

CHARACTERIZATION OF METEO-CLIMATE RISK PHENOMENA IN THE BOTNA RIVER BASIN

Aliona Isac*

Moldova State University, Chisinau, Republic of Moldova

**Corresponding author: isacaliona0224@gmail.com*

ABSTRACT

The Botna River basin, a tributary of the Dniester River, has been significantly influenced by climate change and meteo-climate variations over the past three decades. During this period, risky phenomena such as droughts, floods and soil erosion have become increasingly frequent and intense. Severe and very severe droughts have consistently affected the flows of the Botna River, reducing water availability and having a significant impact on agriculture and local ecosystems. Analysis of hydrological data from 1990-2025 shows a trend of decreasing precipitation in the summer months and an increase in the frequency of droughts. Although drought dominates in many periods of the year, extreme precipitation events in the spring and summer months lead to sudden increases in the river flow, causing local flooding and affecting nearby infrastructure and agricultural lands. The phenomenon is aggravated by unsustainable urbanization and deforestation on the high slopes of the basin. Climate change has led to an intensification of climate risk phenomena in the Botna River Basin. It is essential to implement adaptation measures to cope with prolonged droughts and floods, as well as to protect the infrastructure and ecosystems in the region.

Keywords: river basin, risk meteorological and climatic phenomena, droughts, floods.

INTRODUCTION

The Botna River is an important element of the hydrographic network of the Republic of Moldova, playing an essential role in supplying water and maintaining the ecological balance of the region. As a right tributary of the Dniester, its basin is located entirely on the territory of the Republic of Moldova and is distinguished by a high degree of valorization for agriculture, industry and domestic consumption. This intensive use, combined with the effects of climate change and anthropogenic pressures, makes the Botna River basin extremely vulnerable to risky meteo and climate phenomena. The interaction between global, regional and local processes determines a series of climate risks, such as the reduction of water resources, the increase in the frequency of extreme phenomena (droughts and floods). In this context, the sustainable management of the Botna River basin becomes a priority for maintaining its ecological and economic functionality (Isac, 2024).

MATERIALS AND METHODS

In the research on the theme "Characterization of risk meteorological and climatic phenomena in the Botna River Basin", all available information and documentation resources were used, both national and international, scientific articles,

doctoral theses, research reports, water resources management plans, hydrological studies, results of research projects, etc.

From the point of view of methodology, the work is based on the documentary stage, which is usually the first in the structure of any research project (Coteț and Nedelcu, 1976).

The documentary stage involves accessing and systematizing historical documents, maps, statistical and geospatial data, which provide information about risk meteorological and climatic phenomena in the Botna River Basin. Thus, for the beginning, the activities are directed towards studying bibliographic sources, in order to be up to date with what has been studied regarding the Botna River Basin (reports, theses, articles, etc.). For this purpose, a bibliographic list was drawn up in which works of a climatic nature were highlighted, hydrological, hydromorphological, etc., with emphasis on useful contributions to the characterization of the aspects of the risk weather and climate phenomena.

In achieving the purpose and objectives of the theme, the following methods will be used: cartographic, inductive, analysis, synthesis, comparative, historical, etc. GIS tools were also used for the processing and development of maps and other graphic representations.

GIS tools play an essential role in the research of risk weather and climate phenomena in the Botna River Basin. These tools provide a robust platform for the collection, analysis and visualization of spatial and temporal data, necessary to understand the distribution and frequency of risk weather and climate phenomena.

RESULTS AND DISCUSSION

The Botna river basin is characterized by a temperate-continental climate, with short, mild winters with little snow, and long summers with low humidity. The average annual temperature is 10°C. The highest temperatures are recorded in the summer months and are on average equal to 20 -21°C, and temperatures slightly below 0°C are noted in the winter months (RAILEANU V., Bejan I et al (2021). During the warm months of the year, torrential rains are frequent, which, in some years (1969, 1980, 1994, 1999, 2001, 2010, 2024) caused severe floods. The specifics of the climatic conditions of the basin are determined by the processes and geographical factors of climatogenesis (air mass dynamics, solar radiation, relief, the influence of the Black Sea basin, vegetation). The processes and geographical factors of climatogenesis determine the temporal characteristics and spatial distribution of climatic elements, primarily atmospheric precipitation and air temperature. Atmospheric precipitation is the most important element in the formation of water reserves in the hydrographic basin, the structure of the hydrographic network and, to a certain extent, the quality of the waters. Among the main risk phenomena identified in the Botna River basin are drought and floods.

In the Republic of Moldova, drought is one of the most dangerous natural phenomena, which is a specificity of the regional climate, a state of uneven distribution

The 2020 drought, after the damage caused, was a catastrophic one, causing the greatest material damage to the national economy, especially agriculture, which remains dependent on weather conditions. The 2020 drought is a consequence of the lack of precipitation in the fall of 2019 and spring of 2020, which was recorded throughout the country. In the Botna River basin, the greatest damage was recorded in the Căușeni district (422.2 million lei) (Ministry of Internal Affairs, Civil Protection and Emergency Situations Service, 2020).

In June 2024, the State Hydrometeorological Service issued a hydrological code red warning for the Botna River, indicating a drastic decrease in water flow, which reached 15% or less of the multiannual monthly average values. This hydrological warning indicates a critical situation of severe hydrological drought in the Botna River basin. The low water level, below 15% of the multiannual monthly average values, reflects the impact of climate change and rainfall deficit on water resources. This situation has negative effects on aquatic ecosystems, agriculture and water supply to localities in the area, requiring urgent measures for efficient management of water resources and adaptation to extreme climatic conditions.

According to CHT, severe and very severe drought was recorded in the Botna River basin from June to August 2024 (Fig. 2). This situation was aggravated by illegal irrigation practices, which contributed to a further decrease in the water level in the river.

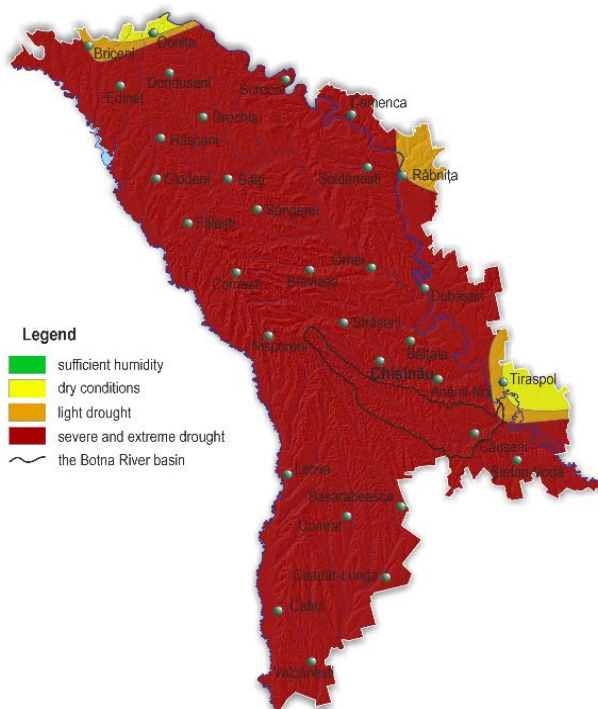


Fig. 2. Hydrothermal coefficient (CHT) for August 2024
Source: *meteo.md*

A comparison with other small basins in central Moldova, such as the Bâc and Ichel rivers, shows a similar pattern of vulnerability to hydroclimatic extremes. These basins, like the Botna, are characterized by relatively small catchment areas, high dependence on precipitation, and significant anthropogenic pressures. During the droughts of 2007 and 2020, both the Bâc and Ichel rivers also experienced drastic reductions in water flow, temporary drying of tributaries, and negative impacts on agriculture and urban water supply. Such parallels confirm that the Botna River basin is representative of broader regional challenges, making it an important case study for understanding and addressing hydrological drought under climate change conditions.

Floods are the most dangerous natural hazards, hitting many regions of the world every year. In recent decades, the damage caused by floods has increased exponentially. This is often exacerbated by inadequate flood planning and management practices.

Floods are the extension of water beyond the normal limits of a watercourse, affecting adjacent land.

In the Republic of Moldova, heavy torrential rains are the main factor causing floods. The event from 2024 August is an example. On the Dniester and Prut rivers, floods are largely caused by intense rainfall and snowmelt, which leads to rapid increases in flow and the rivers overflowing their banks.

The Botna River Basin, located in the central part of the Republic of Moldova, is frequently affected by floods, especially during periods of heavy rainfall. These floods have a significant impact on local communities and infrastructure.

For example, in the city of Causeni, located on the banks of the Botna River, residents of some streets are flooded almost annually due to the rise in the water level in the river. This problem has persisted for over twenty years, seriously affecting households and the quality of life of residents.

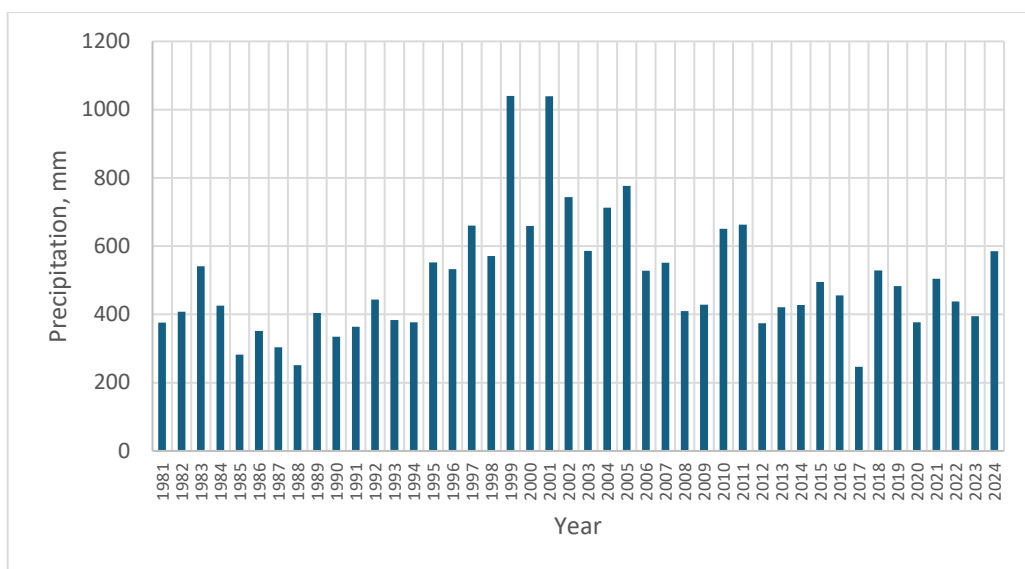


Fig. 3. Annual average precipitation (mm), r. Botna

Source: meteo.md

The analysis of annual precipitation over the period 1981–2024 in the Botna River basin reveals significant interannual variability, with values ranging between approximately 250 mm in the driest years and over 1000 mm in the wettest years.

On average, precipitation fluctuates between 450–650 mm/year, which corresponds to the national mean levels recorded in Moldova. 1990s–early 2000s marked by the wettest interval of the entire record, when precipitation frequently exceeded 700 mm, with extreme peaks of over 1000 mm in 1999 and 2001. This period corresponds to years with increased flood risk in the basin. 2012, 2017 and 2020 represent severe drought years, when precipitation dropped to around 250–350 mm, resulting in reduced river discharge and water scarcity. 2010s–early 2020s characterized by a prevalence of below-average precipitation, with frequent droughts interspersed with only a few wet years. This variability demonstrates the sensitivity of the Botna River basin to climate extremes, alternating between pluvial floods and prolonged droughts. Such fluctuations directly influence the hydrological regime of the river, affecting both the minimum and maximum discharges, and ultimately impacting water resources management, agriculture, and ecosystem health.

In September 2024, in the village of Costesti, Ialoveni district, the Botna River overflowed its banks following torrential rains (Fig. 4), flooding the surrounding area and causing the collapse of fences and the entry of water into people's homes.

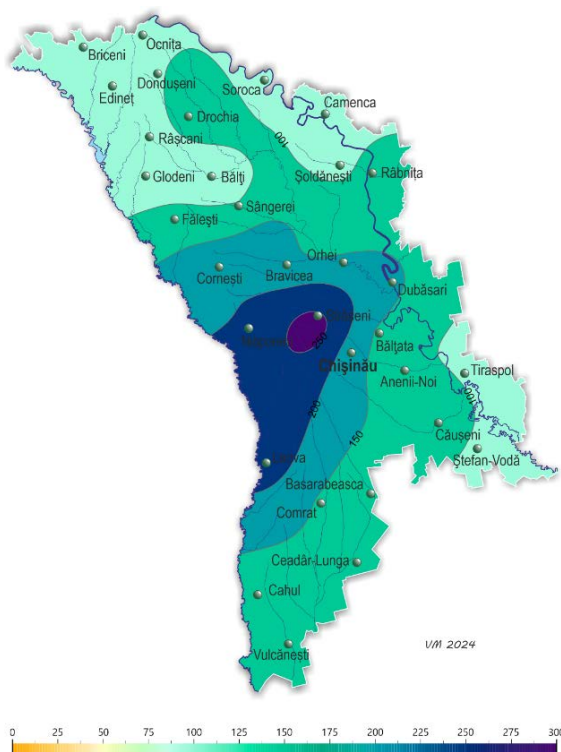


Fig. 4. Amount of precipitation (mm) in September 2024
Source: meteo.md

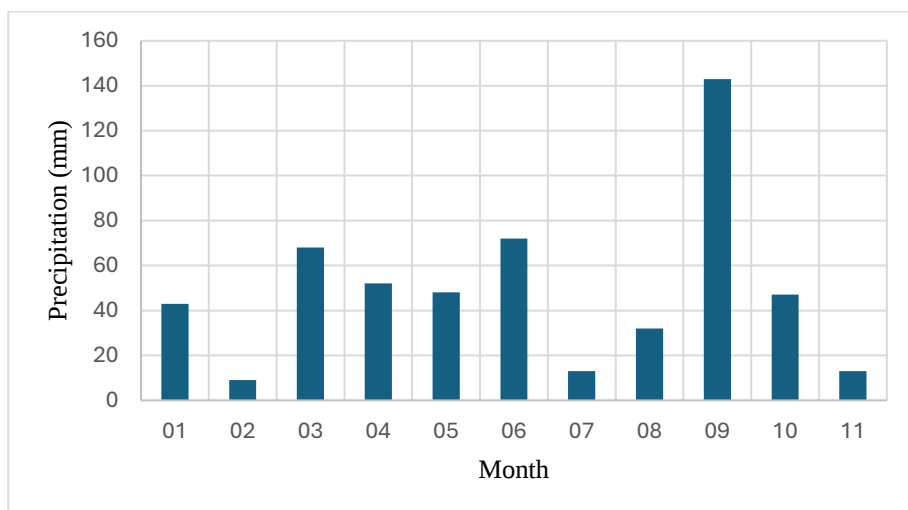


Fig. 5. Amount of precipitation (mm) in 2024, r. Botna

Source: meteo.md

In the upper reaches of the Botna River, precipitation was more than five times higher than the multi-annual average for September, which caused a rapid and significant rise in water levels, exceeding the absorption capacity of the soil and the minor riverbed. This led to intense runoff on the slopes and rapid accumulation of water in the riverbed, favoring the river overflowing. In the lower reaches, precipitation was 2.25 to 3.5 times higher than normal, which increased water flow and prolonged the flood period in low-lying areas, affecting agricultural land, infrastructure and households located near the river (Fig.5).

In order to manage and mitigate flood risks in the Botna River Basin, river basin management plans have been developed. These include measures such as drought and flood risk mitigation, as well as the implementation of climate change adaptation strategies.

The Botna River, as a left tributary of the Dniester, contributes to the hydrological regime of the Dniester basin, which ultimately discharges into the Black Sea. Alterations in water quality, sediment transport, and flow regime within the Botna catchment can propagate downstream, influencing the ecological integrity of the Dniester estuary and the Black Sea. This hydrological connectivity underlines the necessity of integrated catchment-to-coast management approaches, ensuring that interventions at the local river-basin scale also safeguard the ecological balance of marine systems.

CONCLUSIONS

- ✓ In recent years, drought has become an increasingly persistent phenomenon, affecting water supplies, local ecosystems and agriculture in the Botna Basin.

- ✓ Although drought prevails, episodes of torrential rainfall can cause flash floods, negatively impacting agricultural soils, infrastructure and settlements near the river.
- ✓ Efficient water resource management, implementation of water retention techniques and reduction of uncontrolled extraction are essential for mitigating climate risks in the Botna Basin.

REFERENCES

- Coteț, P. V., Nedelcu, E. P., (1976). Principles, methods and modern working techniques in geography. *Didactica și pedagogia Publishing House*, Bucharest.
- Isac, A., (2024). Characterization of the geographical conditions of the Botna river basin in relation to global changes, *Scientific Journal of Moldova State University*, 1(171), 159-163 p. (in Romanian) [https://doi.org/10.59295/sum1\(171\)2024_19](https://doi.org/10.59295/sum1(171)2024_19)
- Isac, A., (2024). The Scientific and Methodological Foundations for Research of the Botna River Basin, Ministry of Internal Affairs, Civil Protection and Emergency Situations Service, (2020). Exceptional Situations Brochure (in Romanian)
- Nedelcov, M., Răileanu V., Chirică L., (2013). Climatic resources of the Republic of Moldova, Academy of Sciences of Moldova, Ministry of Environment of the Republic of Moldova, Institute of Ecology and Geography – Ch.: Î.E.P. Știința (in collaboration with the publishing house Strih SRL, (Combinatul Poligr.), 76 p.
- Raileanu, V., Bejan I et al (2021). Atlas – Climate Change and the Current State of Landscapes, Ed. Impresum, Chișinău, 100 p. (in Romanian)
- Sofroni, V., Puțuntică, A., (2016). Drought as a phenomenon of ecological degradation of the environment, *Acta et commentationes* (Științe Exacte și ale Naturii), no. 1(1), ISSN 2537-6284 /ISSNe 2587-3644.
- Sofroni, V., Mangul, I., (1998). Analysis and monitoring of droughts on the territory of the Republic of Moldova. Results of the communications of the third international scientific-practical conference, Apele Moldovei. Chișinău: FEP Tipografia centrală, p. 226-228.
- Sofroni, V., Mangul, I., Lupașcu, M., Lala, M., (2000). Characterization of droughts in Moldova and measures to mitigate the consequences. Droughts: Forecasting and mitigating the consequences. Chișinău: INECO, p. 14-21.