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NATURAL HAZARDS AND THEIR EFFECTS ON AGRICULTURAL DEVELOPMENT (CASE OF THE REPUBLIC OF MOLDOVA)

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Abstract: The article describes the most frequent unfavorable natural phenomena in the Republic of Moldova, such as drought, hot dry-winds and strong winds, dust storms, hail, frost, glaze ice, invasion of sod webworms and others. Additionally it presents a number of methods for reduction of their damaging influence on the results of agricultural activity. The article showcases the devastating effect of webworms on the seeding of agricultural crop yield in 1975 and the coping measures undertaken in those years. In 2003, as a result of an unusual combination of natural and climate factors, a great damage was done to the seeding of agricultural crops. Similarly, abnormal heat during the summer of 2007 caused a disastrously low crop yield on the territory of the republic.

Key words: Abnormal natural phenomena, crop yield, damage, seeding, drought, precipitation, hail, frost, agriculture.

For Republic of Moldova which essentially has a fully developed land fund and whose economy is substantially defined by the development level of its agriculture, the problem of using land assigned to agriculture has been of vital economic, ecological and social importance. The total geographical area of the country by January 1, 2012 constituted 3384.6 thousand hectares, the area allocated for agriculture – 2498.3 thousand hectares, arable land and perennial plantings – 1812.7 thousand hectares and 298.8 thousand hectares respectively. The arability indicator of Moldova is one of the highest in the world: cultivated land (plow land and perennial plantings) covers 62.4% of the country's total area while farmland covers accordingly 73.8%.

Unfavorable natural phenomena occurring on the territory of the Republic of Moldova have a substantial damage on the country's agriculture. Specific examples can be referred by droughts, strong winds, dust storms, late spring and early autumn frosts, hail and others.

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Droughts represent a large misfortune for national agriculture. They represent a basis for largely reduced crop yield. Conceptually it can also be interpreted as a complex agro-meteorological phenomenon resulting in breaks of plants' water balance. Under the influence of lack of moisture caused by intense evaporation or prolonged dearth, plants turn to fade away and die. Pandey and Bhandari (2009) define drought as a situation of below the long-term average level of rainfall for a particular area having an adverse impact on human welfare.

Generally two types of drought can be distinguished: atmospheric and soil-based.

A major sign of atmospheric drought is typically accepted as an establishment of anti-cyclone weather with prolonged dearth with above-average temperature regime and below-average air humidity, oftentimes combined with strong winds. Particularly strong droughts occur in years with precipitation during the vegetation period of 50% below the period norm, while the average air temperature exceeds the norm by 3-4°C. Strong droughts occur with precipitation at the level of 60%-70% of the norm for the respective period and the average temperature of 2°C above the norm. Average droughts occur in years when precipitation reaches the level of 70%-80% of the norm whereas the positive anomaly of air temperature constitutes 1.0-1.5°C.

Soil drought, on the other hand, is interpreted as a phenomenon at which soil in the root zone dries up significantly as a result of prolonged dearth and insufficient amount of precipitation, leading to plants suffering from lack of moisture. In case of soil drought an imbalance between the plants' need for moisture and the available moisture resources is created. Given this, it oftentimes occurs that atmospheric drought precedes the soil one. When both types of droughts occur simultaneously, their negative effect reaches its maximum.

It is important to note that the territory of the Republic of Moldova is related to a geographical area with insufficient humidification. Drought environment is a widely accepted phenomenon in the country. Scientists' research shows that droughts on average occur not rarer than once in five years.

Besides drought-afflicted years seasonal droughts are also not uncommon, which leads to substantial reduction in yield of specific agricultural crops or particular groups of crops. Among seasonal droughts the most frequent one occurs in autumn (34% of total droughts on average). It tends to start in the middle of September and lasts for 25-35 days. That is why autumn droughts, first of all, have a damaging effect on the course of winter sowing and the development of

crops in autumn as well as on the formation of late-ripening crops, such as beet and corn.

Summer droughts are observed less often (26% of the total average number) compared to autumn droughts and typically occur during the periods of active vegetation, most often in the months of June-August.

Spring drought, in its turn, can be observed in the months of April and May. Its frequency is relatively low and constitutes approximately 15% of total droughts. Spring's unfavorable natural conditions have a negative effect primarily on the wheat crop yield and partially reduce the yield of plow-based and fruit crops.

Drought stands out from other natural phenomena in three distinct ways (Wilhite, 2000). First, taking into account its "creeping" nature, it is quite difficult to determine precisely its clear onset and end. Effects of a drought, e.g. large depletion of farmers' assets, extensive borrowing and other adjustments to meet farmers' consumption needs, could be accumulating slowly and be observed several years following the end of the drought. Second, a variety of existing definitions of drought, including those from meteorological, hydrological and agricultural perspectives, may add to confusion about its occurrence and severity. Finally, in comparison to floods and earthquakes, droughts do not result in damages to infrastructure. Hence, they are often given less attention from mass media, policymakers and politicians, while producing a wide range of complex adverse effects on a number of sectors of the national economy.

Hot dry-winds in the Republic of Moldova oftentimes represent a common type of drought amplified by wind. According to earlier work of Dzerdzeevsky (1956), hot dry-winds represent a range of hydro-meteorological conditions which cause unbalanced short-term hydration of plants due to elevated levels of transpiration, resulting in disruption in their normal hydro- and thermal regimes. A day with hot dry-wind of different intensity is considered to be a day with a particular combination of deficit of air humidity and presence of wind of particular speed. Light drought winds occur relatively rarely on the territory of Moldova – not more often than once in ten years. The highest duration of such winds constitutes three days on average during a warm period of the year, typically during the month of August.

Strong wind, on the other hand, implies wind with a minimum speed of 15 meters per second. The degree of impact of strong wind on agricultural crops depends on the condition of soil as well as crop plants' current stage of development. The average number of days with strong wind during a given

vegetation period ranges from 3 to 17 days. During particular years this number can reach as many as 45-50 days. The highest number of days with strong wind is generally observed in spring.

The most dangerous types of winds are strong or even moderate winds lasting throughout a long period of time and causing soil erosion and, as a consequence, dust storms (Agro-Climatic Resources, 1982).

Dust storm constitutes a dust-laden whirlwind moving across an arid territory being typically associated with "hot dry air and marked by high electrical tension" (Mirriam-Webster Dictionary, 2013). This adverse natural phenomenon happens quite rarely in Moldova and is characterized by moderate severity.

Hail represents precipitation that falls out of cumulonimbus clouds in a form of solid ice particles of different sizes. This unfavorable phenomenon takes place mainly during warm periods of the year. Hail always occurs during thunder storms, typically accompanied by heavy rain and sometimes by squall wind.

Hail falls out either across sporadic "spots" of territories or along "area lines" amounting to several kilometers in length and approximately one kilometer in width. It causes considerable damage to agricultural crops, gardens and vineyards. In Moldova, the most severe hail activity occurs in the months of May and June. The average number of hail days during a warm period of the year usually amounts to one or two.

Ground freezing is characterized by a decrease in air temperatures to 0°C or lower given positive average daily temperatures in periods of agricultural crops' vegetation.

It is important to note that variations in the dates of the first autumn and latest spring ground freezing tends to affect the length of freezing-free periods.

According to the data collected over multiple years (Agro-Climatic Resources, 1982), a spring freezing in Moldova normally lasts until 7th-24th of April, i.e. until the period of steady transition to the average daily air temperature of the period above 10°C. Freezing of the surface of soil last until the end of April – beginning of May. Nevertheless, average time when freezing fades depends mostly on local weather conditions. Among the factors which have the most significant impact on duration and intensity of soil freezing are the type of local topographical forms and existence of water reservoirs in the area. For instance, Southern and Eastern down-hills and broad valleys have a higher air temperature

than other forms of terrain. Topographical forms which are most susceptible to ground freezing are areas of soil surface descent.

Snowstorms represent another common natural phenomenon in the country and can be defined as relocation of snow above earth's surface caused by wind (Cambridge Dictionary, 2013). Snowstorms result in creation of areas of bare land which contributes to the freeze-out of over wintering crop.

Within the territory of the Republic of Moldova the number of snowstorm days ranges from 3 to 13 days. The frequency of snowstorms depends on such local conditions as degree of protection of the area from wind, form of terrain, slope exposure and others.

Glaze ice stands for sediment of atmospheric ice on different surfaces. Emergence of glaze ice is possible under relatively unsubstantial negative temperatures (0…-3 °C).

In northern and central parts of Moldova, glaze ice can be mostly observed in December, less frequently in January and February. In the southern region, however, the maximum number of glaze ice days occurs in January (Agro-Climatic Resources, 1982).

Low negative air temperature (-20°C and lower) causes significant impact on the hibernation of crops, especially during the periods of no snow or glaze ice.

Thaw period is a common phenomenon in Moldova which typically occurs in winter. The number of thaw days in winter amounts on average to 45-60 days, with the number of thaw days in December being higher than in January or February.

The combination of freezing and thawing of soil affects water movements in the soil and, in periods of extremely cold weather without snow, determines the depth of frost penetration and the speed with which it advances (Hall, 1951). Significant number of thaw days creates favorable conditions for the formation of ice crust which can cause mechanical damage to plants and sometimes their death. Formations of ice crust do not take place on the territory of the Republic every year. Nevertheless, ice crust formations can happen as often as several times during a particular winter.

Natural hazards could also be considered to include outbreaks of sod webworms attack which is similar to the impact of large-scale infestations of locusts which took place in Moldova in 1975. Late in July-early in August of 1975 the citizens

of the larger part of the country's southern regions could witness a very rare phenomenon: large populations of sod webworms (each sized at ca. 5-8 centimeters) managed to consume several kilometers of lucerne plants, entire leafage of sunflower plants, larger parts of leafage of corn while damaging other crops. According to research data, these events tend to occur on average once in 65 years. It is important to emphasize that sod webworms generally avoided inhabited places irrupting only into fields with the types of crops mentioned above. Local population attempted to cope with webworms by spraying them with chemical pesticides; however, this measure proved to be fruitless. After 10-12 days the devastating actions of sod webworms came to an end.

A very rare natural phenomenon took place in 2003 when a combination of adverse weather phenomena such as autumn drought, lack of snow and winter frost took place all over the country. Thus, starting from March 11, 2003 during the period of active vegetation of winter crops, the country experienced several days of freezing reaching the level of -14°C. As a result, the harvest of winter wheat amounted to 5 centners per hectare which was 1.5 times below the crop seeding norm.

Abnormal heat in July 2007 when air temperature remained above 42-44°C for longer than a week subsequently resulted in disastrously low harvest of agricultural crops: 4 centners per hectare for peas, 6.9 centners per hectare for sunflower, 8.9 centners per hectare for corn, and 9.5 centners per hectare for barley. Additionally, high temperature caused a physical burn of tomato plantings and other vegetables (Statistical Yearbook, 2012).

In conclusion it is important to note major approaches for natural hazards' alleviation.

It is possible to reduce the negative impact of adverse weather conditions on agricultural crops via implementation of organizational, economic and agro-technical activities. For instance, negative impact of drought could be mitigated by efficiently organizing the irrigation process of agricultural crops.

With regards to dry hot-winds, their damage can be mitigated by the use of modern agro-technical equipment focused on accumulation of moisture supply in soil, timely implementation of irrigation procedures and seeding of drought-resistant plant breeds for consequent improvement in the total structure of soil.

Moldova's accumulated experience in coping with natural hazards might also serve as a proof of the country's high expertise in prevention of hail via implementation of hail suppression installations. The cloud seeding technology,

where artillery shells loaded with seeding agents are fired into an estimated correct position in the cloud, was successfully tested for the first time by the Soviet scientists in the Caucasus Mountains in 1971 (Rabson, 1999) and became widely applied in Moldova since the late 1970s. The total number of such installations in the country, however, has decreased over time. Additionally, due to the lack of financing, hail suppression installations are currently not being operated at full capacity.

Glaze ice covering winter crops, for instance, has to be crashed by several ice rinks which will potentially lead to a better access of oxygen to crops and will prevent possible fading of plants. In case of vineyards, coping measures with glaze ice also contribute to significant reduction of negative consequences caused by unfavorable weather. For this the use of various equipment with shaking mechanisms or even grape-collection machines could be quite useful. Nevertheless, it might also be beneficial not to neglect manual labor.

To avoid the freeze of vineyards during winter times it is not recommended to plant them at low-placed ground spots or on northern slopes.

To achieve a better hibernation of winter crops, it is crucial to follow meticulously the timing of seeding proven by both science and practice. One should not let the crops to either overgrow in autumn or enter their winter hibernation period in an underdeveloped stage of growth.

It is possible to decrease the impact of dust storms by decreasing the proportion of plow-based crops. In 2012 the share of corn, sunflower and other plow-based crops reached 795 million hectares, accounting for 55% of Moldova's total cultivated area. In order to reduce the damaging effects of dust storms on agricultural yield it is suggested to decrease the proportion of plow-based crops to 40% of the country's total cultivated territory.

In conclusion, it is worthwhile to note that agricultural producers have the means noted above whose application will allow to prevent and/or largely reduce the negative impact of natural hazards on crop yields across the country. In the end, it is important at this point that the efforts of Moldova's farmers find significant financial, legal and administrative support from the state government.

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