CLIMATE CHANGE EFFECTS AND RISK MONITORING IN ROMANIA

VASS HUNOR[1*], ȘONCA BOGDAN[1], MĂNESCU CAMELIA[1], SICOE-MURG OANA[1], ȘUSTER GABRIEL[1], MATEOC TEODOR[1], MATEOC-SÎRB NICOLETA[1]
[1]Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara, Faculty of Management and Rural Tourism
*Corresponding author's e-mail: hunor.vass@usab-tm.ro

Abstract: *Climate change has been observed in Europe in the form of higher temperatures, changing rainfall and runoff patterns, and extreme weather events, leading to reports of an increased incidence of weather-related disasters - such as floods, droughts, wildfires, windstorms and heat or cold waves - in many countries in the region. Romania is exposed to several natural climatic and geological hazards: floods, landslides, storms, droughts, extreme temperatures and earthquakes. The country has experienced some devastating earthquakes and floods over the years, which have caused numerous human and economic losses. The authors of the article have analysed various official sources on climate change and the risks involved and came to several conclusions. Educating the general public on the meaning of colour-coded early warning notices and emergency instructions will save lives.*

Key words*: climate change, effects, Romania*

INTRODUCTION

Romania is exposed to several natural climatic and geological hazards: floods, landslides, storms, droughts, extreme temperatures and earthquakes. The country has experienced some devastating earthquakes and floods over the years, which have caused numerous human and economic losses [5].

Romania ranks as one of the most seismically dynamic nations in Europe and therefore a nation at high risk of quakes. Following the 1977 disaster, the damage was calculated at USD 2.05 billion. Two-thirds of the overall losses were recorded in Bucharest, where more than 1400 people were killed and 32 blocks of steel-reinforced cement had collapsed. The immediate direct damage and collateral aftermath of 1977 may have marked the turning of Romania's decade-long economic downturn [2].

The quakes are triggered due to the stress released by the forces of plate tectonics or man-made activities such as reservoir creation, underground drilling, extraction or the injection of fluids into subsurface features. No evidence exists that seismic hazards are directly linked to climate change [7]. However, climate change may affect seismicity by changing reservoir levels or groundwater use. As this study focuses on hazards clearly and linked to climate change, earthquakes will not be considered in this report [1, 4].

Climate change has been observed in Europe in the form of higher temperatures, changing rainfall and runoff patterns, and extreme weather events, leading to reports of an increased incidence of weather-related disasters - such as floods, droughts, wildfires, windstorms and heat or cold waves - in many countries in the region. In this report, we will focus on floods, given their relevance to the country and the availability of data and risk models, but droughts and vegetation fires will also be covered. Windstorms and even tornadoes have started to occur in Romania, but their frequency is very low, so they do not currently warrant an in-depth risk assessment [6].

MATERIALS AND METHODS

The research methodology included thorough scientific documentation, which started with informing sources, data collection, and analysis of official sources and websites.

RESEARCH RESULTS

1. Climate change Effects

In our country, the effect of the changing climate is already being felt, with the warmest year in two decades (11.5°C on average) in 2007, compared to the coldest average of 8.4°C in 1985. In Romania, in 2005, historic floods claimed 76 lives and caused significant material damage, and the worst drought in 60 last years took place in 2007 [9]. The consequences of such severe meteorological phenomena impacted the country through considerable financial losses in the agricultural, water management, power supply and transportation sectors. In the event of global warming of 4°C, the results of global climatic changes will surely worsen the situation in Romania [3].

Over the last 100 years, Romania has experienced a rise in temperature accompanied by a decrease in precipitation. Romania has a transitional temperate-continental climate and the average temperature in the Danube Delta region, for example, is 10-12 °C [14]. The average annual air temperature increased by 0.8 °C over the period 1901-to 2012. As for precipitation, analysis of the data recorded over the same period revealed a decrease in the annual amount of precipitation (23.6 mm). Figure 1 below shows the changes [8].

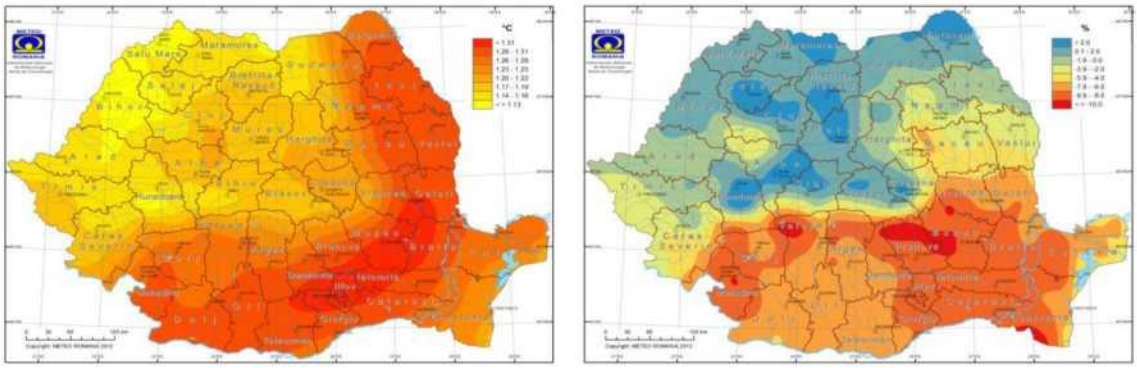

Figure 1. Multi-year average changes (2011-2040)compared to 1916-1990): air temperature (in °C on the left) and precipitation (in % on the right).

Source: https://www.fonduri-ue.ro, 2022 [10]

We anticipate that the same trends will continue and accelerate into the 21st century. In the long term, the average temperature increase for Romania is expected to be about 3°C-4°C for the summer months in the range 2061-2090, compared to the range 1961-1990 [13]. In terms of precipitation, the annual amount of precipitation is expected to decrease in the summer months, more pronounced for the higher carbon scenarios and stronger towards the end of the 21st century. More intense and localised precipitation events are likely, although rainfall patterns could also become more erratic and more difficult to forecast [15].

2. Floods

Romania is known as one of the most flood-prone countries in Europe. The country was the hardest hit in Europe between 2002 and 2013 in terms of the number of flood deaths - 183. Historic floods killed 1,000 people in 1926; 215 people in 1970; 60 people in 1975; 108 people in 1991; and 33 people in 1995.

Heavy rains in April and May 2005 caused the worst flooding in Romania in 50 years, causing at least €1.66 billion in damage. This represents 2.1% of Romania's GNP.

The floods also affected some 656,392 ha of agricultural land, 10,420 km of roads, 23.8 km of railways, 9,113 bridges and footbridges and contaminated 90,394 wells.

In 2006, extreme floods in April-August were among the most devastating natural disasters in Romania's recent climate history. Estimates show that 12 counties were affected between April and May, with total economic damage exceeding 1% of Romania's GNP.

The number of affected localities was 160; the estimated number of affected households was 10,000. About 600 km of roads and 300 bridges were damaged and a total of 21,000 ha of agricultural land was affected.

Most recently, at the end of June 2010, the floods were the result of an extreme weather event that hit Romania. At least 21 people died and economic losses were around 0.6% of GDP.

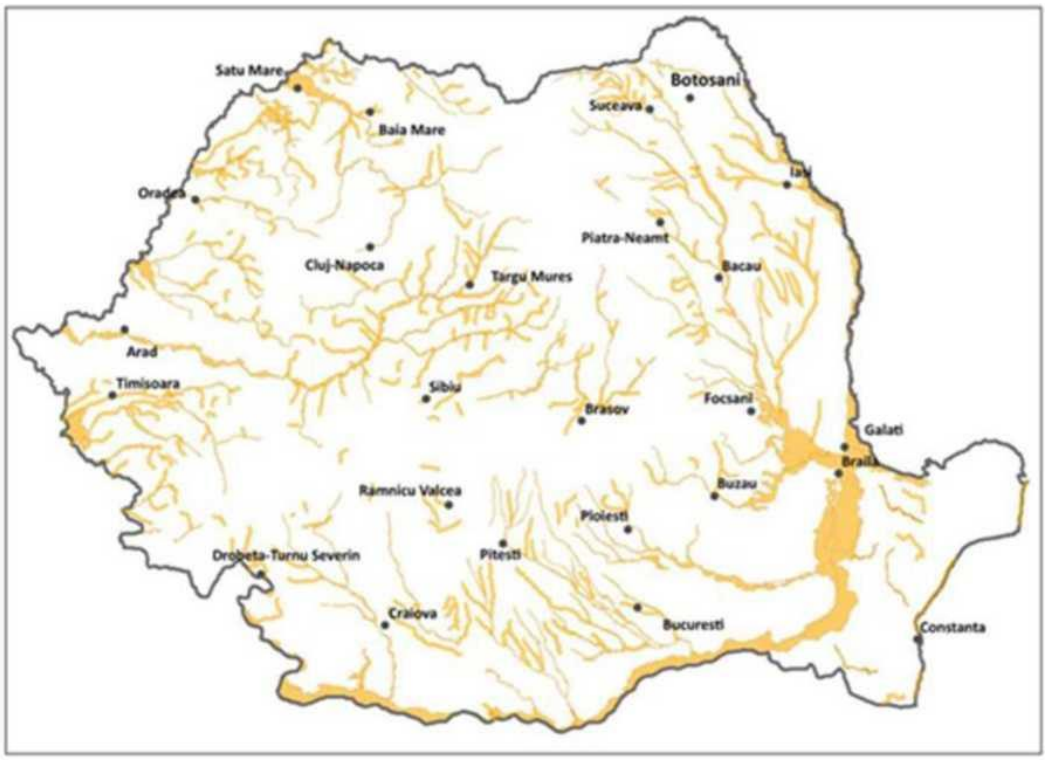

Figure 2. Flood risk areas in Romania

Source: ANAR, 2022 [11]

Figure 2 provides an overview of flood risk areas in Romania. In general, water-related hazards such as floods caused by prolonged and/or intense rainfall are starting to occur more frequently. The increased frequency of rainfall extremes is in line with anticipated human-induced changes in climate. Floods that have occurred in the last decade have been of comparable intensities to those recorded in the last few hundred years and have occurred only a few years apart. Moreover, the increased frequency of localised high-intensity rainfall has generated several flash floods that have affected localities and caused concentrated damage. These localised processes are difficult to predict and their damage is usually recorded together with that of more widespread regional flooding. Figure 3 shows the spatial distribution of historical average yearly losses from regional floods and flash floods.

Rising Black Sea levels due to Climate Change are a matter of serious worry. The observed impacts of climate change in Europe are a general increase in global sea levels in the majority of low-lying coasts; alterations in the freshwater supply systems, for example,

a decrease in stream flows in the southern and eastern regions and an increase in reported flooding. Romania has estimated that Black Sea levels will rise by 12-25 mm/year, or up to 0.5 m by 2050, under a negative scenario. Our Black Sea is nearly enclosed and has a comparatively poor salt content (12-19 ppt) and tides. However, when added to the increased magnitude and incidence of fast flooding and thunderstorms, there is likely to be an increase in coastal erosion, a loss of freshwater fauna and flora, and significant damage to coastal infrastructure and settlements.

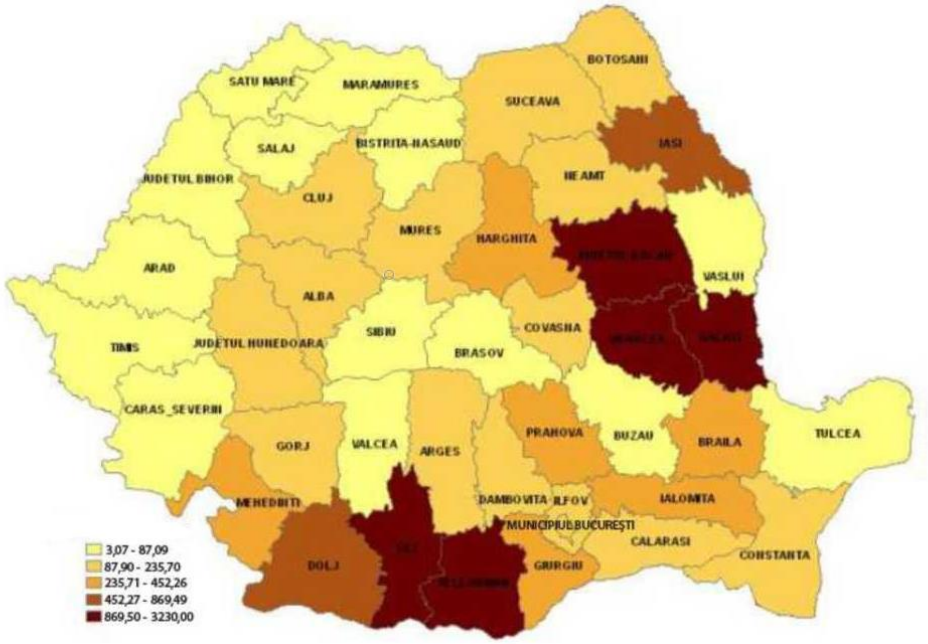

Figure 3. Historical average yearly losses due to regional floods and flash floods
Source: ANAR, 2022 [11]

An important element that can create risks, especially to health, is water quality. Water quality includes both surface water and groundwater and is influenced by various causes, such as environmental pollution, which are not directly related to climate change. However, water quality is affected during floods and droughts and thus can be altered by climate change. The direct impact of water quality on health makes it necessary to monitor both flows and quality of surface and groundwater.

The Danube River ecosystem and the Danube Delta ecosystem are also clearly affected by upstream changes, such as pollution and handling of spilt water, and sediment run-off into the Danube. According to the Lower Danube River Administration, this can be seen from the reduction in the depth of the water, which means that the number of restricted navigation days is increasing.

3. Droughts

As in the case of floods, the droughts of the last decade have been of comparable intensity to those of the last few hundred years and have occurred only a few years apart. For example, the drought of 2003, when the flow of the river Danube got so shallow that it dropped to a new record, was followed by floods in 2005, when the record flow was at the other extreme and very high. Figure 4 gives an overview of historical droughts affecting river flows and water scarcity in Europe. As can be seen, Romania was affected by droughts and water scarcity in 2002, 2003, 2011 and 2012.

In addition to increasing intensity and frequency of droughts affecting river flows, Large seasonal variations are expected as well, as Romania experiences smaller flow rates in the summer and greater in the winter. As a consequence, the droughts and the water stress are likely to increase, in particular in Summer. Floods are expected to become increasingly widespread in many catchments, notably in spring and winter, but estimates of the change in the occurrence and extent of flooding are uncertain.

Danube delta is to be significantly influenced by increasing annual temperatures and more frequent weather phenomena. Air temperatures will rise by an estimated 1.5°C on average by 2050, leading to more drying, more extremely hot days and a significant decrease in snow cover. Part of the area analysed, i.e. part of Dobrogea, is even considered to be at risk of desertification.

Forecasts have also shown that shifts in average temperature and precipitation are coupled with changing statistics of extremes, such as increased frequency of droughts, flash floods, thunderstorms, hail, etc.

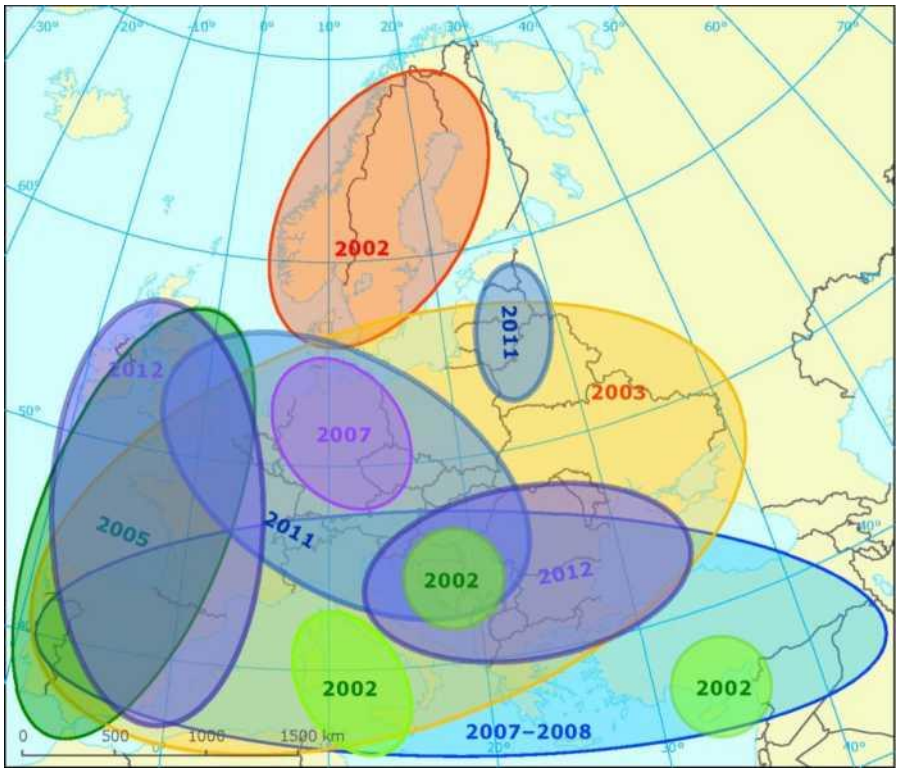

Figure 4. Historical droughts affecting river flows in Europe, source: European Environment Agency, Droughts affecting river flows (CLIM 18) - Assessment,
Source: http://www.eea.europa.eu/data-and- maps/indicators/river-flow-d rought-1/assessment, 2022 [12].

4. Landslides

Earthquakes are caused by the release of stress generated by plate tectonics forces or anthropogenic activities such as reservoir creation, mining, or injection of fluids into underground formations. There is no evidence that seismic hazards are directly linked to climate change. However, climate change may affect seismicity by changing reservoir levels or groundwater use. Landslides are driven by the forces of gravity but are triggered by a variety of processes. Some of the most common triggers include earthquakes and periods of prolonged and/or intense rainfall. Deforestation can increase the likelihood of landslides. The frequency of landslides may therefore increase as a result of climate change and associated changes in rainfall.

5. Vegetation fires

Wildfires are an environmental phenomenon that can be caused by anything from a natural event, such as an electrical lightning strike, to intentional or unintentional acts of man. Nevertheless, already when a wildfire is started by man-made causes, like wildfires or arson, such a fire will be intensified by climate factors like high temperatures, high winds and poor humidity.

The likelihood of vegetation fires is influenced by climatic variability over several periods. For example, inter-annual climate variability leads to comparatively humid and comparatively dry periods. In wet periods, there is a build-up of overgrowth, providing fuel for wildfires in drought periods. A projected rise in rainfall seasonality could lead to more favourable conditions for vegetation fires.

The frequency of these fires in Romania has increased recently. The damage caused by vegetation fires can be substantial, especially in economic terms. In Romania, 33% of wildfires in 2013 involved the burning of vegetation.

CONCLUSIONS

In the framework of the National Climate Strategy, municipalities are required to upgrade and update their hazard plans and preparedness scenarios using the climate change scenarios provided by the ANM. Based on early forecasts from the ANM and ANAR, municipalities assess the interventions needed to mitigate the risk. Local decision-makers need to have a good understanding of the complex information provided by ANM and ANAR. Local authorities' climate risk evaluation and mitigation would benefit from ensuring that local decision-makers are adequately trained on the interpretation and use of the information provided by both ANM and ANAR.

The network of communications between IGSU, other authorities and agencies is based on fairly old technology and should be modernised as quickly as should be possible. Adequate monitoring and management of climate risks depends to a large extent on a communications system that allows for continuous and rapid online exchange of information among all the agencies and interested parties. Fast capture and processing of data is crucial to supporting policy-making, in particular in emergency situations. A well-functioning automated communications system would allow the country to benefit more from early warning announcements. Monitoring of climate hazards would greatly improve by upgrading both fixed and mobile field devices and hardware and software, with modern programmes allowing two-way data exchange and providing enhanced data transfer and archiving capabilities

Educating the general public on the meaning of colour-coded early warning notices and emergency instructions will save lives.

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