an overall stability and growth of agricultural sector.

Incentives for adaptation and mitigation of climate change are available to Serbian farmers. Such incentives include investment subsidies for purchase of agricultural machinery, equipment and buildings in plant and livestock production (including anti hail nets, covering materials for frost protection, shade nets and irrigation systems for frost protection) as well as subsidies aiming to reduce risk related to climate change (subsidized insurance premiums).

Nevertheless, agricultural extension services in cooperation with scientific institutions are the key actors in dissemination of knowledge and information concerning climate change and mitigation measures. However, their capacity to play that role are rather limited because they are in charge of number of other tasks, they have the lack of human resources as well as limited technical possibilities.

There is not enough knowledge on effects of extreme weather events on production and economic results of agriculture. There is even less research regarding its influence on certain farm types, agricultural sectors, regions or agricultural products. The existing models and simulations of climate changes do not include economic variables (especially not on the level lower than the national one). Our findings could provide a useful contribution to evidence-based policy making, i.e. to the improvement of the set of mitigation measures provided by national agricultural policy.

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