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Vulnerability assessment and mitigation measures in Republic of Moldova

Armaş Andrei[1] **Man Teodor Eugen[1]** **Sabău Nicu-Cornel[2], Ţîţei Victor[3]** **Cuzic Ovidiu[1]**

Abstract: This paper presents the main vulnerabilities and mitigation measures regarding drought and desertification in the Republic of Moldova. The most important droughts that took place in recent years are analyzed through agricultural, environmental and economical damages that resulted from them. Water resources and quality is also a key element taken into consideration when assessing drought impact as well as the extensive use of the natural ecosystem which affects biodiversity and forest vegetation at all levels. The paper is also concerned with the emergency relief and drought response. In the conclusion, crop production is tackled in the context of precipitation deficiency.

Keywords: drought, mitigation, precipitations, forest, irrigation.

1. INTRODUCTION

Climate changes together with pollution are the two major concerns humanity has to find urgent solutions for, ever since the middle of the last century. It is imperative for the world`s governments to put together a global strategy to minimize their effects especially when human life itself is put to jeopardy.

Drought represents a dangerous, mainly, meteorological phenomenon which affects on a long term relatively big land areas causing material damages, environmental degradation, even human losses because of lack of water [18].

Draught and desertification quickly became the most harmful weather related events if we take a look at the last 50 years. Countries worldwide are struggling to find the most suitable solutions according to their possibilities and their needs. Of course, the Republic of Moldova makes no exception.

Being complex meteorological phenomena, dryness and drought are characterized primarily through absence of rainfall and through a growth of potential evapo-transpiration [3].

Each country worldwide has identified its most vulnerable areas and year after year calculates potential losses. On the territory of Moldova certain areas have already been labeled as Desertification and Drought Sensitive Areas as shown in the figure 1.

Of all the climatic phenomena the ones of dryness and drought can be considered the most

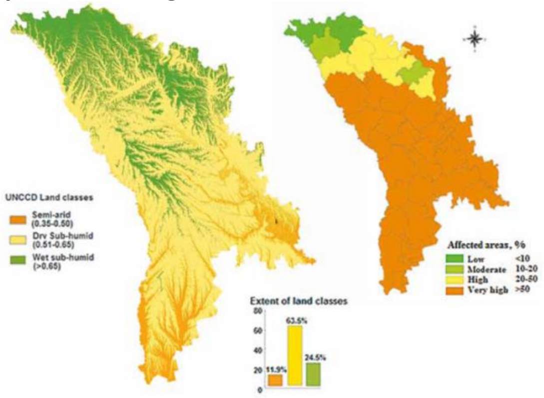

Figure 1. Desertification and Drought Sensitive Areas (DDSA) at high resolution and affected administrative districts (rayons) of the Republic of Moldova [9].

complex, because for their outburst many factors participate: rainfall, soil water reserve accessible to plants, moisture and air temperature, evapo-transpiration, wind speed, etc., i.e. the main climatic parameters that define the status of dry or drought time.

Moreover droughts are accountable for almost seventy percent of the economic losses caused by weather (Figure 2).

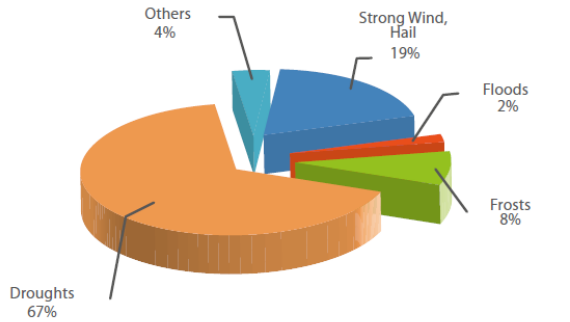

Figure 2. Attribution (%) of the economic losses to weather and climate related hazards (Republic of Moldova) [9].

Due to the fact that drougt has such a great percentage it is imperative for all the involved factors

[1] Politehnica University of Timisoara, Department of Hydrotechnical Engineering, George Enescu Street 1/A, Timişoara, 300022, Romania, e-mail: ing.armasandrei@gmail.com
[2]University of Oradea, Department of Environmental Engineering, 24, Gen. Magheru Blvd., Oradea, 41057, Romania
[3]Botanical Garden (Institute) of the Academy of Sciences of Moldova, Chisinau, 18 Pandurii Street, MD 2002, Republic of Moldova

to find suitable sollutions regarding it. Agriculture is by far the most involving human activity and it also seems to be the most important area that needs prompt intervention.

The continuous development of human society facilitated the invention of new technologies meant to provide aid in improving one`s life. The necessity of producing at an industrial scale resulted in both cheap goods and pollution. In agriculture the soil received various treatments regarding crop improvement, many of them with devastating effects to it and the environment as a whole. Together with the natural processes of soil degradation these factors can lead to land infertility for extended periods of time [1].

2.MATERIAL AND METHOD

When discussing about vulnerability of the agricultural ecosystem productivity it is widely known that drought leads to wide spread failures of agroecosystem production and food shortages in the Republic of Moldova. Household production in home gardens, a mainstay of food supply for most rural families, is also extremely reduced.

Drought impacts hit directly small holder farmers and agricultural workers whose income is 40-70% weather depended and comes from agriculture [24]. Droughts considerably reduce their savings and worsen both the overall quantity and the composition of their nutrition. In addition, in rural areas where 45% of the population rely on wells as their main source of drinking water, negative social effects of droughts are exacerbated by reduced access to potable water.

In some years the negative impact of droughts may acquire the scales of a nationwide environmental and socioeconomic catastrophe. As in 2007, the estimated losses caused by drought reached 23% of the Gross Domestic Product [8]. In monetary terms losses for the agricultural sector were estimated at close to US$1 billion. The greatest losses were experienced by fruit and vegetable growers (US$ 550 million), livestock producers (US$ 305 million) and cereal growers (US$ 132 million).

Table 1. Impact area (%), duration and economic losses from recent droughts, 2000-2012 (Republic of Moldova) *

Drought of year	Affected area,%	Duration, seasons	Economiclosses	
			Million Moldovan Lei(MDL)	Million US$
2000	75	spring-autumn	2098,1	169,7
2003*	86	summer-autumn	-	-
2007	78	summer-autumn	11970,0	987,0
2012	80	summer-autumn	2500,0	200,5

Regarding the drought of 2007, the high temperatures and insufficient rainfall between May and July designed unfavorable conditions for the autumn crops, on agricultural lands the productive humidity reserves in the soil`s upper and medium layers were insufficient most of the summer period, moreover at the end of July they were missing completely[5].

Recent drought of 2012 [24]. Throughout late 2011 and 2012, Moldova suffered the effects of a combination of extreme weather conditions. Exceptionally hot spring and summer of 2012 (in June-July temperatures were 3.5-5.0 °C higher than average) with extremely low precipitation (15% to 60% of the average climate) across the country had severe impacts upon crop production. The 2012 drought was part of a series of extreme drought events that have impacted the country in the past 12 years.

Although at the aggregate national level, the impact of the 2012 drought has so far been less severe than that of the previous major drought of 2007, in the south of Moldova the impact of the 2012 drought is reported to have been more intense. The southern region registered the most severe drops in production in the country, in particular for the maize and sunflower crops.

According to the assessment of the Word Food Program, in the areas visited in this regions, the situation was reported by all interviewed farmers and local authorities as worse than in 2007 – the 2012 drought was described as affecting the full length of the yearly crop cycle, impacting most crops.

Drought and floods are natural hazards induced by climate phenomena and processes that generate losses of human lives, great material damage and important ecological unbalance in the normal evolution of the environment [14].

The severity of the above described weather conditions had grave impacts on most crops grown during both the winter and summer growing season: winter wheat, spring barley, maize and sunflower as well as household vegetable production, i.e. affecting food, fodder and cash crops. Full details can be found in the crop assessment of 2012 report from the Ministry of Agriculture and Food Industry of the Republic of Moldova (Table 2).

Table 2. Crop production of 2012 compared to the recent average of 2009-2011. Source: Ministry of Agriculture and Food Industry of the Republic of Moldova, 2012 [24].

Crop	Region	Production, % from average 2011-2009
Wheat	North	-4%
	Centre	-19%
	South	-31%
Barley	North	-20%
	Centre	-33%
	South	-35%
Maize	North	34%
	Centre	-49%
	South	-86%
Sunflower	North	-11%
	Centre	-51%
	South	-88%

Regarding drought impact on water resources, hydrological drought can considerably decrease water resources, which leads to serious water shortage in Moldova. As a result there are inadequate and insufficient water supplies in the nutrition of people in the affected areas, especially of those who use their own water resources (wells and springs).

The drought of 2007 in Moldova can serve as a case study when assessing the impact of droughts on surface water [12]. Reduced precipitation in the early spring of 2007 (compared to the average multiannual precipitation) and high temperature, in combination with increased water demand, caused a reduced flow in the Prut and Nistru River, which was up to 50% below the average level.

Water quality does not show significant changes for both Prut and Nistru River during the 2007 drought. However, generally in periods when the river flow is lower, an increased content of Ammonium (NH4) and a low content of Nitrates (NO3) and dissolved Oxygen can be observed. This is an indicator that the water is to a certain extent polluted from urban waste water and/or livestock farming. In some cases the concentration exceeds the limits for drinking water quality.

The available data are from monthly measurements only and it must be assumed that the limits are exceeded more frequently. Most likely discharged untreated waste water causes the pollution, which becomes more obvious in periods when there is reduced dilution of waste water through lower flow in the rivers.

The concentration of Ammonium is significantly lower when the dilution is higher in the rivers. In this connection climate change can be seen as an exacerbating factor of other stressors on water quality in figure 3.

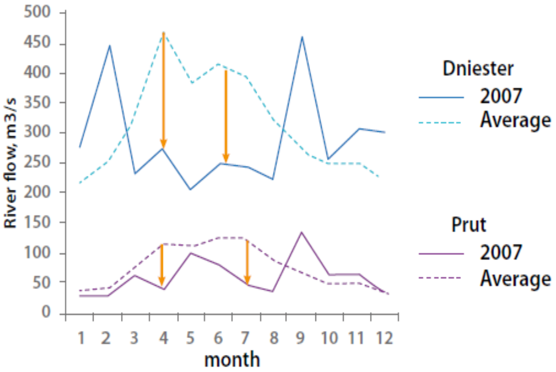

Figure 3. Dniester and Prut flow in 2007 compared to the multiannual average values. Source: Government of the Republic of Moldova and European Union, 2013 [12].

Statistics show that a considerable number of people, especially in rural areas, use water from their own water sources. Regarding the problem of water supply from own sources in rural areas, particularly wells, such important issues are raised as feasibility of the well (depth) according to the aquifer level, water quality and position in relation to sources of pollution.

The shallowness of the wells, which determines high possibility of their pollution, fluctuation of water level depending on weather conditions, can also lead to total drying out and thus to an acute shortage of water for several villages. In case of intensive drought (2003, 2007, 2012) water table fell more than 5 m below normal average, which led to drying out of lots of wells.

Impact of drought on natural ecosystems and forest vegetation Increasing temperatures and lack of precipitation in the growing period with consequent drought are a major constraint on forest growth and productivity.

Even small ongoing changes in regional climate could greatly affect forests growth and their survival in the Republic of Moldova. The most vulnerable areas are forest ecosystem margins and thresholds. High temperatures with precipitation deficit in a summer time are also the main factors predisposing forest ecosystems to pests and fungal diseases.

Irrational and extensive use of natural ecosystems and increasing drought intensity and frequency affect biodiversity and forest vegetation at all levels. Cutting of floodplain forests and windbreaks/shelterbelts from agricultural lands, wetlands drainage and channelization of small rivers, damage to the integrity of natural ecosystems, pollution of natural and agricultural ecosystems acquired threatening scales in the last few decades. Degradation processes and drought impact have already increased in secondary succession in ecosystems, expanding the areas occupied by aggressive synanthropic species and secondary phytocenosis with an extremely poor biodiversity.

Intensive slope erosion of soils, salinization of floodplain soils, falling of groundwater levels, drying out of many small rivers during summer have noticeably increased as a result of biodiversity losses. In the semi-arid areas of Moldova drought occurs every 2-3 years, extremely damaging natural ecosystem`s functionality. For example, the spring-summer drought of 2007 that damaged 5.5% of the national forests caused a physiological weakening of plants, a premature defoliation of trees and bushes and affected about 20 native and non-native forest species.

Impact of drought and heat wave on the health of population. The heat wave causes strong thermal stress in human body and during hot wave periods an increase in the general rate of death, especially caused by cardiovascular diseases is recorded. The risk of the population getting ill increased in some areas where the aridization process was accelerated by irresponsible actions of ecosystem destruction.

Swamps drainage and clear cutting of floodplain forests lead to disappearance of the local wind which keeps air humidity, decreases plants wilting coefficient and lowers daytime temperature during summer. This wind is replaced by a hot and dry wind. These changes at climatic level contribute to emphasizing the process of desertification accompanied by real dust and sand storms, which causes increase in the number of people suffering from asthma, especially among children according to the Third National Report on the implementation of the United Nations Convention to Combat

Desertification in the Republic of Moldova, 2007 [21].

Depending on the environment or the stages of the hydrological cycle in which its effects take place, duration and amplitude drought can be tackled from many perspectives: meteorological drought, agricultural drought and hydrological drought. As a direct consequence of the manifestation of all these drought types and their negative effects overlapped with a region`s social and economic activities, a new type of drought can be defined: the socio-economic drought [3].

Emergency relief and drought response Recent droughts have been followed by emergency interventions supported by the FAO, such as the Emergency Procurement and Distribution of Vegetable Seedlings and Maize Seeds to Drought Affected Farmers (US$337,000) in 2001 and the Emergency Supply of Winter Wheat Seeds to Frost and Drought-Affected Farmers (US$374,000) to partly relieve the 2003 frost followed by drought.

In 2007 the Government of Moldova approved the allocation of 16.5 million US dollars (MDL 200 mln.) to cover the costs incurred by farmers for tillage and sowing of winter crops.

In the fall of 2007, through the Relief and Technical Assistance Response to the Drought in Moldova project, which was managed by the UNDP Moldova in partnership with the FAO and the Government of the Republic of Moldova, as well as the NGO sector and local public authorities that were implementing partners, over 383,000 drought victims received wheat seeds, fertilizers, diesel fuel, fodder, corn seeds, and food packs -UN 2008.

Through this project, 22 communities in districts that were severely affected by drought also received cash assistance to carry out public works to rehabilitate various facilities in these communities.

To mitigate the impact of drought in 2012 the government subsidized the production factors for sowing winter crops in 2012 (fall campaign) to severely affected farmers through the Ministry of Agriculture and Food Industry. The MAFI, through the contribution from a FAO project also distributed 161.5 tonnes of seeds of winter wheat to farmers severely affected by drought.

Moldova Red Cross, in cooperation with the Service of Civil Protection and Emergency Situations and Ministry of Labour, Social Protection and Family, also intervened in reducing the negative effects of the 2012 drought and provided assistance to the affected population (5,800 beneficiaries) in eleven regions.

Desertification is the land degradation process from arid, semi-arid and subhumid resulting from various causes, including climatic and human activities [11].

In the context of drought impacts the problem specific to Moldova is the lack of flexibility of the testing means used to assess the needs of rural households severely impacted by drought [24]. As the potential income from land holdings is part of the means testing formula, it is calculated based on pre-drought data, while drought-hit farmers and rural households leasing land may not have their actual situation and need for assistance correctly assessed.

Among the practices to alleviate drought impacts various methods are used in agriculture in order to mitigate risks triggered by drought: irrigation, cultivation of drought and aridity resistant plant species, application of advanced agricultural technologies, use of fertilizers. From a broad variety of primary response options for reducing drought impacts the practices applied in Moldova mainly focus on “win-win” situations, when interested stakeholders implement a particular option for increasing current agriculture productivity[7]. These measures are not considered an effective medium and long-term perspective for the farming and livestock systems across various natural and socioeconomic conditions of Moldova.

Harmful influences can be reflected into damage produced to characteristics and functions of soil, respectively in their bioproductive capacity, especially in damaging the quality of agricultural products as well as food security, with serious repercussions concerning quality of life [1].

Currently the agri-technical measures that improve soil moisture retention, such as minimum tillage and maintaining vegetative cover are the most common practices to alleviate drought impact. They also include introduction of drought-resistant crop varieties, optimization of sowing and planting times in accordance with agri-meteorological information, and elimination of weeds, which can reduce evaporation and promote effective use of soil moisture.

The most efficient measures are irrigations, but for increasing crop resistance to these conditions of high thermic regime and productive moisture deficit in the soil some selection and plant mitigation works can be made. This will lead to the emergence of a more stronger hybrids which would be able to use water resources from deeper grounds [4].

Irrigation is a valuable option of mitigating drought risk in Moldova. It influences the hydrologic regime both of soil and of the lower air layer, having a double role: on the one hand, it provides the necessary moisture for plants productivity, and on the other hand, it reduces the thermal effect and processes of evapotranspiration. Depending on the technological level of the company (farm) different types of irrigation can be used: sprinkler irrigation, canal and channel irrigation or drip irrigation that reduces the loss of water and energy used for adduction.

Irrigation needs to be applied based on correct weather monitoring. Otherwise irrigation can not only be unprofitable, but also trigger other risks and worsen the agricultural landscape. To ensure the efficiency of these works and the normal development of agricultural landscape,measures for monitoring the irrigated soils are required. In normal years irrigation contributes to increasing yield by 25%-50%, while in drought conditions it considerably averts losses.

The most widespread irrigation systems in Moldova are irrigation by canals and sprinklers. In recent years small-scale modern on-farm irrigation technologies have been introduced, based on dripping method combined with fertilization. Although dripping method is considered the most efficient system in view of a changing climate and reducing water resources, it is not widespread in Moldova.

In order to increase crop resistance to the conditions of high thermal regime or high moisture deficit, the application of crop selection and amelioration is important. It results in production of hybrids with a deeper root system that can use water resources from deeper horizons. In order to mitigate the negative effects of the mentioned phenomena, the following measures are being taken: ecological location/combination of crops, planting windbreaks/shelterbelts, use of black fallows, snow retention, respecting optimal norms for seeding, differentiated soil works [10,22].

Of vital importance is also aligning climate information with management design information to facilitate decision making in drylands. The potential value of increasingly sophisticated weather and climate information for various practical applications in a changing climate is supported by significant body of climate and social science research [7,13,16].

A range of governmental and CSO organizations related to the DLDD issues are also aware of the value of climate information and actively recognize the role that climate information can play in risk reduction, early warning and actions.

However, the experience of practical implications of climate information in the most vulnerable sectors, such as agriculture, as well as a dialogue with stakeholders clearly identifythat current tools and models are not appropriately aligned with the stakeholders' skills and do not meet stakeholders' needs [16; 8].

One of the main reasons for a missing link between climate information and its utilization by the end user farmers is unfortunately, the farmers' reduced ability to apply it.

This information needs to be designed in a more usable manner that would promote farmers' motivation and ability to use it to assist in agricultural decision making. In this context, translation of the climate data and modelled information into simple and, at the same time, effective decision support tools (DST) can provide incentives for designing more sustainable land management plans [8].

Hence, it is evident, that success and efficiency of the response action plans depend on the effective actions on the national and local level. Climate DSTs help policy decision makers understand the impact of climate variability and have implications for developing effective communication strategies, motivating people to take action, improving readiness and devising appropriate response strategies.

In the Republic of Moldova land use is to a large degree a private sector activity and the decisions on land management and investments are often a prerogative of the private actors at the local level. This being a lot of times beyond government reach and attempts to call these private owners to formal meetings may prove sometimes to be tedious.

Wide involvement of the stakeholders and agricultural producers is, therefore, highly critical for the improved use of weather and climate DSTs [16,8]. The section below successfully demonstrates regional and community based climate services for improving the use of weather and climate DSTs in the DLDD risk assessment and management.

Regarding the attribution of agro-ecosystems production to climate variability and agricultural technologies, the simple relationship between agro-ecosystems production and drought is likely to be veiled by practices used to increase productivity in affected areas. To eliminate climate component, the agro-ecosystems productivity (Yi) has been examined through a sum of two components [6]: $Yi = Yi\ (T) + \Delta\ Yi\ (T)$, where Yi (T) is a contribution of science and technology factors that lead to the gradual intensification of agriculture and include the implementation of advanced agricultural practices and technologies, the use of high productivity varieties and fertilizers, irrigation, etc.

These factors are expressed using a time depended function (trend) that describes the contribution of the socio-economic and scientific variables to the agro-ecosystems productivity in the average climate of a given location. Linear or nonlinear regression methods are usually used to assess the impact of these factors [6, 17, 20].

The second (Δ Yi (T)) component is controlled by climate variability. Herewith, it is assumed that in case of positive values of Δ Yi (T) there is no significant negative climate impact on the agro-ecosystems productivity, and, on the contrary, decreased (negative values) productivity, exceeding the certain level, is conditioned by excessive or insufficient quantity of the main climate factors.

Since the Republic of Moldova is sufficiently provided by heat resources and fertile soils, significant failure of the agro-ecosystem productivity is due to water deficiency and drought [7]. To evaluate crop production under the climate variability $\Delta Yi(T)$, the deletion of the science and technology component of the agricultural ecosystems productivity is used according to the equation [6]:

$$\mathbf{\Delta Yi(T) = Yi - Yi\ (T)/\ Yi\ (T)}$$

As a criterion for identification of dry (wet) climate environment for crop production, values of the estimated errors of the technological component approximation (S Yi (T) %) have been accepted. This approach allows to eliminate a "climate mediocrity" that just complicates getting a quick estimate for operational purposes.

Examination of the linear trends of major agricultural crops productivity over the recent decades shows a sustainable increase in the majority of crop yields before the 1990s [7,20]. By the beginning of the 1990s the contribution of the technological factors Yi (T) reached the historical maximum.

A comparison between the 1980 and 1990 decade may provide some sort of clarification regarding crop productivity and yeld in general for most of the crops.

For example, the average yield of winter wheat at the end of the 1980s was at its peak and varied over the territory of the country from 3.1 to 4.3 t/ha, which is a high attainment in the specific technological and climate conditions of Moldova. This can be better analized in the following figure.

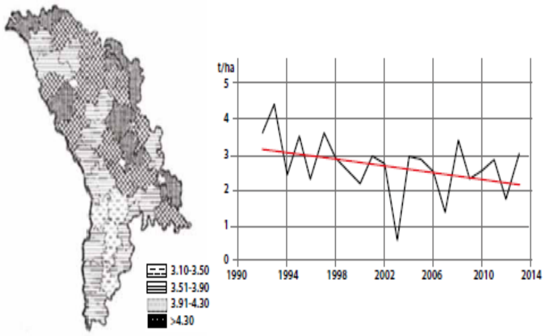

Figure 4. Yield (t/ha) of winter wheat at the level of the 1990 agriculture technology and its trend component over the recent decades described by linear approximation (Republic of Moldova).Source: Adapted from Daradur et al., 2007; 2014 [7,8].

Starting from the 1990s, a dramatic yearly decline in the resiliency of the agricultural ecosystems promoted a decrease in crops productivity. Non-linear approximation of the time depended agro-ecosystems productivity clearly indicates such a dramatic trend. The overall level of agricultural technology in Moldova has been turned 35-40 years back to the end of the 1960s with the average productivity of crops at the level of 1.5 - 2.0 t/ha.

The consequences and operative quanti-fication of benefit losses due to degradation of agricultural technologies can be estimated using a trend extrapolation of the post 1990 period based on the approximation estimates for the previous period of time (1950-1990) and this hypothetical trend can be further compared with their actual values in the recent decades (Figure 5).

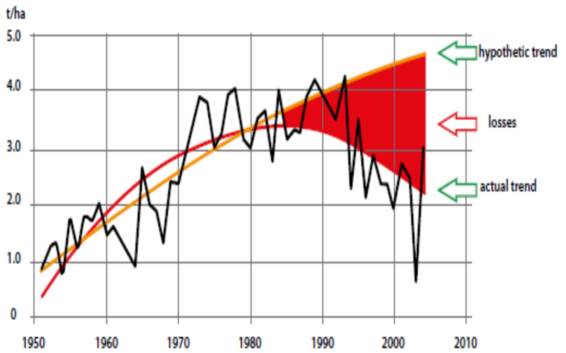

Figure 5. Comparing the actual and hypothetic trends of the yield for operational estimation of crop production losses due to degradation of technological factors (Winter wheat, Republic of Moldova). Source: Adapted from Daradur et al., 2007 [7];

If we accept the available statistics for the average annual acreage Sy (ha), then the corres-ponding annual losses of production, Ni Sy can be easily calculated using the expression:

Ni Sy = Yi' (T) - Yi (T)*Sy were Yi' (T) is an extrapolated (hypothetic) trend of crop production.

According to the available sources [7] the benefit losses for winter wheat production in the 1990s reached the value of 1.5 mln tons.

This underperformance can be attributed to a set of drivers resulting from launching the land reform in 1991. Since the proclamation of independence (1991) Moldova has gone through an unprecedented economic transformation which, due to the rapid and often chaotic transition process, has accelerated environmental degradation and has been associated with increasing poverty and rural vulnerability.

The post-Soviet land reform has cardinally changed the agriculture land ownership and tenure pattern form. Transition to the new forms of management in agriculture has negatively affected the sector by promoting expansive overexploitation of the land resources and the unsustainable land use. Losses of benefit have been further exacer-bated by the risks posed by the increased extreme drought frequency in the recent decade.

Just in the recent years (2000-2014) the Republic of Moldova has already experienced several (2000, 2003, 2007, 2012) long lasting droughts which have created a challenging environment and had a dramatic effect on all development sectors. The challenges for agricul-tural ecosystems productivity created by this unfavorable environment are expected to significantly increase in the changing climate, making the issue of enhancing drought adaptation capacity highly relevant.

At present, despite the high level of natural soil fertility and favorable climate for the main crops, productivity of agricultural ecosystems in Moldova is very low. This is best illustrated by comparing Moldova to other countries (Figure 6). For example, the comparison reveals that the total cereals yield in Moldova is approximately 2 times lower than the average for the European Union countries. Compared to certain countries (such as Netherlands), the yields are 3 or even more times lower.

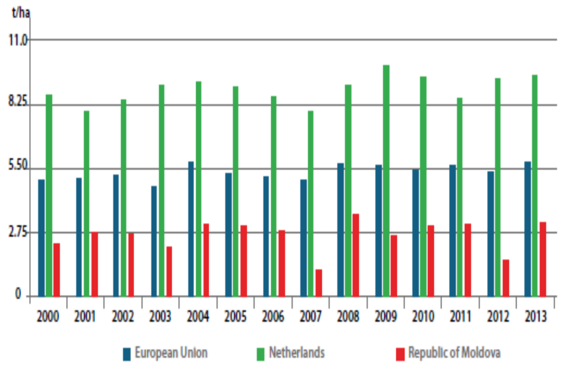

Figure 6. Comparison of the total cereals yield (t/ha) in the Republic of Moldova, Netherlands and the European Union. Adapted from Daradur et al. 2014; [8].

Temporal and geographical features of yield variability defined by climate components are given in the figures below. Note that the failures in yield production in Moldova tend to steadily rise in time, which indicates an increase of agro-ecosystems vulnerability to climate and drought. A concerning fact indeed regarding the major regresion from european standards and efficiency but understandable considering the economic differences.

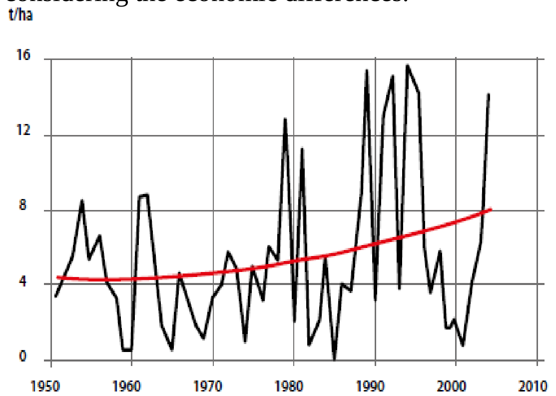

Figure 7. Time depended contribution of the climate component to variability of agro-ecosystems productivity (maize, Republic of Moldova). Source: Daradur et al., 2007 [7]

It is widely known that for mitigating risks triggered by drought phenomena in agriculture several methods are used: irrigation, cultivating breeds of plants which are able to endure dryness, drought and also winds that blow with an extremely high temperature and reduced humidity which are typical to steppe and semi-desert areas [4]

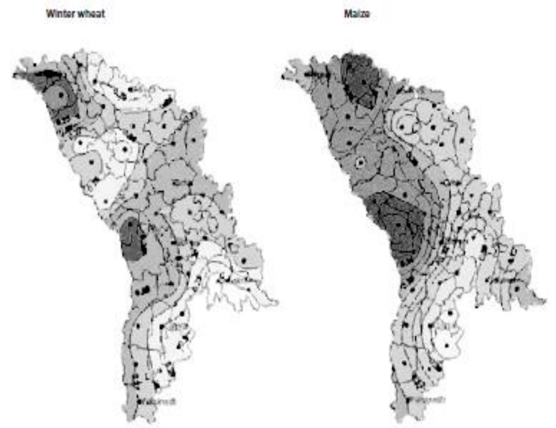

Figure 8. Contribution of climate to variability of agro-ecosystems productivity ΔYi(T) in the Republic of Moldova. Source: Daradur et al., 2007, [7].

For diminishing the effects of the above phenomenon some specific actions can be taken: ecological placement of agricultural crops, planting protection strips, using dark fields, snow retention, respecting the optimal terms and norms for sowing and of course differentiated work of soil.

Drought in Moldova, which is one of the most dangerous natural phenomenon, representing a specific feature of its regional climate, is conditioned by the irregular distribution in time and space of atmospheric precipitations due to the high values recorded of air temperature.

In contrast to other natural hazards, draughts represent a gradual process with long term negative consequences. Although they solely do not lead to human lives losses, tens of thousands of people can suffer of starvation. That is why after the material damages (22%), droughts worldwide are surpassed only by tropical cyclones (30%), and considering the social effect, this phenomenon has no similarity [4].

Crop gathering for the main agricultural late growing (corn, sun flower, beetroot sugar, tobacco, fruit bearers) can be compromised on a large scale, and enterprises from the above sectors may experience without raw material in the case of a catastrophic drought. An extremely grave situation regarding the provision with filling may occur in the zootechnic sector in the case of a grave drought.

Assessment of the amount of water needed to reach agroecosystems potential productivity in drylands is the key element for fighting with drought and desertification and assuring a sense of production continuity.

In the drylands, where water resources are the main limiting factor of the agroecosystems productivity, the estimates of water shortage are requested by a variety of models and decision making. Using the values of the Precipitation Deficiency (PD) is an example of the effective tool for risk assessment and mapping climatically predisposed to drought risk areas (DRAs).

Regarding drought risk it is important to underline that risk represents assuming the hazard by the system, whose integrity is jeopardized, and the disaster derives from the way in which the human society reacts to events -destructive phenomenon [2]. Of course, droughts can lead to natural disasters, due to the damages produced by them [15].

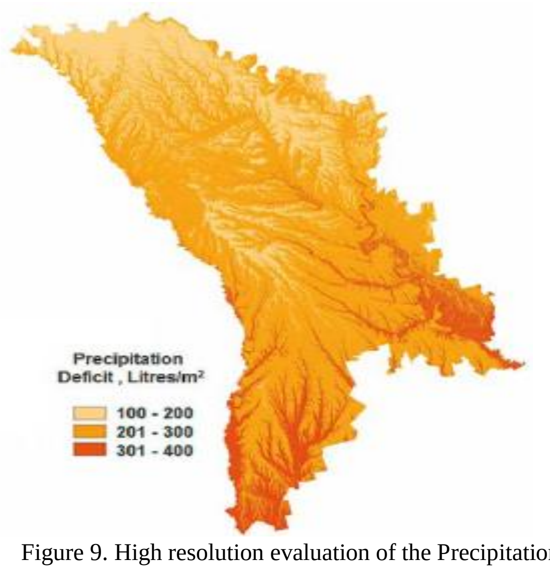

Figure 9. High resolution evaluation of the Precipitation Deficit (PD) within the UNCCD land classes. Source: Daradur et al., 2014, [8].

The PD accumulated values are equivalent to the amount of water that needs to be added to reach agroecosystem potential productivity, for example, by irrigation. The PD estimates are therefore essential for designing smart agriculture that provides an effective approach for rational use of the limited drylands water resources with intensive agriculture [6, 23, 19].

They are given in liters per square meter and, therefore, are useful and usable for practical implementation. In case of the Republic of Moldova Precipitation Deficit (PD) was calculated monthly and accumulated for each month over the growing period (April-September). The above Figure shows the values averaged over 63 years (1946-2012) for the 90 m x 90 m gridded data. These estimates are represented at high resolution since Moldovan complex orography gives specific climate response to spatial variability in the PD.

CONCLUSIONS

According to the estimates the zonal values of the PD values experience a 100-400 liters/m2 rate. The areas that are under a potential desertification and drought risk (the major part of the Moldovan territory - 74.5% - that corresponds to the category of "drylands") experience a considerable water deficit (>200 liters/m2). Accumulated values of PD over the growing period (April-September) show that the local variations of the PD values at the community level can reach 100-150 litres/m2, which is comparable to the zonal changes.

This suggests that a different rate of agro-ecosystem services is needed to reach balanced water conditions for maintaining a sustainable productivity of agro-ecosystems within limited areas. This also assumes an unequal market capability for agricultural producers that needs to be considered in assessing the value of the agro-ecosystem services.

Regarding the agro-ecosystem services it is the small rural household productions that are the most severe struck by drought and afferent repercussions and the action plans should be focused mainly on aiding these type of granges.

Overall economic losses are of great concern as well, because they affect the well being of the entire country and the distribution of the national budget can be severely altered in case of a natural catastrophe such as droughts.

The water supply and its quality has a key role in managing extensive drought periods and the government should have strategies ensuring a high quality especially to small household wells.

Irrigation may well serve as a handy and conveniently sollution, but certain aspects have to be taken into consideration when applying it to various types of lands. Together with crop selection, its rotation and drought resistent breeds, irrigation may prove to be the winning card.

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