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Climate Change and its Consequences for the Countries of the Danube Region

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Abstract: Climate change is not globally evenly and affects some regions more than others. Climate change over the past 20 years has affected the environment. The consequences of climate change for tourism in the countries of the Danube region are inevitable. The region will face consequences. There will be gradual changes. In the future, the countries of the Danube region will be forced to make more use of the non-main tourist season. The southern regions have already faced a significant drop in tourist demand. The article considers the main causes of climate change and environmental degradation in the region under consideration (rivers dry up and become shallow, the Dniester dries up, soils turn from chernozems into a desert). As a result, we meet the deterioration of the harvest, grain and bread prices have already increased this summer. The most likely prospects and activities in the countries of the Danube region to improve the situation are considered.

Keywords: climate change; Danube region; desertification of soils; drought; drying up of rivers; falling tourist demand

1. Introduction

Over the past three decades, the climate of the countries of the Danube region, including Ukraine, has changed dramatically. Abnormally high temperatures, prolonged heat, droughts, forest fires, devastating downpours, floods and other extreme weather events have become commonplace.

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2. Objectives

The aim of the article is to consider the current situation with climate change in the region, and prospects for the next 30-40 years, as well as to propose options to mitigate the effects of global warming.

The study of climate change and its effects on some regions in the Danube region is described in the works of such scientists, researchers and experts as B. Hamududu, A. Killingtveit, J. E. Neumann, W. R. Sutton, J. P. Srivastava and others. Despite a number of the works in this area, there is still a need for further research in the climate change and its consequences for the countries of the Danube region.

3. Climate Zones and Their Transformation in Global Warming

Since the purpose of this article is to consider the issue from the point of view of the impact of climate change on the countries of the Danube region, we shall highlight the main climatic zones and climate features in such countries of the Danube region as Ukraine, Romania, Bulgaria, Serbia, Slovakia.

1) Ukraine. It has a temperate continental climate with cold winters and warm summers. Winters are cold with frequent snowfall, temperatures can drop to -20°C . Summers are warm and sunny, the average temperature in July is about $+25^{\circ} / +35^{\circ}\text{C}$. Differences in climate between the west (closer to the Carpathians) and the east (closer to the Black Sea).

2) Romania. The predominantly continental climate with some subtropical manifestations on the Black Sea coast. Winters are cool, there is less precipitation than in summer, and the temperature in January is about 0°C . Summers are hot, the average temperature in July is about $+23^{\circ} / +32^{\circ}\text{C}$. The Carpathian Mountains affect the climate of the western part of the country, making it wetter and cooler.

Both countries, Ukraine and Romania, have a variety of climatic zones and subzones, due to their geographical location and topography.

3) Bulgaria. Located in the south of the Danube River, the country has a Mediterranean climate with mild winters and hot summers.

4) Serbia is also located in the south of the Danube River; the country has a continental climate with cold winters and hot summers.

5) Croatia has a Mediterranean climate on the Adriatic coast and a continental climate in the interior.

6) Slovakia is a country with a continental climate, with cold winters and warm summers.

Thus, on the territory of the countries of the Danube region and Ukraine in particular, a continental, temperate continental climate and a subtropical, Mediterranean type prevail. But it is possible that by the end of the century the maps of climatic zones in textbooks will have to be updated.

According to scientists' research, even with an increase in world temperature by 2° C, about 5% of the Earth's land will be in a new climate zone. But at higher rates of warming, this fate may threaten as much as a fifth of the planet. This is primarily relevant to the countries of the Danube region.

Not so long ago, researchers at the Swiss Higher Technical School of Zurich published a paper on climate change, which the major cities of the world will survive by the middle of this century. According to this map, the countries of the Danube region will be in the zone of influence of a semi-arid climate by 2100. For understanding, it should be pointed out that at the moment a temperate and subtropical climate prevails in these territories (Hamududu & Killingtveit, 2012).

4. Features of the Semi-arid Climate

A semi-arid climate is a type of climate characterized by very low rainfall, which leads to the development of semi-desert vegetation and sparse vegetation. Temperature fluctuations during the day are quite high due to the lack of clouds, which leads to sharp temperature fluctuations between day and night.

In the countries of the Danube region, such as Romania, Bulgaria, Serbia, Slovakia, Croatia, and Ukraine, the climate will become increasingly dry and semi-arid. An increase in temperatures and changes in precipitation will lead to soil degradation, droughts, a decrease in water reserves in soils and groundwater, as well as a decrease in land fertility.

In the future, the semi-arid climate may become even more extreme, which will lead to an increase in the frequency and intensity of droughts, floods, forest fires and other natural disasters. This can greatly affect agriculture, the economy and the quality of life of the population in the region.

The impact of climate change is already clearly recorded in the countries studied. And that's how this global warming is affecting the ecological system of many countries, including Ukraine and Romania. Let's consider some specific examples of this influence:

1) River shallowing. As a result of climate change, including global warming, there is a decrease in water levels in many rivers. For example, in Ukraine, the Dniester River faced the problem of shallowing due to lack of precipitation and increased evaporation. This can lead to deterioration of water resources for use in agriculture and industry. In the last decade, during the summer season, environmentalists have also recorded a sharp shallowing of the main artery of the Danube river countries in the summer. Up to the point that navigation was suspended in some parts of the Danube in the summer.

The same process of shallowing occurs with numerous lakes in these countries. Ukraine: one of the most famous lakes located near the Danube River is Yalpug Lake in the Odessa region. It is a popular holiday destination and an ecologically clean body of water. Warming can lead to changes in the ecological balance of the lake, including an increase in aquatic plants and algae.

In Romania, one of the most famous lakes located near the Danube River is Lake Sinoe in the Danube-Black Sea region. It is a nature reserve and an important place for protected fish and bird species. Warming can lead to changes in the biodiversity of the lake and its ecosystem.

In Bulgaria, a famous lake located by the Danube River in Bulgaria is Lake Sreberna. This lake is known for its unique natural heritage, including protected species of fish and birds. Warming can have an impact not only on the shallowing of lakes, but also on the biodiversity of the lake and increase the risk of extinction of some species.

2) Soil degradation. Global warming also affects soil conditions. Romania has problems with soil erosion, especially in arid areas, deterioration of soil composition and quality, which can negatively affect agriculture and the country's economy.

3) Ecosystem change. Climate change leads to shifts in ecosystems. For example, in Ukraine, there is a change in vegetation cover as a result of global warming, which can lead to a decrease in biodiversity and threats to local plant and animal species.

One of the striking examples of changes in vegetation cover in Ukraine as a result of global warming can be given by the example of wheat culture. In a changing climate, wheat yields are gradually decreasing due to high temperatures and dry soil. At the

same time, against this background, there is an increase in the number of pests. All this, in the long term, can lead to lower yields, higher prices for wheat products and a threat to food security.

There is also an increase in temperatures and a decrease in precipitation in a number of regions of Ukraine, which contributes to a change in the composition of vegetation cover. At the same time, some crops, such as corn, may become more popular due to their ability to tolerate heat better. However, some other local plant species that cannot adapt to changing conditions are destined for extinction.

As for the animal world, a number of bird species inhabiting Ukraine, for example, will disappear due to changes in inhabitants and deterioration of conditions for them. Some insect species, such as bees, may also be at risk due to climate change and loss of food sources.

Climate warming may affect the bee population in the southern regions of Ukraine. Firstly, due to changing climatic conditions, the flowering times of plants may change, which may lead to a decrease in the availability of nectar and pollen for bees. This, in turn, can negatively affect the productivity of bee colonies and the yield of crops pollinated by bees.

In addition, droughts, floods, and strong winds can also negatively affect bee populations and their ability to survive and reproduce.

However, at the same time, some plant species can adapt to changing climatic conditions and begin to bloom sooner or later, which can create additional food sources for bees. In general, changes in vegetation cover in Ukraine as a result of global warming may lead to a decrease in biodiversity and threats to local plant and animal species, as well as economic and social problems for the population.

The ongoing processes can hurt flora and fauna. In a pessimistic scenario, the countries of the Danube region: Ukraine, Romania, Bulgaria and other countries have every chance of turning from countries with good soils and a high level of agricultural exports into a man-made desert.

For example, the degradation of natural landscapes is already being observed in Ukraine. And without them, there can be no great biodiversity. In particular, pollinating insects suffer. Losing their natural habitat, they give way to domestic bees, “which are not able to effectively pollinate all crops, especially wild plants”. And this is just one of the links in a long chain.

Currently, about 30 species of bees and bumblebees, up to 60 species of butterflies, which are the main pollinators of wild and cultivated plants, are listed in the Red Book of Ukraine. It should be understood that pollinators disappear in the process of warming. After them, rare plants disappear, and this leads to the impoverishment of the landscape. It looks like a rolling snowball that sweeps away biodiversity in its path and leads us to a place from which there will be no return – to monocultures of several cultivated plant species and several thousand synatropic (not domesticated, but related to humans) species of animals and plants.

These examples show that global warming processes have a tangible impact on the natural resources and ecological system of Ukraine and Romania and other Danube countries. It is important to take measures to mitigate these negative effects and protect the environment.

According to the estimates of the Ukrainian Ministry of Natural Resources, in the next 30-40 years, Ukraine is threatened by desertification and drought. Similar prospects apply to other countries of the Danube region.

The intensity of agriculture has a significant impact on the well-being of residents of the Danube countries of Ukraine, Romania, and Bulgaria, since huge territories here are occupied by fertile soils. For example, Ukraine ranks ninth in terms of arable land area. This is 33 million hectares, of which 60% is chernozem. But the share of ploughed land is the highest in the world – it is 54%, that is, half is ploughed. It doesn't seem to be a problem, but due to careless handling of the land, in particular, depletion of crops such as sunflower, soy, rapeseed, which take away nutrients, first of all, the humus content decreases. Improper farming also leads to wind erosion due to the increase in such phenomena as dust storms. Experts say that 20 million hectares in Ukraine are already covered by dust storms. This indicates a trend towards desertification of large areas in the south of the country (Sutton, Srivastava & Neumann, 2013).

This is one of the possible scenarios, but there are others. For example, a few years ago, researchers from the Ukrainian Hydrometeorological Institute developed their own forecasts of climate change in the country until the end of the century.

It is assumed that by the end of the century, winters and springs here will become snowier and rainier, whereas in summer, on the contrary, precipitation will decrease, and these territories will become more arid.

If the temperature continues to rise, then the difference in warming will be felt not only by ecology, flora and fauna, but also by people themselves. Along with climate

change, heat waves, droughts and fire threats are coming to us, which are now happening more often. According to the journal *Nature*, in 2022, more than 60 thousand people died due to extreme heat in Europe.

For many countries, the difference of half a degree is a matter of survival. When it becomes impossible to live there due to the lack of water and the inability to grow food, mass human migration to more livable regions will begin. A new concept of “climate refugees” will arise.

And of course, the ongoing processes also affect the tourism sector of the economy. Global warming has a significant impact on the tourism sector in the countries of the Danube region. Since climate change leads to an increase in extreme weather conditions, this can negatively affect the infrastructure of tourist facilities and lead to a decrease in comfort for vacationers.

The seasonality of tourism is also changing. For example, more and more tourists prefer to spend their holidays not in the summer, but in autumn and spring, when the temperature regime is more favorable for humans.

Some regions may become less attractive to tourists due to increased temperatures and periods of drought, while other regions, on the contrary, may become more popular due to improved climatic conditions.

Some countries may face a decrease in the number of tourists due to adverse weather conditions, while other countries may attract more tourists due to an improved climate.

In general, global warming has a complex and multifaceted effect on tourism in the countries of the Danube region, and requires an integrated approach to the problem of adapting the tourism industry to changing climatic conditions.

5. Is There a Way Out? Measures to Adapt to the New Realities of Warming

In order to resist changes, it is necessary to use adaptation mechanisms to reduce climate risks, as well as take measures to reduce greenhouse gas emissions and negative environmental impacts. It is also important to strive to preserve biodiversity, use natural resources wisely, and switch to renewable energy sources. To overcome the negative effects of the semi-arid climate, it is necessary to take measures to adapt to changed conditions, such as the introduction of sustainable

farming methods, rational use of water resources, protection of forests and soils from degradation, as well as measures to reduce greenhouse gas emissions to combat global warming.

The good news is that, in fact, humanity is already developing solutions, technologies and practices that can mitigate the effects of climate change and save resources.

In order to confront the new realities in the form of significant warming in the countries of the Danube region in the coming decades, it is necessary to take a whole range of measures. Some of them may be as follows:

1) The introduction of new crops and technologies in agriculture that can withstand high temperatures and periods of drought. This may include the selection of crops adapted to changing climatic conditions, as well as the use of ecological farming methods to preserve soil fertility. One of the positive examples is the experience of Ukraine in growing cotton crops that are not typical for this area. In Ukraine, due to climate change, cotton production has become more relevant. Ukrainian farmers have begun to develop cotton cultivation actively, especially in the south of the country, where the climate is more favorable for its cultivation.

One of the ways that is used to grow cotton in Ukraine is the use of modern technologies and plant varieties that are more resistant to climate change and diseases. Irrigation and fertilization methods are also used to provide cotton with optimal conditions for growth.

The prospects for cotton cultivation in Ukraine are very encouraging. This culture is in demand on the market and has good prospects for development. Ukraine has the potential to increase cotton production and expand its exports.

At the same time, it is important to consider not only the possibilities of production growth, but also the environmental aspects of cotton cultivation, such as the use of fertilizers and pesticides. It is important to use sustainable methods and technologies to minimize the impact on the environment.

2) Implementation of measures to reduce the greenhouse effect, such as reducing greenhouse gas emissions by switching to renewable energy sources, improving energy efficiency and reducing dependence on fossil fuels.

3) Development of infrastructure to increase the availability and efficiency of water resources, such as the construction of irrigation systems, dams and ponds for water

storage, as well as the introduction of technologies for efficient use of water in agriculture and industry.

4) Managing urban population growth by creating sustainable urban spaces, developing public transport, reducing vehicle emissions and creating conditions for sustainable urban development.

5) Cooperation and exchange of experience with other countries and regions, active participation in international initiatives and agreements on climate change.

A way out of these global warming problems is possible only through an integrated approach that includes the joint efforts of States, public organizations, the private sector and the public. It is also important to consider the specifics of each country when developing and implementing measures, as well as strive for sustainable development, balanced use of resources and conservation of the natural environment.

These include sustainable agriculture: smart irrigation systems, the use of cover crops to protect against soil erosion, minimal tillage, permaculture, abandonment of chemical fertilizers and chemical protection products.

The introduction of highly efficient water conservation technologies will help to manage water resources in regions where irrigation is needed, as well as consider the amount of available resources.

Since most greenhouse gas emissions occur in cities, the way out of the warming situation may be the creation of green areas and reservoirs, urban gardening, new technological and engineering solutions such as sustainable drainage systems.

A reasonable addition to the above solutions would be to change our diet. The food industry produces 30% of greenhouse gas emissions. In many countries, there is a problem of overconsumption of products with a large carbon footprint.

It is reasonable to assume that in order to reduce this anthropogenic warming factor, people should adhere to a healthy, balanced diet and reasonably reduce their consumption of meat and dairy products, which will help to reduce pressure on nature. A healthy full-fledged diet is good for both nature and people.

Thus, global warming is a real danger and challenge for all mankind. And only together, through joint efforts, Ukraine and other countries of the Danube region can cope with this challenge.

6. Conclusion

Thus, summing up the results of the research, we can propose prospects and activities in the countries of the Danube region to improve the situation: the introduction of new crops and technologies in agriculture, the introduction of highly efficient water conservation technologies, cooperation and exchange of experience with other countries and regions and many other methods and technologies to minimize the impact on the environment.

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