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Professional paper

ADAPTING AGROECOSYSTEMS TO CLIMATE CHANGE TO MAINTAIN SUSTAINABILITY

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ABSTRACT
Changes in agroclimatic indicators present a challenge to maintain the sustainability of agroecosystems. Evidence of the change in climate factors is of great importance to reflect on long-term and environmentally compatible solutions. The study is focused on a multi-year analysis of the main climate indicators, such as temperature and precipitation. Climatic data collected in the district of Korça, Albania, were processed and compared with the relevant data indicators of the previous 30-year periods. The solution to climate change is based on the use of a very high level of biodiversity and changes in the technology of agricultural crops. The correct answers have emerged based on experimental studies for different agricultural crops. Conducting these studies aims that climate change from a problem to turn into an opportunity for increasing the productivity of agricultural crops and sustainable agricultural development in harmony with the environment.

Keywords: agroecosystems, biodiversity, climatic factors, sustainable development.

INTRODUCTION

Traditional agriculture is already under renovation. The farmers are the protagonist of a transition, i.e., the transformation from conventional agriculture and productive to sustainable and eco-compatible agriculture (by the environment). For several decades agriculture main goal was to increase the production level. This challenge of course is overcoming already thanks to the so-called "green revolution". Based on the development in genetic, chemical, biochemical, and mechanic research has achieved an increase in food productivity, but at the same, there is a strong impact on all the elements that compose the ecosystem. In this perspective, the agriculture plants are only one of the parts of the production process chain, that does not take into consideration a rational usage of the natural resources and the protection of the environment. Today is not possible to be reasoned based on such parameters. The agriculture eco-compatible is important for the present and the future. Of course, there is a list of problems that should be resolved including the protection to a large extent the model of the sustainable farm, which is based on a new concept of production.

The large increase in modern agriculture, in many cases, is accompanied by the degradation of the environment (soil erosion, pollution caused by pesticides, salting); social problems (the elimination of the family farms, centralization of the land, resources, and harvests, the increase of the agribusiness that controls the production of the farm, changes in the migration, and reports of population urban/rural and by the excessive usage of the natural resources. Lastly, agriculture is under the increasing pressure of the limitations that come from the increase of petroleum.

Climate change is one of the major concerns for all countries of the world. Their influence is reflected in many sectors, among which agriculture occupies an important place.

Climate changes affect the sustainability of crop production. The producers of crops are burdened with difficulties due to the increase in temperature and fluctuations in the distribution of rainfall. In their scientific work, researchers from other countries, argue that climate indicators are constantly changing. However, these data cannot be used for other agro-climatic zones. Climatic factors affect the development of plants in an integrated way and not separately. In addition, the focus was not only on the separate processing of the indicators of temperature and precipitation but also on the integral indicators.

The study conducted by Peçuli and Kopali shows that the yield of crops varies from year to year. Although the cultivation techniques remain the same. Consequently, this variability derives from the direct or indirect influence of climatic factors and their interactions that do not depend on humans [1,2].

Climate changes affect the entire cycle of plant development [3].

According to various studies conducted by the IPCC, in Southern Europe, where Albania is located, it is forecasted that the occurrence of climate changes will induce increases in temperatures and decreased rainfall [4].

The temperature increase as a result of climate changes has significantly affected the productivity of crops that are cultivated in spring, such as: beans, potatoes, sugar beets, etc, as well as those planted in the fall, such as barley and wheat.

The Mediterranean region (Albania is part of it) has been defined as one of the regions in which will occur important climate changes [5, 6]. Cultivar selection is one of the best ways against the negative of climate change and environmental stresses [7, 8].

Conducting these studies aims to turn climate change from a problem into an opportunity for increasing the productivity of agricultural crops and sustainable agricultural development in harmony with the environment.

Referring to our studies regarding the impact of climate change on different agricultural crops

The most accurate assessment of climate change is the use of scientific methods in the collection and processing of climate data for a particular area. To draw correct conclusions, the comparison of the processed data should include long periods. The use of this practice is necessary to avoid "accidental" change in a short period.

Based on these studies, the plants most stressed by the increase in temperature are the bean and the potato.

The optimal temperatures in flowering and seedling formation are 18-25 ºC. This is the period when beans are quite sensitive to this factor. When the temperatures are around 29-32 ºC accompanied by a lack of ground moisture cause a massive fall of the flowers, and prevents the pollination of the grains. Greater sensitivity to the bean plant is due to the significant temperature shifts [9].

Potato is highly susceptible to high temperatures above 25-30°C. The continuous and long-term action of high temperatures above 30°C at the time of tuber formation especially at night brings the so-called ecological degeneration. As a consequence, there is a decrease in the quantity and quality of production and production capacity of tubers for the next year [10].

The selection of cultivars is one of the best ways of adapting to negative climate changes. Among the best examples in this direction is the alpha cultivar in barley, peas of Voskopoja, etc. [11]. These two cultivars have created the possibility of planting in the autumn (barley and fodder peas are traditionally planted in the spring), influencing in increase the 2-3 times of production.

Another important way is to change the cultivation technology of agricultural crops. The change in planting dates has been quite effective as it affects the modification of the phenological periods of plants by moving them to more suitable periods for the plants.
For the bean, potato, and sugar beet, planted 10 days earlier than the traditional planting dates, it turned out to be quite positive [12].
The objective of the study is to assess the changes in climatic indicators for the region of Korce in Albania, based on scientific parameters. The study aims to provide producers of agricultural crops with clear indications and conclusions on climate changes.
Agroecology is not organic farming, which has some European standards and a regulation that defines it and is subject to labeling under very precise conditions. Agroecology is more about a very different respect for nature than the complementarities that ecosystems have between humans, plants, and animals. The farmer reproduces these complements at the level of cultivated land. Unlike the paradigm of industrial agriculture, which is based on the domestication of nature and the planting of monoculture crops in rows that are light up to be processed by machines, agroecology sees nature as an ally and not as an adversary.
Agroecology involves replacing pesticides with biological control methods, such as interbreeding different types of plants to protect against weeds; replacing chemical nitrogenous fertilizers with green fertility or by planting legumes; or row planting of trees and shrubs that prevent erosion by protecting from the wind and ensuring that rainwater does not run off too quickly, thus allowing the soil to capture moisture. Agroecology also guarantees greater agrobiodiversity and greater resistance to climate shocks, because a large number of different plants are cultivated on a small surface. Resistance is also economical because there is no complete dependence on a monoculture.
Unlike the paradigm of industrial agriculture, agroecology sees nature as an ally rather than an adversary.
But agroecology is not just a series of agronomic techniques; it also involves reshaping the entire food chain and relationships between stakeholders. The fight for agroecology today is not only a fight for agronomic techniques that are more environmentally friendly, but it is also a fight for different production systems and ways to reward producers.

MATERIALS AND METHODS

Materials: In this study are used climatic data, concerning meteorological stations located in the plain area of Korça and Bilisht in Albania related to meteorological indicators (temperature, precipitation, relative humidity, wind speed and direction, solar radiation). Korça lies at an altitude of 850 m above sea level and is characterized by a Mediterranean mountainous and partly continental climate, with cold winters and hot and dry summers. The average annual temperature reaches up to 10.6 ºC. January is the coldest month, while August is the hottest. November is the wettest month with an average rainfall of 104 millimeters, while the average annual rainfall reaches 720 millimeters.
For this reason, in our study, have been collected and processed, data on agroclimatic indicators of 120 years (1901 - 2020). The data are grouped then into 30-year periods: 1901 – 1930, 1931 – 1960, 1961 – 1990 and 1991 – 2020.
In the study, we reflect more detailed data for a shorter period 2018 – 2021 because in this period we have set up some experiments related to the impact of climate change as well as finding the most appropriate solutions to respond to these changes in some agricultural plants such as barley, corn, fodder peas, potatoes, small grain beans, sugar beet, etc.

Map of Albania **Map of *County* of *Korçë***

Methods

The data are obtained from different sources, such as:

- ✓ Hydro meteorological Institute - Academy of Sciences. Climate of Albania, Volumes I and II (data for the corresponding years 1931-1960 and 1961 - 1990)
- ✓ Institute of Geosciences (data for the corresponding years 1991-2021)
- ✓ Monthly climate bulletins, Institute of Geosciences publications [20] (data for the corresponding years 2018 - 2021)

The data observed for the respective time periods are processed, and obtained different values of climate variables:

- ✓ Records on average, maximum and minimum monthly and annual temperatures;
- ✓ Records on monthly and annual rainfall;
- ✓ Daily and monthly records average, maximum, and absolute minimum temperatures;
- ✓ Monthly recorded values on the number of days with relative humidity equal to or lower than 50 %;
- ✓ Monthly data of the number of days with a relative humidity greater than or equal to 80%

(≥ 80 %) for 14 hours;

RESULTS AND DISCUSSION

Results: From the data processed, were determined the climatic features of the field plain of Korçë and Bilisht, based on the four analyzed variables: average rainfall (mm); average annual temperature (ºC); average number of days with relative humidity ≥ 80 % annually, and average number of days with relative humidity ≤ 50 % per 14 hours. The obtained results have been processed and compared with the data of the study conducted in 2013, in order to compare the pace with which these changes are occurring in recent years [14].

Months	Minimum average atmosphere temperature (°C)		Maximum average atmosphere temperature (°C)		Average atmosphere temperature (°C)		
	2018-2021	1961-90	2018-2021	1960-90	2018-2021	1931-1960	1961-1990
January	-3.3	-3.8	5.6	3.8	1.1	0.5	0
February	-1.2	-2.2	8.7	5.4	3.8	1.8	1.6
March	1.6	- 0.2	12.1	9.8	6.6	4.9	4.8
April	4	4.4	17.1	14.4	10.6	9.7	9.4
May	9.2	8.1	21	19.7	15.3	14	14.5
June	13	11.4	25.4	23.6	19.2	17.8	17.5
July	15.1	12.8	28.2	26.2	21.6	20.5	19.5
August	15.3	12.6	27.7	25.6	21.5	20.8	19.1
September	11.8	9.8	25	22.6	18.4	17.3	16.2
October	8.2	5.5	19.7	17.1	13.9	11.5	11.3
November	3.6	1.9	13.2	10.7	8.4	7.2	6.3
December	-0.3	-2	8	5.8	4	2.8	1.9
Average	6.5	4.9	17.5	15.4	12	10.7	10.2

Table 1. Records of monthly and annual temperatures for the corresponding years

After processing the data on the average, were analyzed the maximum, and minimum of monthly and annual temperatures, and the differences between them.

Month	Precipitation mm						
	2018	2019	2020	2021	Average 2018-21	Average 1961-90	Average 1931-1960
January	52	145	15	172	96	47	70
February	47	12	45	87	48	54	68
March	123	12	115	52	76	46	53
April	12	55	54	53	43	48	54
May	128	82	41	18	67	62	58
June	145	65	41	85	84	45	42
July	25	74	38	32	42	32	21
August	160	21	112	22	79	23	25
September	8	17	32	35	23	38	44
October	12	25	56	67	38	76	85
November	156	184	12	52	101	105	112
December	42	74	71	65	63	75	89
Total	910	766	632	740	760	651	721

Table 2. Average precipitation for the corresponding years in the Korça region. *[Meteorological Bulletins published by the Institute of Geosciences, Energy, Water and Environment, related to monthly and annual amount of rainfall in the Korça region.]*

The data shows that the climate is becoming drier and warmer.
From the records presented on Table 3, it is observed that compared to multi-years data, the highest amount of precipitation (910 mm) recorded in 2018, and minimum (632 mm) recorded on 2020, are closer to the probability of coincidence with 75%.

Discussion

From the data presented an increase in the average air temperatures was observed. The average annual temperature of Korçë 1991-2021 compared to the years 1961-1990 has increased by 0.74 °C.
For the corresponding period 2018 – 2021, the average minimum atmosphere temperatures was increased by 1.6 °C, average maximum temperature was increased by 2.1 °C, while the average temperature show ed an increase by 1.8 °C.

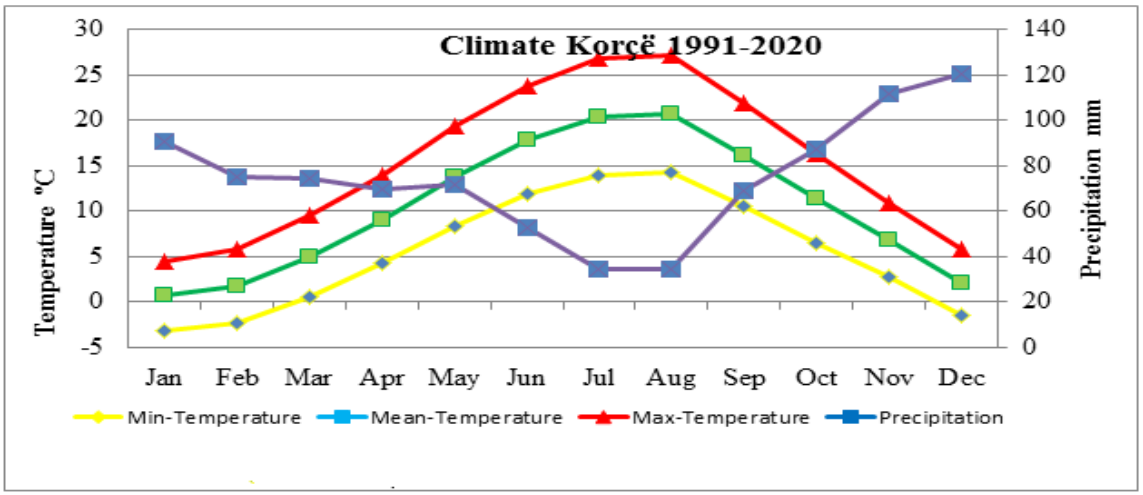

Figure 1. Climate graph, Korçë 1991-2020

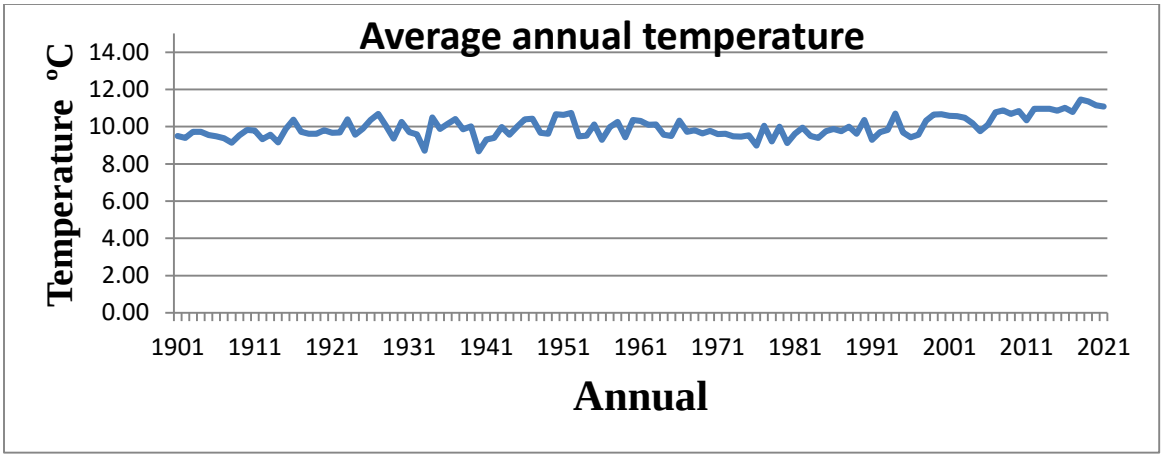

Figure 2. Average annual temperature Korçë 1901-2021

There are also significant changes in monthly precipitation for this period. The data observed indicate a trend of increased temperatures throughout the year, while it is difficult to conclude the same for the amount of precipitation. From the study of these diagrams, we conclude that climatic factors affect the development of plants not separately but integrated.

CONCLUSIONS

In the agro-climatic context, for the period 2018 – 2021, drought started from the first 10 days of June and continued until the 20th of October. Based on that, it is concluded that there is a one-month extension of the drought period. For the same period, significant changes in the monthly precipitation have occurred. It is a trend of increased temperatures throughout the year, while it is difficult to conclude the same for the amount of precipitation. In the last decade, the average number of days with snow in Korçë Plain has been reduced by about 10 days. The average start date of snow has been postponed for about a month.

The selection of cultivars is one of the best ways of adapting to negative climate changes. Among the best examples in this direction is the alpha cultivar in barley, peas of Voskopoja, etc. These two cultivars have created the possibility of planting in the autumn (barley and fodder peas are traditionally planted in the spring), influencing an increase the 2-3 times in production.
Another important way is to change the cultivation technology of crops. The change in planting dates has been quite effective as it affects the modification of the phenological periods of plants by moving them to more suitable periods for the plants.
For the bean, potato, and sugar beet, planted 10 days earlier than the traditional planting dates, it turned out to be quite positive.
For wheat and barley, the optimal sowing period has been extended by 10 days. The optimal planting period, today is recommended from October 1 to November 10.
The increase in temperatures has had a positive impact on maize productivity. In recent years, is being used the 600 class of corn hybrids (with a cycle of 121-130 days of germination - full ripening)

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