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FLOODS AND THEIR EFFECTS ON AGRICULTURAL PRODUCTIVITY

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Abstract: Romania is located in a temperate-continental climate zone with a moderate precipitation regime, but in recent years, as a result of climate change, there have been significant deviations from the average annual values of temperature and precipitation compared to the multiannual average values, both in Europe and around the world. Agriculture and agricultural productivity suffer a negative impact generated by climate change and extreme weather phenomena, which is added to the negative influence of the anthropogenic factor that causes the intensification of these phenomena through greenhouse gas emissions, deforestation, land waterproofing as a result of the expansion of residential areas, etc. The consequences of the floods affect the level and variability of agricultural production, affect the management of livestock, as well as the location of production as an agro-climatic zone, registering a transition to higher lands. These effects can jeopardize the supply of food on the internal market in some parts of Europe, also leading to increased price instability and an increased risk to farmer's incomes.

At the level of Romania, severe localized phenomena were registered, such as prolonged drought, violent storms, large hailstorms, or extreme precipitation from a quantitative point of view, which led to the occurrence of numerous cases of floods. The succession of mentioned phenomena in recent years has demonstrated the country's vulnerability to extreme conditions. The evolution of the average annual precipitations in Romania in 2018 indicates deviations from the climatological norm in force (multiannual average for the 1981-2010 period) at many meteorological stations in the country. The paper presents a brief synthesis of the precipitation regime in Romania, respectively a case study on the floods produced in 2018 and an analysis of their effects on the agricultural sector from a productive point of view. The work ends with a series of solutions and measures to prevent floods in vulnerable areas.

• Introduction

Floods are natural phenomena that consist of temporary water cover of land, being some of the most common extreme phenomena globally. Floods affect many economic sectors, and agriculture is one of the most exposed, as agricultural activities depend directly on climatic factors. This is important for Europe because almost 50% of its area is agricultural land. Adaptation is a critical challenge for agriculture.

Floods cause massive damage to crops. In 2009, in the southern areas of the Irkutsk region, almost all potato plantations were affected by a fungal disease, with 90% yield losses. As a result of river overflows, even plants became unsuitable for animals because the surface of the leaves was covered with mud. Climate change is an aggravating factor, leading to changes in rainfall and weather patterns, rising sea levels, and, as a result, more frequent and more severe floods. In this diverse climate, there are many problems, from difficulties in adapting to new conditions of plants and animals (the advantage of animal species being their mobility) to improper development of crops and severe damage in terms of quantity and quality of the harvests, from the increase of the prices of the agricultural products to the lack of food sources and the lack of incomes, or even hunger etc.

The risk of floods in Central and Northern Europe is increasing. In recent years, in Romania, floods have caused great material loss and even life losses.

• Material and method

The precipitation regime in Romania

Romania is located in a temperate-continental climate zone with a moderate rainfall regime. The amount of average annual rainfall varies, between 400 – 1200 mm, depending on two main factors: latitude and altitude.

According to data published by the National Meteorological Administration, on the background of global climate change, there have been significant deviations of the rainfall and thermal regimes of Romania. Thus, in the last century, there has been a gradual warming of the atmosphere, as well as a significant reduction in rainfall. Thermal regime anomalies also affect the precipitation regime. The average annual amount of precipitation in 2018 was 698.3 mm, registering an exceedance of approximately 10% of the climatological norm in force. The deviation of the monthly amount of precipitation was positive in 6 of the 12 months of 2018, and in the rest of the months, there were negative deviations (Table 1).

Table 1. The climatological norm in force (1981 – 2010) and the evolution of average monthly amount of precipitation in 2018

	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1981-2010	33.6	31.6	38.3	51.3	66.5	84.5	77.8	64.7	55.0	43.5	41.5	44.8
2018	39.1	55.1	73.3	18.2	56.7	158.8	119.3	32.2	27.0	20.0	39.3	59.3
Deviation (mm)	5.5	23.5	35.0	-33.1	-9.8	74.3	41.4	-32.5	-28.0	-23.5	-2.2	14.5
Deviation (%)	16.37	74.37	91.38	64.52	14.74	87.93	53.34	50.23	50.91	54.02	5.3	32.37

positive deviations; negative deviations

The positive deviations varied between 16% and 92%. The most significant positive deviations were registered as follows: February with 74.37%, March with 91.38%, June with 87.92%, and July with 53.34%. In 2017, the average annual amount of precipitation was 673.5 mm, registering an exceedance of approximately 6% of the climatological norm.

Factors and causes of floods

Floods vary in frequency, location, and intensity due to seasonal and regional variations in rainfall, other weather events, and long-term climate change. The anthropogenic factor also influences the production of floods by: industrial activities resulting in greenhouse gas emissions, massive deforestation in mountain areas accelerates the phenomenon of surface runoff, therefore the risk of flooding increases, waterproofing of lands and urban development, the development of agriculture in floodplains can lead to significant losses in agricultural productivity, hydrographic arrangements.

Effects of flooding

1. The negative effects of floods are felt especially in areas where local communities have developed or in the case of productive lands. Negative effects of floods include: injuries and life losses; material losses and considerable economic costs, mentioning here the damage caused to crops; water saturation of the soil and subsoil and damage to crops; leaching nutrients from soils; damage to the environment and cultural heritage.

2. The positive or beneficial effects of floods consist of: the large supply of water which leads to the recharging of river courses, surface reservoirs (lakes) and underground aquifers; soil fertilization due to the proliferation of microscopic freshwater algae that fix nitrogen in flooded areas; improving the quality of downstream waters by retaining many pollutants by plants and soils of alluvial plains that are a natural filter.

• Results and discussions

Floods. Case study: Romania 2018

Romania is relatively frequently affected by floods and their negative effects. As a result of the heavy rainfall in February and March and the melting of the snow, several streams and rivers in the country overflowed and flooded dozens of hectares of agricultural land and pastures (Figures 1.a - b). In the summer of 2018, more precisely in late June and early July, due to heavy rainfall, there were floods in many areas of the country, the effects of floods consisting mainly of material destruction, flooding tens of thousands of hectares of agricultural land and pastures, but there were also losses of human lives (Figures 1.c - e).

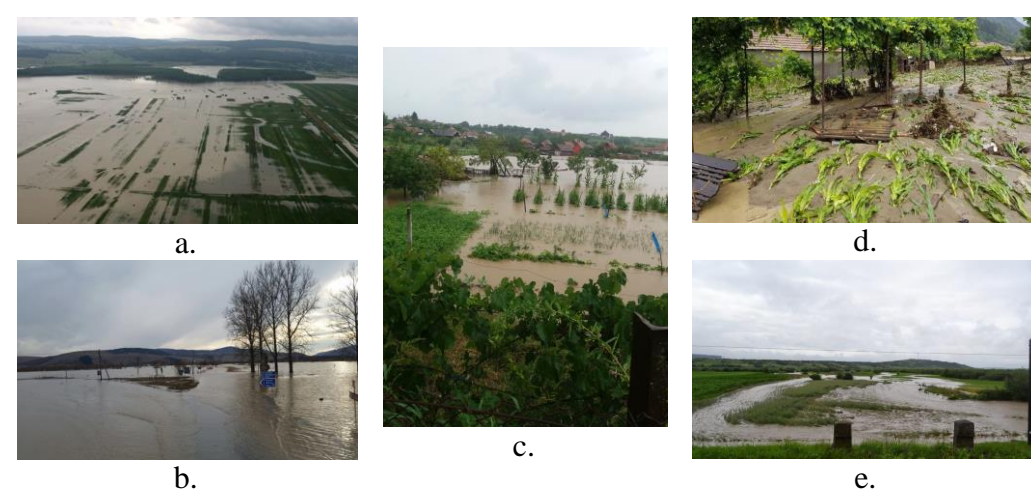


Figure 1. Flooded agricultural lands; a. overflow of the Târnava Mare river; b. overflow of Cormoș stream; c. floods in Bucerdea Granoasa Commune, Alba County; d. individual households and agricultural land affected by floods in Bacău County; e. agricultural land affected by floods in Suceava County.

Identifying the effects of floods on agriculture

As can be seen in Figure 2, the effects of floods can be both positive, leading to an improvement in soil quality and productivity due to the supply of surface and groundwater sources and the intake of organic matter, mineral, and nutrient salts, and negative, these being felt by lower productivity, rising prices, declining producer incomes, lack of food and even hunger, especially in subsistence farmers and affecting the regional economy as a result of worsening soil quality (washing nutrients from the soil, depositing solids on the ground and plants), the inability of the soil to ensure water infiltration, the suffocation of plants etc.

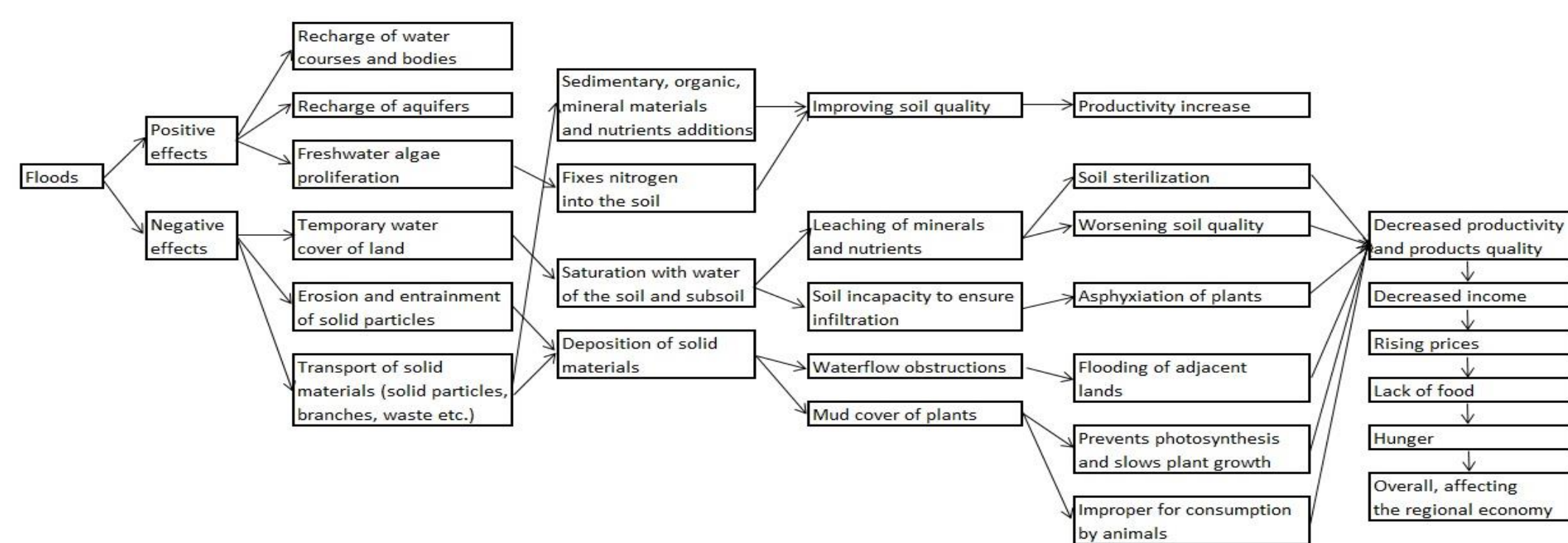


Figure 2. Network for identifying the effects of floods on agricultural productivity

Agricultural productivity at national level

Taking into account the temporal location of floods (February, March, June, July 2018) the assessment of agricultural productivity was based on crops of wheat, rye, oats, rape, corn, autumn potatoes, tomatoes, peppers, white cabbage and grapes. Figure 3 shows the average production (in kilograms/hectares) of the mentioned crops.

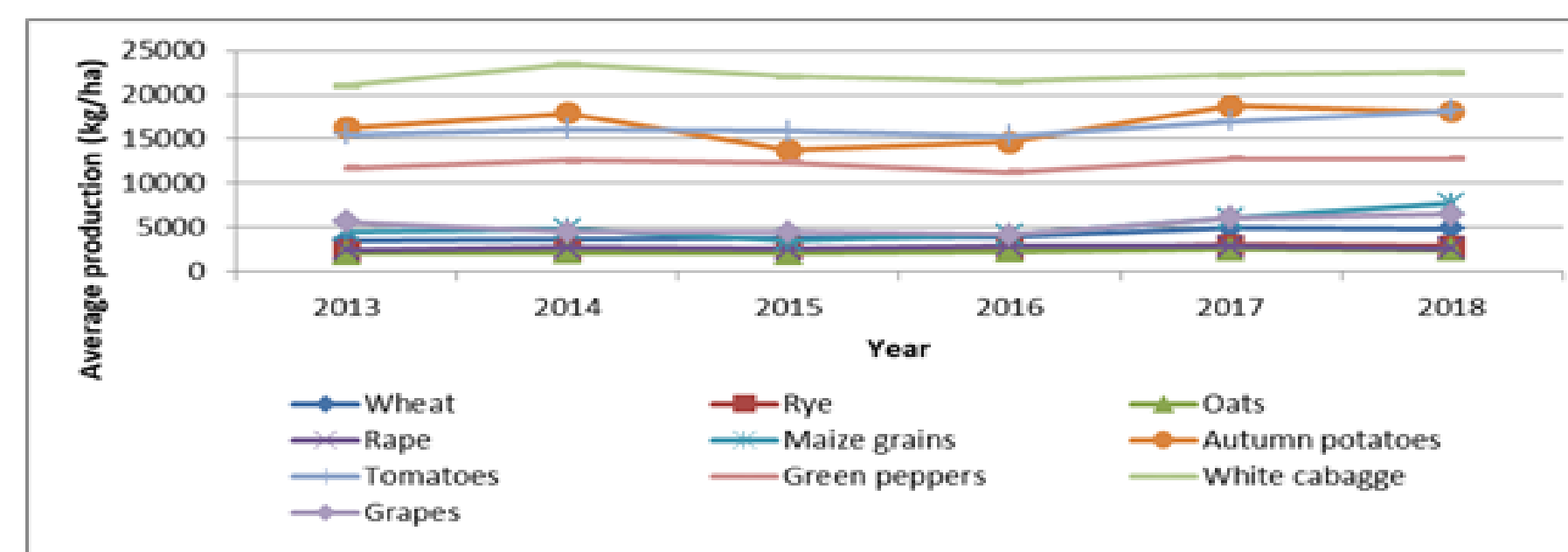


Figure 3. Graph of average agricultural production

The year 2018 is not marked by a worrying decline in production due to floods this year. On the contrary, a worrying decrease can be observed in 2015 due to severe droughts. High temperatures and atmospheric and pedological drought have had a negative effect on the primary agricultural production sector, with many crops being affected by more than 30%. A low production is also observed in 2016, when several dry periods were registered which manifested themselves with different intensities throughout the country.

Considering the available data, their processing was performed in order to compare the average production corresponding to 2018 with the average production of the previous year (2017), respectively with the average production for the 2013 - 2017 period. The results are shown in Table 2.

Table 2. The average production of 2018 compared to the previous year and compared to the average production for the 2013-2017 period

Crops	Average production						
	2013-2017 period	2017	2018	of 2018 compared to the average of the previous 5 years		of 2018 compared to the average of the previous year	
	kg/ha				%	kg/ha	%
Wheat	3934	4888	4793	+859	+21.84	-95	-1.94
Rye	2512.2	2937	2790	+277.8	+11.06	-147	-5.01
Oat	2174.6	2460	2376	+201.4	+9.26	-84	-3.41
Rape	2628.8	2798	2546	-82.8	-3.15	-252	-9.01
Corn grain	4567.6	5959	7644	+3076.4	+67.35	+1685	+28.28
Autumn potatoes	16255	18759	18081	+1826	+11.23	-678	-3.61
Tomatoes	15944.4	16978	18235	+2290.6	+14.37	+1257	+7.40
Green peppers	12097	12759	12775	+678	+5.605	+16	+0.13
White cabbage	22069	22220	22513	+444	+2.012	+293	+1.32
Grapes	4927	6020	6447	+1520	+30.85	+427	+7.09

Compared to the average production of the previous 5 years (2013-2017), the average production of 2018, increased in almost all cases (of 2 to 67%), except for rape, which registered a decrease of 3.15%. Compared to the previous year, the results indicate a decrease in average production in 2018 in the case of cereals, rape, and autumn potatoes (of 2 to 9%), the largest decrease being registered in the case of rape. In the other cases, compared to the previous year, there is an increase in productivity, especially for corn grains (of 28%), tomatoes (of 7%), and grapes (of 7%), possibly due to the 2018's rainfall and floods, which do not seem to have been destructive, but rather were favorable for these crops.

The decrease in productivity registered in 2018 compared to 2017 can be explained by the higher amount of rainfall in 2018 (by 4% compared to 2017) and their regional and temporal distribution. Higher rainfall in early 2018 compared to 2017 (when there were negative deviations in January and March and positive deviations in February of 2%, but insufficient to cover the previous month's deficit and to ensure the following deficit) and the floods produced as a result of these precipitations, can represent the cause of the decrease of the productivity of cereals, rape, and autumn potatoes. Sowing in these crops takes place in autumn (wheat, rye, rape, autumn potatoes) and early spring (oats), and the conditions offered by excessive rainfall seem to have had a negative effect on agricultural productivity. Despite all fears, agricultural productivity at the national level has not been severely affected, but the negative effects of the floods have been felt strongly in subsistence agriculture. Subsistence agriculture is particularly affected because it has lower adaptability. This can increase the risk of hunger, given that their own production is the only food source for some farmers.

Measures to prevent flooding

The following measures are recommended for protection against floods: avoiding the construction of houses and social, cultural and/or economic objects in the potentially floodable areas of the major riverbeds; promoting adequate land use practices; control of the use of minor riverbeds; carrying out works designed to reduce the surface runoff (reforestation or afforestation, construction of torrents retention basins); the geographical delimitation of the natural risk areas for floods; implementation of forecasting, warning, and alarm systems for flood cases; creation and maintenance of existing flood and riverbed protection infrastructures; educating the population about the risk of floods and how to act in emergency situations.

• Conclusions

Floods are normal phenomena, so it is natural for the waters to invade the major riverbeds in periods of heavy rainfall. Special problems arise in situations where anthropogenic objectives (roads, rural and urban agglomerations, industrial objectives) and productive land are located in these areas at risk of flooding.

Floods can have both positive and negative effects on agriculture. The positive effects consist of increased productivity due to the improvement of the soil quality, recharge of the aquifers and surface watercourses and bodies, intake of organic matter, mineral, and nutrient salts. The negative effects determine the decrease of productivity, the increase in the prices of agricultural products, declining producer incomes, lack of food, and even hunger, especially in subsistence farmers. The regional economy can be seriously affected. The negative effects of floods on agriculture result from: worsening soil quality (washing nutrients from the soil, depositing solids on the ground and plants), the inability of the soil to ensure water infiltration, the suffocation of plants etc.

The result of the study showed that floods that occurred in Romania in 2018 did not affect, in a worrying way, the agricultural productivity at the national level (as it happened in the case of the drought of 2015). The average production of 2018:

- increased in almost all cases (of up to 67%), except for rape (registering a decrease of 3.15%), compared to the average production of the 2013-2017 period;
- increased in more than half of the analyzed crops compared to the previous year, possibly due to the climatic conditions which seem to be favorable for this type of crops; high increases (of up to 28%) were registered in the case of corn grains, tomatoes and grapes;
- decreased in the case of cereals, rape, and autumn potatoes (of 2 to 9%; highest decrease was registered in the case of rape), compared to the previous year, as a result of higher amount of rainfall in 2018 (by 4% higher compared to 2017), floods and their regional and temporal distribution.

The climatic conditions of 2018 (excessive rainfall and floods) seem to have had a negative effect on agricultural productivity. However, the negative effects of the floods have been felt strongly in subsistence agriculture as a result of the lower adaptability of the small crops.