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EVOLUTION OF AGRICULTURE IN THE CONTEXT OF CLIMATE CHANGES

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Abstract: The foundation of contemporary society is agriculture, which is a significant part of human civilisation. Reduced arable land, climate change, water scarcity, and widespread population and labour migration from rural to urban areas have all slowed agricultural development rates. Therefore, enhancing agricultural output requires the implementation of novel strategies. Agriculture can play a crucial role in promoting economic growth because of its strong forward and backward links with the secondary (industrial) and tertiary (services) sectors. However, this industry has continued to face a number of difficulties, including rising input costs, climate change, temperature variations, a water deficit, and changes in precipitation patterns. Particularly in the areas of the world with the greatest food insecurity, the escalating effects of climate change could further reduce crop production. The paper presents the evolution of agriculture and the main crops grown at national and European level in the context of climate changes.
Keywords: agriculture, greenhouse gas emissions, population growth, climate change

1. INTRODUCTION

A remarkable worldwide development in agriculture began in the late 20th – early 21st century, with the advent of new irrigation and crop management techniques (1960), the integration of rotary combines allowing crops to be cut and separated in a single pass across the field (1975), the use of satellite technology to monitor crops (1994), the advent of drones, robots that help farmers to manage crops more efficiently (2000), the advent of digital platforms that combine data from farming practices and agronomic models with soil and weather conditions to provide detailed information to users (2010), and the advent of artificial intelligence, digital modelling, etc. (2020) (https://www.bayer.com/en/agriculture/article/technology–agriculture–how–has–technology–changed–farming).

In the European Union, the agricultural sector is made up of 60% arable land, 34% permanent pasture and 6% permanent crops (fruit, citrus, vines, nuts, etc.) (Schrijver R., et al, 2016). In Romania, of the total agricultural area, most hectares are arable (8.3 million ha), grassland and meadows (4.5 million ha), permanent crops (0.3 million ha) and household gardens (0.2 million ha) (Management Authority for PNDR, Socio–Economic Analysis in the Perspective of Rural Development 2014–2020, 2013).

Over the years, agricultural yields have varied from year to year. It is worth noting that worldwide, between 1961 and 1999, there was an increase of 2.1% per year in agricultural production of wheat, rice and maize (Summary report, World agriculture: towards 2015/2030, 2002). In Romania, during the period 1999–2012, unfavourable weather conditions and drought in 2007 had a major impact on crops and, as a result, no major progress was noted in increasing yields of wheat and maize (MARD, Strategy for the development of the agri–food sector in the medium and long term 2020–2030, 2015).

Globally, between 2013–2015, cereal production was ranked 1st with an average of about 300,000 tonnes, beet production 2nd with about 120,000 tonnes, potato production 3rd with about 50,000 tonnes, rapeseed 4th with about 10,000 tonnes and sunflower 5th with about 5,000 tonnes (Anghel M–G., et al, 2017). By 2050, world cereal production is expected to reach 4.3 tonnes/ha (Alexandratos N., el at, 2012). Both in Romania and globally, climate change and population growth are starting to have a negative impact on the agricultural sector and greenhouse gas emissions are expected to increase by a further 4°C by 2060 (Ministry of Environment and Climate Change, Program on climate change and green, low–carbon growth, 2013).

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2. MATERIALS AND METHODS

Climate change and variability are becoming more pronounced in recent times, affecting all sectors, especially the agricultural sector. Lately, there has been a decrease in rainfall, especially in summer, and the most affected plants are annual cereal and grassland crops (http://www.ipcc.ch).

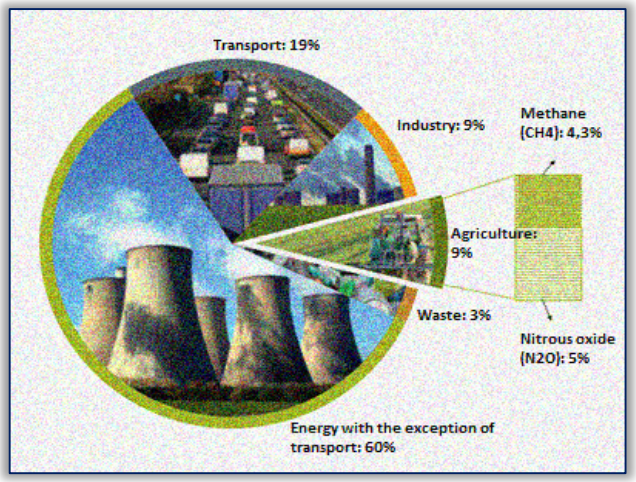

Figure 1 – The EU–27's greenhouse gas emissions distribution (http://publications.europa.eu/resource/cellar/)

Sudden changes in temperature, lack or abundance of rainfall and CO_2 concentration directly influence the life cycle of plants (Gupta A.K., et al, 2020). In addition, climate change can lead to the emergence of diseases, pests and weeds in agricultural crops (Schneider U.A., et al, 2011). Studies predict that droughts will become more frequent and more intense especially in southern Europe, Africa, the Middle East, South Asia, Australia, Southeast Asia, due to large and still growing populations, urban expansion and increasing water requirements (https://en.wikipedia.org/wiki/).

In Romania, of the 14.7 million hectares of agricultural land, about 7 million hectares have been affected by drought for a long time and, in addition, some areas in the south of the country are regularly affected by drought because rainfall is only 4 – 500 l/m² (https://www.voltromania.org/en/agriculture). Greenhouse gas emissions directly affect plant growth, human life and economic development, and global warming has been, and still is, a key issue to be addressed at global, national and local levels (Ministry of Environment and Climate Change, Program on climate change and green, low–carbon growth, 2013). Another factor influencing agriculture is population growth, which will also have consequences for the agricultural sector, as demands for food and water will increase considerably, as well as for energy, space, living conditions, better medical conditions, etc. (https://www.azolifesciences.com/article/The–Impacts–of–a–Growing–Population–on Agriculture.aspx).

It has been found that large population numbers have already begun to have negative impacts on the quantity and quality of natural resources due to over–exploitation, fragmentation of land areas and intensive agriculture. It is projected that about 1.8 to 2.4% of the world's cultivated agricultural area will be lost by 2030 due to urban expansion. In the year 2000, 4% of the total area under maize was on land expected to be urbanised, 9% for rice, 2% for soya and 7% for wheat (d'Amoura C. B., et al, 2017).

At European level, total cereal production in 2021 was 297.5 million tonnes, about 4.2% more than in 2020, but still less than in 2014 when total cereal production was 307.9 million tonnes. Romania made a significant contribution (9.6 million tonnes) to the increase in total cereal production in 2021, followed by France with 10 million tonnes. In contrast, Spain, Hungary and Lithuania recorded significant cereal losses, hence their lower

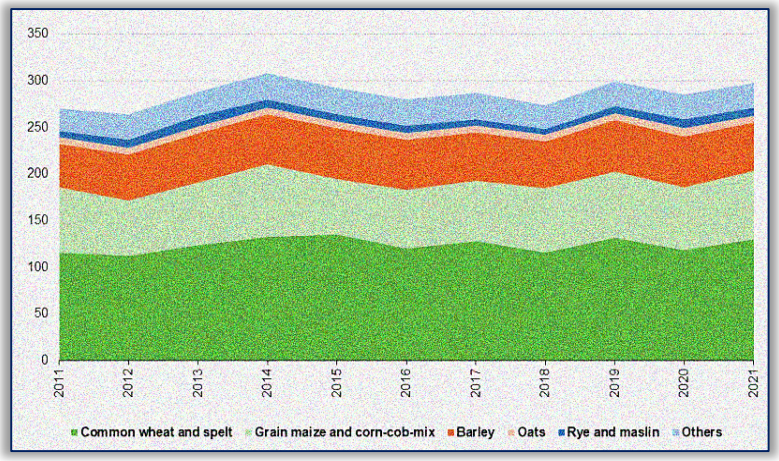

Figure 2 – Cereal production at European level (2011–2021) (https://ec.europa.eu/eurostat/statistics–explained/)

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contribution to total production (6.6% to 18.4% less) (https://ec.europa.eu/eurostat/statistics–explained/).

Since 1960, wheat has been the most cultivated cereal in the world, with its area under cultivation varying between 1961 and 2018 from 33.4% to 29.4%. In the case of maize, there has been an increase in the share of area from 16.4% in 1961 to 26.6% in 2018, compared to barley, millet, oats and rye whose yields have steadily decreased since 1960 (https://olivierfrey.com/agridata).

In 2009, the older EU Member States had lower cereal yields than the other new EU members (Table 1).

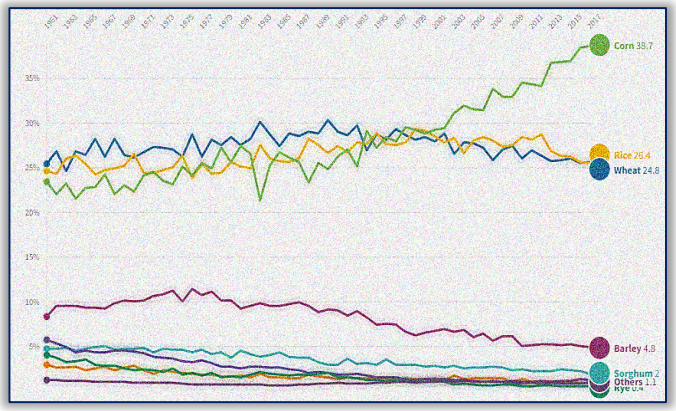

Figure 3 – Various cereal type's share of the world's total cereal area, expressed as a percentage (https://olivierfrey.com/agridata–n2–evolution–of–the–cereal–production–in–the–world/)

Table 1. The percentage of various goods in each EU member state's overall agricultural production (2009, in %) (Tangerman S., et al, 2013)

	Wheat	Sugar beet	Potatoes	Fruit	Vegetable
Belgium	4.2	1.9	4.3	5.4	10.7
Bulgaria	19.7	0	3.1	4.7	6.6
Czech Republic	19.2	2.3	2.6	1.4	1.4
Denmark	11.5	1.3	1.7	0.4	2
Germany	12.1	1.2	3.1	1.1	4.3
Estonia	14.9	0	3.4	1.2	4.6
Ireland	3.1	0	1.6	0.7	4.1
Greece	8.7	0.5	3.5	15.9	19.2
Spain	7.9	0.5	0.9	16.4	17.3
France	13.2	1.4	1.8	4.6	4.9
Italy	7.1	0.3	1.5	11.1	14
Cyprus	1.5	0	5.7	18.7	12
Latvia	20.8	0	6.3	0.5	5
Lithuania	24.7	1.5	3.9	0.5	3.9
Luxemburg	5.3	0	1.6	0.8	1.1
Hungary	23.9	0.4	1.5	5.2	9.3
Malta	0	0	4	5.7	26.9
Netherlands	0.9	1.2	4.6	2.5	7.6
Austria	7.7	1.4	1.1	6.3	3.5
Poland	14.2	2.6	4.4	4.2	8.1
Portugal	2.4	0	1.3	13.6	12.5
Romania	15.9	0.2	8.8	7.1	12.9
Slovenia	5	0	1.8	8.7	5
Slovakia	20.7	1.5	1.5	2.4	6.6
Finland	11.2	0.6	3.2	2.3	8.7
Sweden	10	1.3	4	1	4.1
United Kingdom	12.6	1.3	3.5	3.1	5.7
EU–27	10.5	1	2.7	6.4	8.8
EU–25	10.1	1.1	2.5	6.4	8.7
EU–15	9.2	1	2.3	6.7	8.9

According to Table 1, Lithuania had the highest share of wheat production (24.7%), Poland the highest share of sugar beet production (2.6%), Romania the highest share of potato production (8.8%), Cyprus the highest share of fruit production (18.7%) and Malta the highest share of vegetable production (26.9%).

3. RESULTS

Agriculture is one of the main sectors of activity in Romania, both large and small crops support this sector by the number of cultivated areas and the resulting total yields, thus most of the arable land in Romania is cultivated (https://ascenza.ro/ro/resources/cerealele). The advantage of the cereal crops is that they can also adapt to the low temperatures of the winter season, but in order to obtain the highest total yield, it is necessary to carry out land preparation and maintenance work on the land and the crops; for example, soil is first prepared by weeding, then ploughing, followed by seedbed preparation, sowing, rolling (for certain crops), crop monitoring and the application of phyto–technical measures. The most important cereal crops in Romania are maize, wheat, barley and sunflower (National Phytosanitary Authority, Cereal Information Guide, 2019).

Maize contributes most to total cereal production, being grown on an area of about 49–52% of the total area sown to cereals (Petcu Gh., et al, 2008). The best soils for proper maize growth are loamy and rich in nutrients and water (Petcu Gh., et al, 2008). The first work to prepare the land for cultivation with this plant is ploughing in early spring (https://wikifarmer.com/maize–soil–preparation–soil–requirements–and–seeding–requirements/), followed by seedbed preparation and then sowing (Petcu Gh., et al, 2008). For the healthiest crop, some maintenance work is

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necessary, such as weed control through: crop rotation, preparing an efficient seedbed, improving fertilisation practices or mechanical and manual weeding (Petcu Gh., et al, 2008). The best time to harvest maize is in September (https://playtech.ro/stiri/cand-se-culege-de-fapt-graul-si-porumbul-137784).

Sunflower is one of the most important crops in Romania, the areas that meet the best requirements for the establishment of this crop being the plains, hills and plateaus (Csep N., 2018). Land preparation consists of ploughing immediately after the pre-planting of the land where the sunflower crop is to be established, followed by seedbed cultivation (Petcu Gh., et al, 2008; Samuil C., 2007). Sunflower is a plant that is sensitive to light especially in the first 25–30 days after emergence. In order to avoid weeds, it is recommended to rotate crops on the same area of land, or they can be eliminated by ploughing or herbicides (https://www.agrimedia.ro/articole/lucrarile-de-ingrijire-la-cultura-de-floarea-soarelui). Sunflower is usually drought-tolerant, but the critical periods for water are in July and early August (https://www.agrimedia.ro/articole/lucrarile-de-ingrijire-la-cultura-de-floarea-soarelui). The best time to harvest sunflower crops is between 20 August and 15 September (https://www.botanistii.ro/blog/floarea-soarelui-tehnologia-de-cultura/).

Wheat thrives best on medium, loamy or loamy-clay soils with a pH between 6–7.5 and high permeability (Ion V., 2010). Before growing wheat, weeding must be practised, the plant residues are shredded and mixed with the soil, and the soil surface is shredded (https://www.botanistii.ro/blog/grau-tehnologia-de-cultura/). Ploughing is then carried out, followed by preparation of the seedbed with disc harrows in conjunction with the tine harrow (Petcu Gh., et al, 2008).

In addition to cereal crops, a key category in food consumption is vegetables. Vegetable crops can be grown by direct sowing in the field, by planting seedlings or by planting vegetative parts, and depending on the species and the cultivation system, planting methods can be in the field, greenhouses or solariums. The most important vegetables in Romania are tomatoes, cucumbers, peppers, peas, onions, aubergines, etc.

Table 2. Evolution of areas and yields of the main vegetable species in Romania (https://www.madr.ro/horticultura/fructe–si–legume.html)

Crop	Specification	UM	2015	2016	2017	2018	2019	2020
Tomato	Area	1000 h	44.2	41	40	40.7	40.8	39.4
	Total production	1000 t	701.8	627.1	679.8	742.8	689.4	712.2
Onion	Area	1000 h	31.2	30.3	30	30.2	30.3	30
	Total production	1000 t	360.7	325	325.1	350.1	340.6	326.5
Cabbage	Area	1000 h	48.7	46.2	46.2	47.3	47.1	45
	Total production	1000 t	1078	992.3	1026.5	1065.5	985.8	977.4
Pepper	Area	1000 h	18.4	17.9	17.7	17.9	18.6	17.7
	Total production	1000 t	228.6	201.8	226.4	229.6	223.3	208.2
Other vegetable species	Area	1000 h	99.3	92.7	90.6	90.2	90.9	93.3
	Total production	1000 t	1357.6	1212.1	1353.6	1409.4	1290.5	1277.1

According to Table 2, we can see the period in which the highest vegetable production was recorded and the year in which the largest area of vegetables was cultivated, as follows:

- For tomatoes: The largest area was cultivated in 2015 (44.2 thousand hectares) and the highest total production was obtained in 2018 (742.8 thousand tonnes);
- For onion: The largest area was cultivated in 2015 (31.2 thousand hectares) and the highest total production was obtained in 2015 (360.7 thousand tonnes);
- For cabbage: The largest area was cultivated in 2015 (48.7 thousand hectares) and the highest total production was obtained in 2015 (1078 thousand tonnes);
- For peppers: the largest area was cultivated in 2019 (18.6 thousand hectares) and the highest total production was obtained in 2018 (229.6 thousand tonnes);

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— For other vegetable species: The largest area was cultivated in 2015 (99.3 thousand hectares) and the highest total production was obtained in 2018 (1409.4 thousand tonnes) (https://www.madr.ro/horticultura/fructe–si–legume.html).

4. CONCLUSIONS

Climate change has a major impact on agricultural growth and yields, with sudden changes in temperature, lack or abundance of rainfall and CO_2 concentration directly influencing plant life cycles. On the other hand, if there are no periods of low temperatures and no frost, and if temperatures and rainfall also change, certain types of crops could have longer yields, which would be a good thing on the one hand because farmers can plant long–maturing crops, but on the other hand these changes can be negative for farmers because depending on the type of crop it could require longer periods of irrigation. An opportunity for agricultural growth, productivity and diversification, or for mitigating climate change, could be provided by increasing energy crops on land used for other purposes through agricultural intensification, ultimately leading to higher production yields per unit area.

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