

EVOLUTION OF THE DROUGHT PHENOMENON IN THE REPUBLIC OF MOLDOVA - CONSEQUENCES, LOSSES AND ECONOMIC FLOATING

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Abstract

Natural risks have been and are for agriculture the negative factor, which needs to be taken into account in the development of the agricultural sector. Due to the fact that the Republic of Moldova is located in a climatic zone with insufficient humidity, it is periodically subject to the influence of particularly strong droughts. Droughts in recent years confirm the insufficient level of adaptation of agriculture in the Republic of Moldova to drought conditions, which more and more frequently and with increased intensity, especially in recent years, affect the agricultural sector. This article provides a brief analysis of the general synoptic mechanism of drought genesis in the Republic of Moldova, types of drought, economic impact, probability of occurrence, drought register for the period of X-XXI centuries. The authors emphasize from the beginning the great variety of dangers that appeared in this territory, giving us concrete data and examples. Also in this paper is described the fact that out of all the dangers appeared on the territory of the Republic of Moldova, as well as all over the world, drought prevails, caused by climate change. The completion of the drought register by 2020 indicates a general trend of increasing the frequency of their production, due to the anthropogenic impact on the environment and regional and global climate change. Through this work, the author makes a modest contribution to the study of natural hazards in the Republic of Moldova, with a great destructive potential and which can cause extremely great damage to the economy and the national environment. From this perspective, it is necessary for agricultural entities to analyze the probability of damage and their assessment, because the specifics of their field of activity, are environments in which the risk of drought can manifest itself, mainly. Thus, it becomes necessary to develop urgent as well as long-term measures to reduce the risk of drought.

Key words: agricultural sector, drought, economic impact, natural risk, soil moisture reserves

The basic process, related to the appearance of dry conditions is determined by the appearance on the territory of the Republic of Moldova, of the initially cold polar air, with a reduced amount of humidity. Penetrating further to southern latitudes, this air heats up and as the temperature rises in it, the saturation deficit increases, turning into a dry air mass. The deficit begins to be filled by soil moisture - thus intensifying the process of drought in the soil. Of great importance in the formation of dry conditions are the winds, which blow from eastern Eurasia and southeast (dry steppe wind), or that which forms in the cold, warming air (local dry wind).

Drought is a prolongation of insufficient rainfall and is a natural feature of the climate. It can occur in any climatic zone, but its characteristics can vary from one region to another. Drought is a temporary phenomenon (a year, two or three) and differs in terms of aridity. In ecological terms, drought is a dry period from which an ecosystem often recovers quickly after rains. Prolonged drought years eventually lead to

desertification. Drying is a process as a result of intensified aridity.

Human activity, which includes deforestation, mismanagement of agriculture, improper irrigation, etc., are the main causes of desertification.

Drought produces a multitude of effects that harm different sectors of the economy. The effects of drought can be classified as: economic, social and environmental. Decreased crop productivity, forests, reduced water use, increased mortality rates, unsatisfactory health conditions are some of the characteristics of drought. Many of these factors lead to poor socio-economic conditions of the population, lead to large-scale migration on the one hand and ecological degradation of the environment on the other.

There are two ways to link drought and desertification. Droughts over several years lead to desertification. On the other hand, desertification has an effect on the climate and can cause droughts. The link between drought and desertification is so strong that it becomes almost

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impossible to separate the effects of drought from those of desertification, both processes often take place together.

The agrarian orientation of the economy of the Republic of Moldova conditions the high vulnerability of the economy due to meteorological and climatic factors. A considerable role is played by climate limiting factors, which have a direct influence on the ecological stability of agricultural crop varieties and species, largely determining the nature of annual crop changes. Most of the agricultural land in Moldova is located in the area of insufficient humidity. Droughts, which are reported in certain years, cause enormous damage to the country's agricultural production.

One of the cardinal geographical consequences of climate change may be an increase in the likelihood of climate extremes. This will undoubtedly lead to increasing economic losses and social conflicts in many regions of the world. Moreover, the extreme weather conditions, to which nature and society are less adapted, can be much more receptive to the changes that take place, than to the multiannual average climate, and the consequences of changing climate norms become unpredictable. In this context, changes in the extreme regime need to be seen as the main manifestation of current climate change (Alpatiev A. *et al*, 1958; Bucinschii I. 1957, 1976).

Of all the regions of the world that are more dependent on weather and climate are the arid and semi-arid regions. Namely in the semi-arid regions, to which a part of the southern territory of the republic belongs, the natural ecosystems are more vulnerable to the action of extreme climatic factors, and the degradation processes are destructive, contributing to desertification. Here, the balance of production and consumption often depends largely on the humidity regime, and in some years its deficit can be a serious problem for them. In the last 30 years, the problem of soil degradation in dry regions is becoming more acute. The United Nations Convention to Combat Desertification and Drought designates a qualitatively new conception of ecosystem management in arid, semi-arid - and no less important - regions for the management of sources of development assistance. In the past, arid and semi-arid lands easily regained their productivity after long droughts and dry periods. Under current conditions, they are rapidly losing their biological and economic productivity due to climate change and human activity. Currently, on all continents, also in the republic, there is soil degradation due to droughts due to overexploitation, grazing, deforestation and the use of inadequate irrigation methods. Such over-exploitation is linked to

factors of an economic and social nature without adequate information.

According to existing estimates, climate zones with a higher probability of desertification and drought occupy about 47.5% of the land area, while 69% of these areas are already subject to desertification. 30% of the surface of irrigated lands are degraded, 47% - of non-irrigated sowings and 73% of pastures. More than 110 countries around the world have arid and semi-arid lands, threatened by desertification and drought (Ungureanu V. *et al*, 1995).

Droughts greatly affect the agriculture of the Republic of Moldova. They are part of dangerous natural phenomena, resulting in the destruction of agricultural crops over large areas. Droughts impoverish and pulverize the soil, which causes the destruction of its structure, the occurrence of wind erosion and the desertification process. Currently, the study of droughts and their prediction, the analysis of the genesis and the degree of repetition of the drought phenomenon are of major importance. Increasing the harvest of agricultural crops and productivity in the field of animal husbandry, the efficient use of water and land resources, are related to the study of natural climatic phenomena, including droughts, dry winds and desertification processes (Sofroni V. *et al*, 1994; Sofroni V. *et al*, 1999).

Although droughts can occur throughout the year, most occur in late summer and early fall. According to the intensity, there are several types of droughts (very strong, strong, moderate) (Lupașcu M. 1999; Sofroni V. *et al*, 1999).

Very strong droughts are reported in the years when during the vegetation period precipitation falls less than 50% of the norm, and the average air temperature exceeds the climatic average by 3-4°C.

Strong droughts occur when the amount of precipitation is 60-70% of the norm, and the average air temperature during this period exceeds the norm by 2°C.

Moderate droughts are reported in those years when 70-80% of the precipitation rate falls, and the positive temperature anomaly is 1.0-1.5°C.

So, from the above, it can be concluded that the drought in Moldova is not a random phenomenon of nature, but it is a legality and therefore we must take into account its possible manifestations not episodically, but permanently, ahead of the onset. its destructive force. In this regard, it is necessary to restructure and adapt the existing system of agriculture of the Republic of Moldova to semi-arid conditions.

MATERIAL AND METHOD

This study involves a rather complex environmental issue for the territory of the Republic of Moldova, in the context of global climate change. The research focused on the evaluation of the written sources and the archive data of the State Hydrometeorological Service. In terms of time, the information accumulated refers to the period of the tenth century and until today. The comparative analysis of the climatology works, drawn up in different periods, offers the possibility to highlight the dynamics of droughts on the territory of Moldova and the evolution of the geographical landscape towards a semi-arid one.

The mixed use of comparative, historical methods of analysis gave the opportunity to reveal the distinct features that characterize the current climate of the Republic of Moldova, viewed through its aspects of aridization (drought and desertification).

RESULTS AND DISCUSSIONS

Using the climatological peculiarities of droughts, V. Potop (2012), identified periods of drought, based on hydrometeorological indices and maize harvest. All these served as a starting point for the elaboration of the register of droughts on the territory of the Republic of Moldova during the instrumental observations of the meteorological regime.

Droughts were assessed both for each season (spring, summer, autumn) and for the warm period of the year, based on the average values of temperature and precipitation recorded in the corresponding time period. According to the data obtained, it results that from the period under study the droughts were recorded in 36 years in the warm period, 35 years - in the spring season, 38 and 40 cases in the corresponding summer and autumn season. Of the total number of dry years in the warm period, over 60% of the years had a medium intensity - 14 and strong intensity - 10. Strong and very strong droughts are characteristic for all seasons of the warm period. Droughts in spring, summer and autumn are mainly strong droughts 15-20 cases, more rarely very strong droughts are recorded - in 3-11 years. In the summer months, droughts with strong intensity - 9 cases and very strong - 12 cases dominate. According to the register of very strong droughts in the summer season they became more frequent after the years 1950-1960. There has been a certain increase in the frequency of drought years since the 1960^s, reaching its maximum during the years 1981-1990, after the 1980^s there is an increase in its intensity (Potop V. 2002).

The analysis of the probability of occurrence of droughts after V. Flood (Potop V. 2002), of different intensity showed that in the north of the republic in spring the probability of mild drought is 8% (once in 13 years), in summer the phenomenon is more frequent (once in 8 years), while autumn manifests itself once in 3 years. To the south, drought frequency indices change, in the center of the republic the probability of drought gradually increases for spring and summer up to 20% (once in 5 years), and autumn registers the same frequency as in northern Moldova, mild drought once in 3 years. In the south of the republic droughts of low intensity have a higher probability in spring - once in 4 years, and in summer once in 3 years and in autumn once in 2 years. Analysis of the time and space distribution of medium-intensity droughts indicates that they are subject to the same legalities as weak droughts. In the 3 areas they have a higher probability in the autumn season and especially in the south of the republic, where they can manifest once in 2 years. Strong droughts have a lower probability of manifestation: in the north of the republic once in 13 years in spring and once in 11 years in summer.

The frequency of 25% is manifested in autumn for the entire territory of the republic. The probability of manifesting a very strong drought is lower in northern Moldova, where spring can be once in 33 years, and in the central part gradually increases once every 14 years and 7 years in the south of the republic. For the drought the given intensity is 2% for the warm period of the year.

Based on the analysis of the materials according to the drought registers, performed by S.E. Bucinschi (1957, 1976), O.A. Drozdov (1980) and others, a selection of the dry years was made for the southwestern region of the Eastern European Plain, of which the Republic of Moldova is part, until 1944. Starting with 1945, the selection of these years of was made based on data from meteorological stations in the territory of the republic (until 2020, *figure 1*). For this, the monthly average of the air temperature, the monthly amount of atmospheric deposits and the deficit of air humidity were taken with the deviations from the norm (multiannual average) in each month of the current year, which allowed to appreciate the weather conditions. Since the tenth century, the number of droughts in the region has been steadily increasing, with the exception of the thirteenth and seventeenth centuries. Droughts have become more frequent in the last two centuries, especially in the twentieth century (Bucinschi I. 1957, 1976; Drozdov O. 1980).

Figure 1 suggests the pace of drought development over the last millennium (994-2020).

The analysis of drought years by centuries, even for the last millennium, shows us that a strict periodicity of droughts in the sense of regular repetitions after a stable number of years, of course, is not. However, the systematization of droughts in the historical past is useful and necessary, as the accumulation of such information will succeed in more accurately concluding the manifestation of droughts in the territory of the republic.

The aridization of the land from the second twentieth century, is largely related to the anthropogenic impact on the environment, through the implementation of multiple technologies, irrational exploitation of natural resources, especially soil, forests, water and air basins, etc.

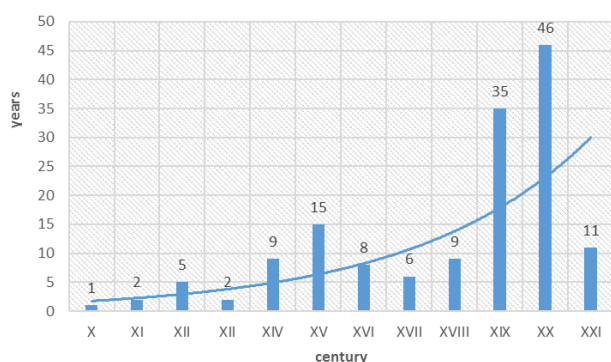


Figure 1 Medium and strong droughts in the Eastern European Plain (number of years per century), including in the Republic of Moldova

Generalizing the specifics of the cyclical development of temperature and deposition regimes, V. Proca (1983), determined the alternation of climatic rhythms. A heating was highlighted and comparatively a low regime of atmospheric deposits between 1860-1870 of 19th century. The yield of agricultural crops during this period was low. Between the years 1880-1890 of the 19th century, a new decrease in temperatures and an increase in the amount of atmospheric deposits developed. This period is characterized by a relatively cold and humid climate. The rhythm of the last ten years of the 19th century and the beginning of the 20th century was characterized by high temperatures and low deposits. After the 1910s, the rhythm began with low temperatures and high humidity. Since the late 1930s, the pace has developed with low temperatures and relatively low humidity. Small rivers flowed annually for a long time. The last rhythm of the twentieth century (conditioned in the mid-1950s by the accelerated development of the world economy), is characterized by a warm climate. The beginning of the 21st century (2001-2020) is characterized by quite warm summers and relatively cold winters (Proca V. 1983).

The analysis of the materials of the state Hydrometeorological service of the Republic of Moldova, from 1890-2020, indicates that during these years, annual droughts of different intensities were registered within 29 years (one in 6-7 years). If we consider that during this period there were also conditions close to drought, then we can mention that the aridity on the territory of the country appears once in three years. During this period there were also cases of biannual drought, when after a year of drought followed a year no less dry. Such droughts were nine in number: 1894-1895, 1923-1924, 1945-1946, 1999-2000, 2002-2003.

Droughts of three and four consecutive years 1923-1925 and 2017-2020 were also observed (**Arhiva de date climatologice; ***Arhiva de date agrometeorologice).

In the years of aridity, the conditions for the formation of agricultural crops are quite unfavorable, which leads to a decrease in fruit from 20 to 50% and more, depending on its intensity.

In addition to annual droughts, on the territory of the Republic of Moldova, there are also seasonal droughts (autumn, spring, summer), which lead to decreased productivity of one or several crops. The most common are autumn droughts. Their beginning coincides, as a rule, with the period of the second decade of September, and the duration oscillates within the limits of 25-35 days.

Summer droughts are rarer than autumn droughts and occur during the active vegetation period of all crops.

Spring droughts (April and May) occur less frequently than summer droughts.

The probability of occurrence of high intensity (catastrophic) droughts (<50% of the climatic norm of precipitation), in certain months of the vegetation period, is increasing from 11% to 41% (from a case in 9 years to a case in 2 years). The strong droughts of the autumn months (September-October) are well expressed in the annual process, and in the southern part of April.

In dry years, the hot and dry weather leads to the mass appearance of pests and diseases of agricultural crops, which in some places completely destroy the fruit. An unfavorable climatic factor for agricultural households, during spring and summer, apart from droughts and sometimes as a component of it, are dry and hot winds (suhovei type). On the territory of Moldova, the probability of their occurrence is 95-100%, with an average durability in the warm period from 6 to 18 days, and in dry years it reaches 45-50 days.

Due to the drought in 2020, the wheat harvest could decrease by 40-50%. May is not as dry as the previous period. It has been raining for the last two weeks, but they are not able to rectify the situation, because the consequences of the deficit of precipitation for the soil are still very pronounced. In a number of districts in Moldova, mainly in the south and center of the country, there is a very difficult situation due to the hydrological drought that prevailed in winter and spring. The precipitation that fell in the first decade of May, in the districts of Căușeni and Ștefan Voda, was not enough, and the humidity penetrated into the soil to a depth of only about 10 centimeters. In some parts of the south of the country there was practically no rain. The mustard and pea plantations near the village of Carahasani, badly affected by the lack of humidity, also look lamentable. And the condition of spring crops, such as sunflower and wheat, is not very good. Spring crops, fruits, vegetables can be saved only by heavy rainfall, which should last at least 5-7 days. Only such rains would help farmers in the south and center of the country to obtain an acceptable harvest for the second group of crops.

In the case of winter crops, at best, it will be possible to harvest 20% - 30% of the expected amount. In the north we should expect an average amount of harvest for winter crops, but significantly lower than last year. In the center and south there is no moisture in the soil. Farmers will be able to harvest less than 50% of last year's harvest volume for basic crops.

In the center and south of the country, he added, the winter crops, wheat, barley and rapeseed, from which biofuels are produced, will suffer the most from the drought.

This year's 2020 drought will aggravate the situation of cereal producers. Growers understand the risks - if the harvest is low, they may reseed some fields. For this reason, there is a tendency to increase prices. Edible wheat cost 3 - 3.5 lei at the beginning of the year, and now costs 3.7 - 3.9 lei.

The situation may also be influenced by the fact that of the 17 countries that have previously restricted food exports to protect their domestic markets, almost half have already lifted restrictions imposed due to the COVID-19 pandemic, including large wheat exporters.

Joint efforts to resolve the current challenges in agriculture as a result and the problems caused by pandemic COVID-19 and drought has been the subject number one in Republic of Moldova.

CONCLUSIONS

We mention that the proposed new principle of analysis of temperature, atmospheric precipitation and humidity deficit (deviation from the multiannual average - norm), offers new climatic indicators, in appreciation of dry and rainy years, as well as establishing degrees of vulnerability of these meteorological elements in the regional plan of the republic.

The completion of the drought register by 2020 indicates the tendency to increase the frequency of their production, we consider due to the anthropogenic impact on the environment and regional and global climate change. Because the most dangerous droughts are those of summer, very strong droughts of the beginning of the 21st century have been identified, such as those of 2002, 2003, 2005, 2006, 2007, 2012, 2015, 2017, 2019.

So, drought in the Republic of Moldova, gradually acquires a systematic character in the context of regional and global climate change, and contemporary society must constantly strive for new possibilities of adaptation (irrigation, afforestation, forest strips, abandonment of agricultural land use in floodplains - their institutionalization as wetlands etc.).

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